The University of Nottingham

Faculty of Engineering
Department of Architecture and Built Environment
Institute of Architecture

Evaluation and Enhancement of Environmental Performance of Refugee Shelters in Palestine

Sanaa Y. H. Saleh

BSc. MSc. (Architecture)

Thesis submitted to the University of Nottingham
for the degree of Doctor of Philosophy

Nottingham – United Kingdom
November 2011

ABSTRACT

Creating appropriate indoor conditions for satisfying human thermal, visual, and aural desires has been recognized to be an essential requirement in building design, since the composition of indoor environment parameters have determined human performance and productivity, as well as physical and intellectual capability. However, achieving optimum indoor conditions for building`s occupants should also be parallel with energy saving in order to achieve green indoor environment. Thermal comfort is the most substantial among other indoor environmental parameters and has the greatest effect on energy consumption. Shelters in refugee camps in Palestine can experience poor ventilation, lack of natural light and solar radiation, and noise problems, as a sequence of high urban density, absence of green areas, and lack of land; whereas refugee camps in Palestine have one of the highest population densities in the world. Moreover, the cost of energy is high in Palestine and it is the most expensive in all countries in the Middle East.

In view of this scenario, this thesis intended to investigate the indoor environment of shelters in Palestinian refugee camps including thermal, visual, and acoustic environment, and other indoor parameters, with focus on thermal comfort, in order to provide suggestions for potential enhancement. The shelters of Special Hardship Cases (SHC) families were selected in this study; whereas the United Nations Relief and Works Agency (UNRWA) for Palestine Refugees in the Near East has been promoting shelter reconstruction programme for SHC families all over the camps. The characteristics of the existing new and old SHC shelters in refugee camps including their design criteria, forms, materials, and surrounding conditions were reviewed to have a better understanding of the nature of these shelters. Studying the two groups of shelters, old and new, was to help assessing the value of the improvement that has already taken place by the UNRWA and to bring greater comprehension of indoor conditions that still need more enhancements.

Two main methods, questionnaire and computer model, were employed in this research. Questionnaires were utilized to evaluate the indoor conditions of the SHC shelters including thermal, visual, and acoustic environment, and other indoor parameters, through interviews with a purposive convenience sample of 155 SHC families from Jabalia refugee camp. The gathered data were analyzed by applying various statistical analysis tests utilizing SPSS. Thermal modelling using Thermal Analysis Software (TAS V9.1.4.1) was employed in this study at two stages; to analyse the thermal performance of the existing SHC shelters and to identify the potential enhancement of the proposed alternate materials. Twenty one shelters, old and new, were simulated while three new shelters were selected to apply the proposed fabrics.

The survey and the thermal simulation of the shelters revealed that heat loss/gain through shelters` envelopes is one of the most influence factors causing discomfort in majority of shelters. Various shelters` components including; walls, roofs, ground floors and windows; and various combinations of them were simulated to reflect the best thermal comfort levels attained and to reflect the optimum energy reduction achieved. The results could be taken as a guideline for the SHC shelters` envelopes in all refugee camps located in hot humid climates. It is also suggested that similar approaches may be adopted for all refugee shelters located in camps in similar climatic regions. However, the techniques employed in this study may be applicable to other buildings in other locations or climatic conditions. Finally, the thesis drew conclusions and identified areas for further research depending on the findings.

ACKNOWLEDGMENT

My praise is to Allah SWT, on whom ultimately we depend, for guiding me to accomplish my research.

The development of this thesis was made possible only by the assistance, and support from many persons and institutions. First of all, my sincere appreciation goes to my supervisor- Associate Professor Dr. Mohamed Gadi, for his guidance, unfailing assistance and constructive comments. His timely and efficient contribution helped me shape this into its final form.

I am indebted to my employer, the Islamic University of Gaza (IUG), for giving me the opportunity to pursue my study at a higher level. I am particularly grateful to my sponsor, Palestinian European Academic Cooperation in Education (PEACE), programme for supporting me financially.

I would like to thank the UNRWA officials in Palestine who have helped in this study by either providing materials or giving me time for discussion, despite the pressure of work. I would like to acknowledge my brother Dr. Saed Saleh for his continuous support and for his assistance in supervising the survey team in Palestine. I would like to express my gratitude to the architect Hana Abuelaish for her work in the survey. My deep thanks go to refugee families, the resident of the studied shelters, in Jabalia refugee camp for their cooperation with the survey team.

I extend my gratitude to my mother and my father for their prayers and sacrifices. My thanks are also due to my sisters and brothers for their endless love. My deepest thanks and sincere indebtedness go to my husband and our children, Khalil and Razan, for their unwavering support and encouragement in making this adventure possible.

Sanaa Saleh, 2011

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AC	Air Conditioning
acr	Air Change Rate
aPMV	Adaptive Predicted Mean Vote
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineering
CFD	Computational Fluid Dynamics
CIBSE	Chartered Institute of Building Services Engineers
DBT	Dry Bulb Temperature
DF	Daylight Factor
FR	Free Running
HVAC	Heating Ventilation and Air Conditioning
MRT	Mean Radiant Temperature
NV	Natural Ventilation
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
RH	Relative Humidity
RT	Resultant Temperature
SHC	Special Hardship Case
SA	Solar Absorption
SWHS	Solar Water Heating System
SHGC	Solar Heat Gain Coefficient
TAS	Thermal Analysis Software
TSV	Thermal Sensation Vote
TL	Transmission Loss
UNRWA	United Nations Relief and Works Agency
VOC	Volatile Organic Compound

LIST OF NOMENCLATURE

Ei	Illumination indoors at the point taken, [lx]
Eo	Illumination outdoors from an unobstructed sky hemisphere, [lx]
f_{cl}	Clothing surface area factor
h_c	Convective heat transfer coefficient, [W/m^2.K]
I_{abs}	Intensity of absorbed sound, [W/m^2]
I_{inc}	Intensity of sound incident on the surface, [W/m^2]
M	Metabolic rate, [W/m^2]
p_a	Water vapour partial pressure, [Pa]
Qc	Conduction heat gain or loss, [W]
Qe	Evaporative heat loss, [W]
Qi	Internal heat gain, [W]
Qs	Solar heat gain, [W]
Qv	Ventilation heat gain or loss, [W]
t	Transmission coefficient
t_a	Air temperature, [^{o}C]
T_{av}	Average temperature, [^{o}C]
t_c	Comfort temperature, [^{o}C]
t_{cl}	Clothing surface temperature, [^{o}C]
T_L	Lower limit temperature, [^{o}C]
Tn	Neutral temperature, [^{o}C]
t_{oc}	Operative comfort temperature, [^{o}C]
t_{out}	Outside temperature, [^{o}C]
t_r	Mean radiant temperature, [^{o}C]
T_U	Upper limit temperature, [^{o}C]
W	Effective mechanical power, [W/m^2]
λ	Adaptive coefficient
ΔS	Change in heat stored in building, [W]

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

It is essential for building designer, as a major responsibility, to provide appropriate indoor conditions for effective human visual and aural perception in conditions of thermal comfort in order to attain healthy, productive, effective, creative, and social acceptable lifestyle in buildings. Achieving optimum indoor conditions for building`s occupants should also be parallel with energy saving in order to achieve green indoor environment compatible with greening of the wider environment. Creating suitable thermal conditions for satisfying human desires for thermal comfort has been recognized to be an essential requirement of the indoor environment. Thermal comfort is the most substantial and it plays a major role among other indoor environmental parameters since the thermal behaviour of a building has greatest effect on energy use and sustainability (Szokolay, 2008 and Hoof, 2008). Therefore, it is essential that thermal comfort in buildings must be taken into serious consideration.

In recent years, many researchers studied thermal environment and occupant`s comfort in residential buildings of different climatic zones at various geographical locations. Specifically, in Palestine, such field studies have never been conducted on shelters in refugees camps. Refugee camps are unique in terms of urban structure and political conditions, and the lifestyle and the economic status of camps` occupants are different from those in other areas in Palestine. Due to the historical unstable political situation in Palestine, the refugee camps suffer from major drawbacks and the occupants are the most vulnerable. The refugee camps in Palestine have one of the highest population densities in the world, for instance, 108,000 registered refugees live in Jabalia camp whose area is only 1.4 km^2 , i.e. the population density exceeds 77,000 persons per km^2. In order to improve refugees' living conditions in camps, the United Nations Relief and Works Agency (UNRWA) for Palestine Refugees in the Near East has been promoting shelter reconstruction programme for Special Hardship Cases (SHC) families all over the camps. The UNRWA has reconstructed SHC shelters according to criteria, which have been developed by a team of architects and engineers to comply with international standard housing criteria, and in view of the UNRWA experience in the field of shelter rehabilitation and re-housing programme in order to have functional, safe and comfortable one (UNRWA, 2010).

This study intended to investigate the indoor environment of SHC shelters including thermal, visual, and acoustic environment and the occupants' satisfaction with focus on thermal comfort. Both SHC shelters; the shelters which are not reconstructed by the UNRWA yet (referred to as old shelters), and the shelters which already were reconstructed by the UNRWA (referred to as new shelters), were considered and examined and a comparison between them was conducted. Studying the two groups of shelters, old and new, was to help assessing the value of the improvement that has already taken place by the UNRWA and to bring greater comprehension of indoor conditions that still need more enhancements. There are 29 recognised refugee camps in Palestine, 21 camps in the West Bank and 8 camps in the Gaza Strip. Climatic conditions of Palestine are extremely diverse despite the country's small size and could be divided into four climatic zones, which are; the coastal climate, the hilly areas, the Jordan valley, and the Naqab desert (ARIJ, 2001). Gaza strip is located in the coastal zone while the West Bank is located in the hilly areas and the Jordan valley. In this study, refugee camps in Gaza Strip which are located in hot humid climate were considered for the investigation.

1.2 FORMULATION OF THE PROBLEM

The shelter problems of the Special Hardship Cases in Palestinian refugee camps range from substandard to hazardous conditions, in particular, structurally unstable walls, inadequate ventilation or limited space. The objective of the Shelter Rehabilitation Programme conducted by the UNRWA is to ensure that dwellings meet the minimum requirements of space, health conditions and the needs of the family. However the shelter is not just a barrier against unwanted influences (rain, wind, cold), but its envelope should be considered as a selective filter to exclude the unwanted influences and admit the desirable ones, such as daylight, solar radiation and natural ventilation (Szokolay, 2008). Since shelters in refugee camps are influenced by a wide range of complicated factors, including dense urban environment, economic limitations, absence of regulations, environmental issues, and political consideration; the design of these shelters is more difficult. The following is discussion for these factors.

1.2.1 Urban Structure

The refugee camps in the Gaza Strip have one of the highest population densities in the world exceeds 77,000 persons per km^2. This high population density is reflected in the overcrowded urban environment of the camps. According to Givoni (1998), urban density is a major factor that influences the urban ventilation conditions, as well as the urban temperature. Urban density and lack of land and space are the key factors limiting the achieving of comfort indoor conditions and make it difficult to find suitable design (Hui, 2001). In hot humid climate, the urban structure should be scattered and loose in order to channel winds through the streets and inside buildings. However, in refugee camps, under the crowded and stressful urban environment, the shelters can experience poor ventilation and lack of solar radiation which may have unhealthy effects on the occupants. In addition, urban density may reduce the potential for natural lighting which may increase the need for electric lighting. As Gaza Strip is located in warm humid climate, these features would lead to a high level of thermal stress and to increased use of energy for mechanical ventilation. The use of natural lighting, natural ventilation, and solar energy in refugee camps will be strongly affected by closely spaced as the alleys inside the camps are narrow, sometimes only a 0.6 metre wide, making the design optimisation of the shelters more complicated. Designing comfortable shelters requires special care to; the analysis of the climatic conditions, the urban structure, the coordination of energy systems, the integration of architectural elements, and the utilisation of construction materials.

All in all, shelters in dense urban environment require more careful design in order to achieve comfort indoor conditions, maximise energy efficiency, and satisfy other social requirements.

1.2.2 Economic Limitations

Bearing in mind the economic conditions of SHC families, it is important to recognise that solutions to the indoor conditions problems are not simply a matter of utilizing construction materials or applying technology. A challenging task of architects and other building professionals is to design and promote comfort and low energy shelters in a cost effective way. More cases have been added to the list of SHC as a result of the natural growth rate and the poor economic conditions. Hundreds of SHC families are still on the waiting list for shelter reconstruction; with funds drying up the UNRWA is unable to keep to its targets (UNRWA, 2010). Besides, economic considerations do not allow the use of mechanical means to control indoor environments. The occupants who can afford it have to pay the highest percentage of their earnings to make their lodgings habitable but the most is unable to pay for their energy bills. The cost of electricity is high in Palestine and it is the most expensive in all the countries in the Middle East (PEC, 2010). The creation of liveable indoor environment is the task of the designer which will lead to minimise energy waste and that means saving money through lower energy bills.

1.2.3 Environmental Issues

There are many excellent reasons why all shelters should take energy efficiency seriously through comfort indoor environment, from economical saving to helping to reduce damage to the environment by reducing the energy consumption. Wasting energy not only wastes money; it results in unnecessary pollution, particularly through emissions of the main greenhouse gas, carbon dioxide, leading to global warming which is the single most important environmental issue. By using energy more efficiently, the shelters will be reducing its impact on the environment. A contributing factor to the inefficiency in SHC shelters in refugee camps is that some occupants have to use low energy content fuels and inefficient heating methods such as burning wood or using kerosene fires affecting not only the indoor environment but also the exterior environment. Even the electricity in Gaza strip, which is used for heating and mechanical ventilation, is generated in a diesel based power plant. That plant is one of the most environmentally damaging activities, if air pollutant emissions are not controlled. When it is realised that the traditional energy sources are finite and their rapidly increasing use has serious environmental consequences, it should be the designer's aim to ensure the required indoor conditions with little or no use of energy (Szokolay, 2008).

1.2.4 Absence of Regulations

Another factor which strongly has influenced the shelters in Palestinian refugee camps is the absence of law enforcement body to supervise the rules of construction activities in the camps. Neither the UNRWA nor the Palestinian National Authority has re-assumed legal power in refugee camps. Lax regulations have resulted in many complicated social and physical problems. When the old cramped rooms of refugees' shelters became unfit to absorb the increasing numbers of family members, refugees started to extend their shelters by adding new rooms or enlarge the old ones causing pathways to become further narrowed. Other refugees had the ability to demolish their shelters in order to construct new ones with the discretion of owners and the contractors and without any technical supervision. Further, refugees started to construct three and four stories on top of their shelters and it was observed that these added floors are composed of rooms built on top of each other. On the other hand, many shelters which remained without any vertical extension have affected acutely when the adjacent shelters became two or three stories. Thus these shelters, located between the high dwellings, were deprived of solar radiation, natural light and ventilation in addition to visual privacy. The proximity of the shelters to each other and the non-compliance to technical regulations has caused observable problems of the indoor environment.

1.2.5 Design Criteria

In 1993, under Peace Implementation Programme, the UNRWA has strived to provide SHC families living in unsafe and unhealthy shelter with adequate shelter provision. The design criteria of these shelters are adopted by the UNRWA in view of its experience in the field of shelter rehabilitation in order to have shelters defined as follows: structurally and environmentally safe, no overcrowding, connected to basic infrastructure, provided with sanitary facilities, properly lit and ventilated, and has a suitable access.

By reviewing the above criteria, it is obvious that they do not entail any considerations for climatic issues and energy conservation in such shelters. It can be seen therefore, that there is a definite need for research in this field to study the role of architects by designing a good quality shelter to be comfortable and energy efficient.

1.2.6 Political Issues

Finally, in present context, it is difficult to propose one concrete solution for the shelter problems in the Palestinian refugee camps. The root answer to this problem and others facing refugees is directly connected to the political dimension of the postponed refugee question. Then, only under a situation where they exercise their right of return to their previous homes can a viable solution exist. Nevertheless, this should not hinder improving living conditions. It is their right as human beings to have an acceptable standard of living, since it is evident that no contradiction exists between improving living conditions in refugee camps and adherence to the right of return (Elkahlout, 2001). Therefore, efforts should be concentrated on improving the indoor environment in refugee camps.

From the above discussion it is evident that a concerted effort is required to find appropriate solutions. In this study it is proposed that the above problems could be addressed simultaneously by enhancing the indoor environment and energy efficiency of SHC shelters in realizing the economic, social and environmental benefits it brings to the refugees. The adequate shelters which have significantly comfort indoor conditions and lower energy consumption can be achieved through good design practices and effective use of construction materials. As environmental design is becoming more and more complicated, there is a need to use methods and skills, such as simulation and modelling techniques for the evaluation of indoor environment conditions of shelters and the analysis of design options and approaches. Passive and low energy architecture has been proposed and investigated in different locations of the world. However, at present, little information is available for studying comfort and low energy shelter design in areas such as those of refugee camps

1.3 THE AIM AND OBJECTIVES OF THE STUDY

The principal aim of this thesis is to evaluate the indoor environment of SHC shelters such as thermal, visual, and acoustic environments, with focus on thermal conditions, and to provide suggestions for potential enhancement in order to achieve thermal comfort taking in consideration the economical issues. By evaluating shelters in this manner, occupants` comfort in SHC shelters could be addressed and achieved while improving other attributes, such as substantial gains in energy reduction. In order to achieve the aim of this thesis; the following research objectives have been identified:

1- To understand the climatic parameters of the Coastal region in Palestine and their effect on shelter design.

Shelters should be designed to keep comfort indoor environment irrespective of fluctuations in the outdoor climate. To create desired internal environment, knowledge of outdoor environment conditions is an essential part in design process. Therefore, the first step in any environmental design approach is to examine the given climate and establish the nature of the climatic problem with relation to human requirements. This will significantly affect the choice of thermal properties of external building envelope.

2- To provide a detailed description of the existing SHC shelters in refugee camps.

A clarification and analysis of the SHC shelters of Palestinian refugees helps to have a better understanding of the nature of these shelters; their growing, forms, materials, and surrounding conditions, which have affected the occupants.

3- To assess the current indoor environmental quality of SHC shelters and occupants satisfaction

Many characteristics of the indoor environment, such as temperatures, ventilation and lighting may affect comfort, health, and productivity of building`s occupants. As an example, lighting characteristics influence the quality of vision and can have psychological influences on mood and on perceptions about the pleasantness of a space (IPMVPC, 2001). It is necessary for the designer to be able to control the physical elements of the environment; temperature, ventilation, lighting and noise, and to establish the limits of acceptable levels by the building itself or by implementation of efficient systems. Therefore, clearly recognition and analysis of indoor environment conditions is important to be prior to design process.

4- ***To gain better understanding on parameters that affect thermal comfort level in hot humid climate***

It is of significant importance to have a detailed understanding on the thermal comfort and its parameters. Thermal comfort is the most substantial feature of internal environment, as the thermal behaviour of a building has greatest effect on energy consumption (Hoof, 2008). Identifying thermal comfort parameters in low cost shelters is essential in order to address its relevance to shelter thermal performance. Hot humid climates are the most difficult ones to achieve thermal comfort (Szokolay, 2008). The temperature maxima in the Coastal Plain in Palestine may not be as high as in the hot dry climates, but the humidity is high and evaporation from the skin is restricted leading to increasing of discomfort level. Therefore, maintaining thermal comfort in natural ventilated buildings such as the studied shelters is much more difficult in this kind of climate.

5- ***To explicate the effectiveness of the fabrics of the existing SHC shelters in terms of thermal performance.***

The aim is to investigate the potential of building materials commonly used in SHC shelters and their effect on thermal environment. Building envelope should operate as a filter to exclude the undesirable external conditions but admit the required ones such as natural ventilation in summer and solar radiation in winter. The heat exchange between the indoor and the outdoor environments depends mainly on the thermal properties of the building materials used. When appropriate properties are selected, it is possible to achieve comfortable internal conditions, or at least to minimise the discomfort, and to reduce energy consumption, inconsequently of the fluctuation of external conditions. Building fabrics are considered to be one of the most significant factors affects the thermal comfort and consequently the energy performance of buildings (Foros, 2006). Substantial concern of material performance and efficiency should be considered in SHC shelters` envelope especially those located in hot humid region and dense urban environment.

6- ***To develop comfort and energy efficient shelters through modification in shelters` envelope.***

Depending on the above discussion, it is clear that high-performance shelter is possible to be developed through the optimisation of building materials. Thermal analysis software "TAS" is used in this study in order to discover the most appropriate materials for shelters located in hot humid climate in refugee camps taking into account the effects of the dense urban environment. The results could be taken as a guideline for roofs, walls, ground floors, and glazing of the SHC shelters in refugee camps, considering the limited financial capabilities.

1.4 SCOPE AND LIMITATIONS

In this study, the evaluation of the indoor conditions of the SHC shelters includes thermal, visual and, acoustic environment (with concentration on thermal comfort) and other environmental factors such as; amount of space, security and quality of air. Due to time and efficiency limitations, it is not possible to simulate and enhance all indoor environment conditions of the SHC shelters at once. Therefore, this study focuses on the thermal environment where the thermal performance of the shelters is simulated and analysed followed by suggestions for enhancement. Because of time and cost restrictions, this study could only be conducted on shelters located in one camp, which is selected from the camps located in the hot humid region in Palestine.

1.5 RESEARCH METHODOLOGY

Having identified the scope and objectives of the study, it is necessary to follow an appropriate research methodology which refers to a set of methods. In this study, various research methods have been chosen to suit the different aspects of the research. These include two main methods; questionnaires and computer model, along with secondary methods such as observations and interviews. Employing these techniques helped indicating the efficiency degree of the SHC shelters in terms of comfort indoor environment, exploring thermal performance of these shelters, and examining the potential effects of proposed materials. Different methods have different strengths and weakness; however, using a range of methods can produce a more complete picture (Gillham, 2008). Further, a multi-method approach has the potential of enriching, as well as cross-validating, research findings. The research methods which have been practised in this study are explained below.

1.5.1 Observations

Observation is a technique of data collection in which the situation or the behaviour of research subjects is watched and recorded without any direct contact (Bryman, 2005). This method is used in this study as firsthand information about the features and the problems of SHC shelters in refugee camps such as urban structure, shelter forms, construction materials, economic situation, and social and political issues. The information of these features is not gathered only since the beginning of this research, but also through living and staying in one of refugee camps for more than twenty years. All of these data helped in formulating and defining the problem in this study. In addition, these data drew clear picture about the studied shelters and played an essential role to find the most appropriate and possible solutions.

1.5.2 Interviews

Interviews are particularly useful for getting the story behind a participant's experiences. The interviewer can pursue in-depth information around the topic. Informal and semi structure interviews are carried out with key figures in the UNRWA who through their position or role know a lot about the SHC shelters reconstruction programme which developed by the Agency. The interviews are structured to encourage respondents to express themselves, allowing them flexibility to air their own agenda. These interviews provides a reasonable and efficient means of gaining deeper insights into the SHC shelters reconstruction and issues relating to design criteria and scoring systems applied.

1.5.3 Questionnaire

A questionnaire is a research instrument consisting of a number of questions that the respondent has to answer in a set format for the purpose of gathering information from respondents in a standardised way. It is one of the most widely used and important instruments in survey research as it provides useful data when the problems, concepts and dimensions to deal with are well defined (Brace, 2004). The questionnaire in this study is used as a main tool to examine the indoor environment conditions; with focus on thermal comfort, and to assess occupants' satisfaction in the SHC shelters. Since two groups of SHC shelters are to be evaluated in this study; shelters that are reconstructed by the UNRWA (new shelters) and shelters are not yet (old shelters); one questionnaire is designed for each group. Data gathered from the questionnaires are analysed using statistical analysis software **SPSS** (***Statistical Package for the Social Sciences***).

1.5.4 Computer Model

Computer simulation or computer model is a computer program that attempts to simulate an abstract model of a particular system. Simulation of building's thermal performance is necessary to quantify the environment to which occupants are exposed, to predict occupants` comfort, to identify energy consumption, and to examine alternate enhancements for achieving better indoor thermal environments and energy efficient buildings. The computer programme **TAS** (*Thermal Analysis Software*) is selected in this study as a main tool for the simulation of the both groups of SHC shelters, new and old shelters. Depending on the characteristics of these shelters and on the required outputs, which are specified in this study, TAS is chosen after conducting number of tests on several computer programmes.

TAS is employed in this study at two stages as follow:

- To assess the level of thermal comfort in both groups of SHC shelters and to analyse their thermal performance in order to get clear picture about the thermal efficiency of the fabrics in this kind of shelters.
- To identify the potential enhancement in thermal comfort and the potential energy saving of the proposed alternate materials for shelters` envelope in order to explore the most appropriate ones.

1.6 STRUCTURE OF THE THESIS

This thesis includes two main parts; Part 1: Literature Review; and Part 2: Primary Research Work. Part 1 comprises three chapters, which give the required background to establish the theoretical framework. This part of the thesis investigates the processes and principles relating to the topic based on the current knowledge. Developing an understanding of the issues involved is important for the analysis of research results. The next six chapters in Part 2 reflects the main body of the research itself; covering the methodology, the survey, the computer model and the thermal enhancement. These two parts are shown graphically in figure 1.1 at the end of this chapter. The research outline is fulfilled in the following chapters as summarised below:

Chapter 2: An Overview of the Refugee Camps in Palestine: This chapter reviews the situation of refugee camps in Palestine. The Physical characteristics of Palestine are provided along with analysis of the climatic conditions with focus on the hot humid zone of the Coastal Plains. Energy situation in Palestine is inspected with explanation for the available energy sources and their consumption and prices, followed by clarification for the establishing of refugee camps. The current urban structure of refugee camps is also illustrated and then refugees` shelters including their types, layout, occupant density and construction materials, are addressed.

Chapter 3: Indoor Environment: This chapter looks at indoor environments conditions including visual environment, acoustic environment, and other environmental factors such as indoor air quality, adequacy of space and building security. The importance of indoor environment is highlighted followed by investigation for the visual environment including visual comfort, visual amenity, and design strategies for daylight. Then, principles of sound environment are explicated in order to help identifying noise control approaches, which are investigated later. In addition, sources of indoor air pollutants and methods to reduce them are elucidated followed by review for security measures in buildings and adequacy of space concept as one of the aspects of indoor environment evaluation.

Chapter 4: Thermal Comfort & Buildings` Thermal Performance: Parameters that could affect thermal comfort are explicated to help identifying the methods of thermal comfort prediction, which are elucidated later in this chapter. Thermal comfort conditions preferred by the people in hot-humid climates are also determined. Then, factors influencing the rate of heat gain/ loss as well as the major categories of building thermal models are reviewed. The chapter then highlights different types of thermal insulation including, resistive, reflective and capacitive insulation along with illustration for their applications. Glazing properties related to heat transfer are then presented combined with parameters impact windows` thermal behaviour. The chapter finally explicates the main aspects which related to the selection of materials in hot humid climates.

Chapter 5: The Studied Shelters And Fieldwork Methodology: This chapter provides a description for the studied shelters (the SHC shelters) along with an introduction to the SHC programme conducted by the UNRWA. A summary of the population and the economic situation of the SHC families is presented followed by analysing of the conditions and the physical aspects of old shelters. Shelter reconstruction programme, which has been promoted by the UNRWA for SHC families, is also discussed. Then, description of fieldwork procedures are provided along with highlighting for the flow and the administration of the work. Criteria of selecting case studies for computer modelling are addressed too, followed by summarizing of the difficulties in conducting the fieldwork.

Chapter 6: Questionnaire Design: This chapter highlights questionnaires objectives as an applied research tool and defines the information needed. Questionnaire collection method utilized in this study is clarified, followed by discussion for the characteristics of the questions used. Rating scales and attitude measurements which are employed in questionnaire design are also reviewed, and techniques applied to avoid response errors are then presented. Questionnaire physical layout is addressed and the translation process of questionnaire is examined, followed by reviewing of pretesting phase. At the end, the chapter represents ethical issues considered in questionnaire design, and reviews survey data processing.

Chapter 7: Survey Results And Analysis of Indoor Environment: This chapter represents the first phase of the evaluation for the indoor environment of the SHC shelters, which was carried out utilizing questionnaires instruments. Background information about new and old shelters, is firstly summarized. Analysis of the indoor environment including visual, acoustic and thermal environment is presented. Thermal comfort is investigated in more details for both old and new shelters along with exploring for the energy consumption for heating and cooling. Then, reasons of thermal discomfort and potential correlations between thermal comfort and several factors are explored. Afterwards, the chapter inspects other environmental features comprising; adequacy of space, indoor air quality, and security and highlights the effect of openings on the indoor environments. At the end, general evaluation for the indoor environment of SHC shelters is discussed.

Chapter 8: Selection of Thermal Modelling Computer Programme: This chapter develops criteria for selecting thermal software and highlights the studied shelters` characteristics, which have effect on the selection process. Then, the results of several comparative tests conducted on two selected computer programmes (Ecotect & TAS) are clarified; comprising comparative tests for thermal mass, solar gain, ventilation, and external shading. At the end, a comparison between those programmes, depending on the suggested criteria and the findings of the comparative tests, is discussed

Chapter 9: Thermal Simulation and Analysis of SHC Shelters Using TAS: This chapter represents the second phase of shelters` evaluation conducted using thermal modelling software (TAS V9.1.4.1). The thermal performance of both old and new shelters is assessed and a comparison between their performances is accomplished. Thermal comfort is also predicted in these shelters followed by investigation for parameters affect indoor thermal environment. Comparisons, between the field survey results and the computer modelling results is also discussed.

Chapter 10: Improving the Fabrics of New SHC Shelters: This chapter concerns with the enhancement of the thermal environment in new SHC shelters by improving shelters` envelopes. The results of thermal simulation of proposed shelters` components including; walls, roofs, floors and windows, are discussed. The potential improvement in thermal environment is investigated by applying each element separately as well as combinations of them, followed by discussion for cost analysis for the proposed fabrics.

Chapter 11: Conclusion and Recommendations: This final chapter draws conclusions, and provide various recommendations for further research.

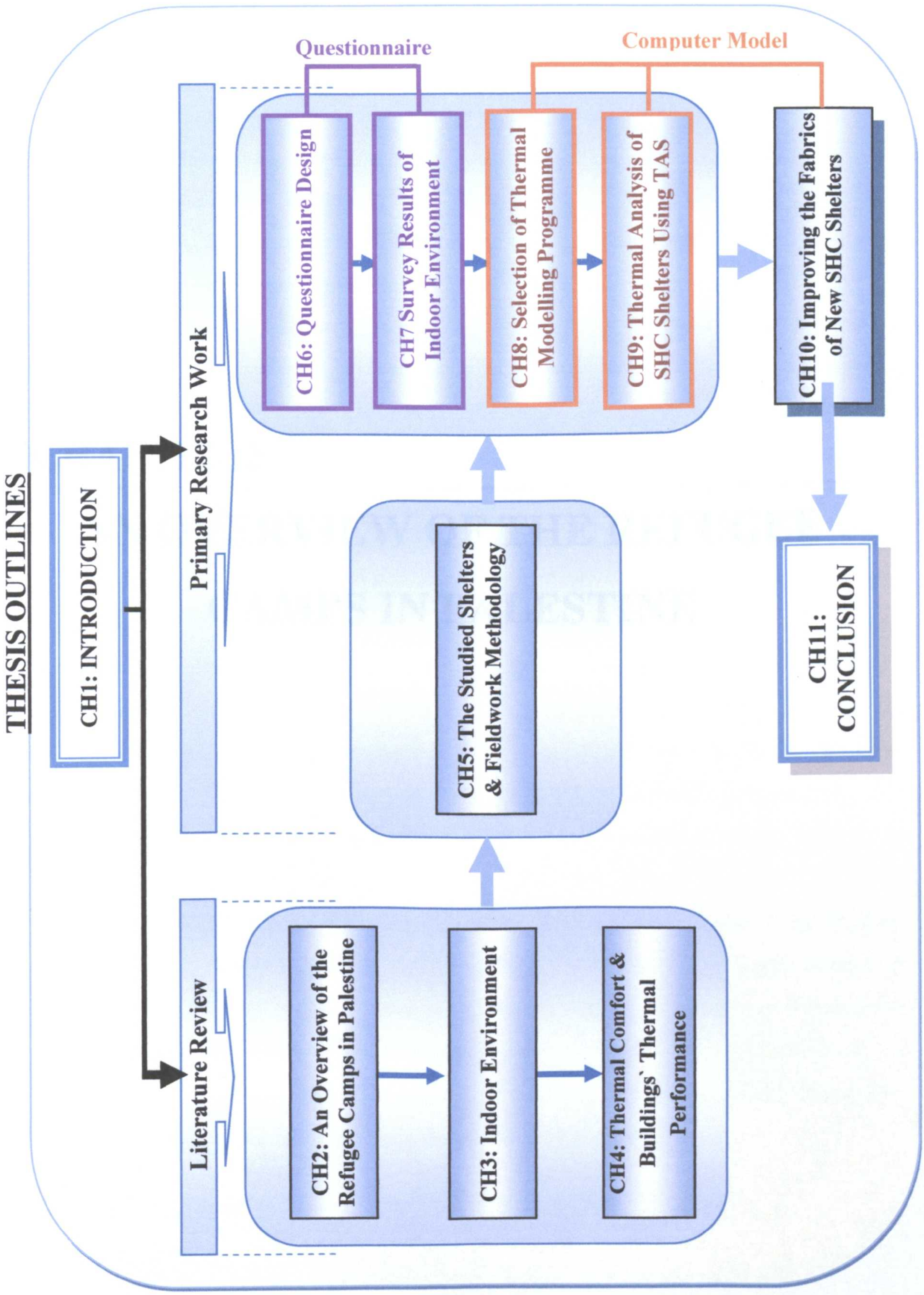


Figure 1.1: Thesis Outlines

2.1 INTRODUCTION

"*Palestinian refugees suffer the twin misfortunes of being both the largest refugee population in the world, and one of the oldest.*" (Brynen and Rifai, 2007, P1) The refugee issue traces its origins in 1948 to the forced displacement of some three quarters of a million of Palestinians from their homes within what had become the territory of the new Jewish state (PCBS, 2009). The homes and properties that they left behind were seized by the occupation government. Most refugees were barred from returning and took refuge in surrounding towns and villages and in neighbouring countries. In 1949, the United Nations created the United Nations Relief and Works Agency "UNRWA" for Palestine refugees in the Near East to take over relief operations (Schiff, 1995).

The UNRWA established the refugee camps to accommodate homeless refugees in its five fields of operations, which are; the West Bank, the Gaza Strip, Jordan, Syria and Lebanon. With the natural growth of refugee population and the passage of more than two generations of time, Palestinians refugee camps became one of the highest population densities in the world. There are 29 recognised refugee camps in Palestine; 21 camps in the West Bank and 8 camps in the Gaza Strip (UNRWA, 2010). The West Bank has the largest number of camps in the UNRWA's five fields of operations. The Gaza Strip is unique amongst the UNRWA's five fields of operations as the majority of its population is refugees.

This chapter reviews the situation of refugee camps in Palestine. The Physical characteristics of Palestine are investigated including analysis of the climatic conditions with focus on the Coastal Plains. Energy situation in Palestine is inspected followed by explanation for the establishing of refugee camps. The current urban structure of refugee camps is described and clarification of refugees` shelters including their types, layout, occupant density and construction materials, is presented.

2.2 PHYSICAL CHARACTERISTICS OF PALESTINE

2.2.1 Location

Palestine can be considered as a focal point of the world's three monotheistic religions. It has a global influence which greatly exceeds its small size. It is a tiny piece of land located at the meeting point between Asia and Africa (ARIJ, 1997). (Figure 2.1 shows the geographical location of Palestine)

Palestine was a bridge for Commercial activities and military incursions across so many different historical eras. In the ancient time, Palestine represented one of the most important trade routes. Palestine is located in the middle of several Arab countries; so, it was a bridge or crossing point for people over a long period. Moreover, the strategic location which Palestine enjoys allowed it to be a connecting point between the continents of the ancient worlds of Asia, Africa and Europe. Palestine lies to the west of the Asian continent at 31°30′ N 34°45′ E. The latitude and the longitude of Jerusalem, the capital of Palestine, are 32° 05' N and 34° 48' E respectively. Palestine is surrounded by Jordan to the east, Syria to the northeast, Lebanon to the north, the Mediterranean Sea on the west and Egypt on the south.

Figure 2.1: The geographical location of Palestine, reproduced from WCIP, 2010

Palestine consists of three distinct areas: the "West Bank", the "Gaza Strip" and the "48 Occupied Land", which refers to the areas which have been occupied since 1948. The total area of Palestine is a proximately 27,009 km^2 where the West Bank covers 5,844.5 km^2 and the Gaza Strip covers 365 km^2 (ARIJ, 2001).

2.2.2 Demography

According to the Palestinian Central Bureau of Statistics, the actual population living in the West Bank and Gaza Strip including East Jerusalem is 3.77 million people in 2007, of which 1,916,490 males and 1,859,572 females. 2.35 million Palestinians live in the West Bank (30.9% refugees) and 1.42 million live in the Gaza Strip (67.6% refugees) (see table 2.1). The number of Palestinians living in "*The 48 Occupied Land*" reaches 1,184,466 in 2007. Palestinians have maintained a high natural growth rate, which now stands at 3.3%. Population densities in the West Bank and Gaza Strip are high, which reaches 342 persons per kilometre square in the West Bank, whereas the situation in the Gaza Strip is much worse with population density reaches more than 3,600 persons per kilometre square. The total number of Palestinian population in the Diaspora at the end of 2007 was estimated to 5.0 million.

Table 2.1 : Palestinian Population by Region and Refugee based on the 2007 Census, (PCBS, 2008)

	West Bank	Gaza Strip	Palestine
Refugee	30.9 %	67.7 %	44.6 %
Not Refugee	69.1 %	32.3 %	55.4 %
Total	100 %	100 %	100 %

The 1948-war in Palestine resulted in the eviction of over 714,000 Palestinians from their lands and homes, forcing them to become refugees in the neighbouring Arab countries or in the West Bank and the Gaza Strip (ARIJ, 2007). Those refugees were owners of properties and lands which are occupied by what is called "Israel" and known as (*The 48 Occupied Land*). These Palestinians, who have been refugees for the last 63 years, are still denied the Right-to-Return to their lands.

The registered Palestinian refugees in 2007 were 4.6 million, one-third of them (nearly 1.4 million) live in 58 recognised refugee camps in Jordan, Lebanon, Syrian, the Gaza Strip and the West Bank, including East Jerusalem (see figure 2.2).

There are 29 recognised refugee camps in Palestine, 21 camps in the West Bank and 8 camps in the Gaza Strip (see table 2.2). The West Bank has the largest number of camps in UNRWA's five fields of operations. The Gaza Strip is unique amongst UNRWA's five fields of operations as the majority of its population is refugees. The refugee camps in Palestine have one of the highest population densities in the world. For instance, 108,000 registered refugees live in Jabalia camp whose area is only 1.4 kilometre square, i.e. the population density exceeds 77,000 persons per kilometre square (UNRWA, 2010). Due to natural growth, Palestinian refugees have grown in number and part of them has to leave the camps due to overcrowding and lack of housing.

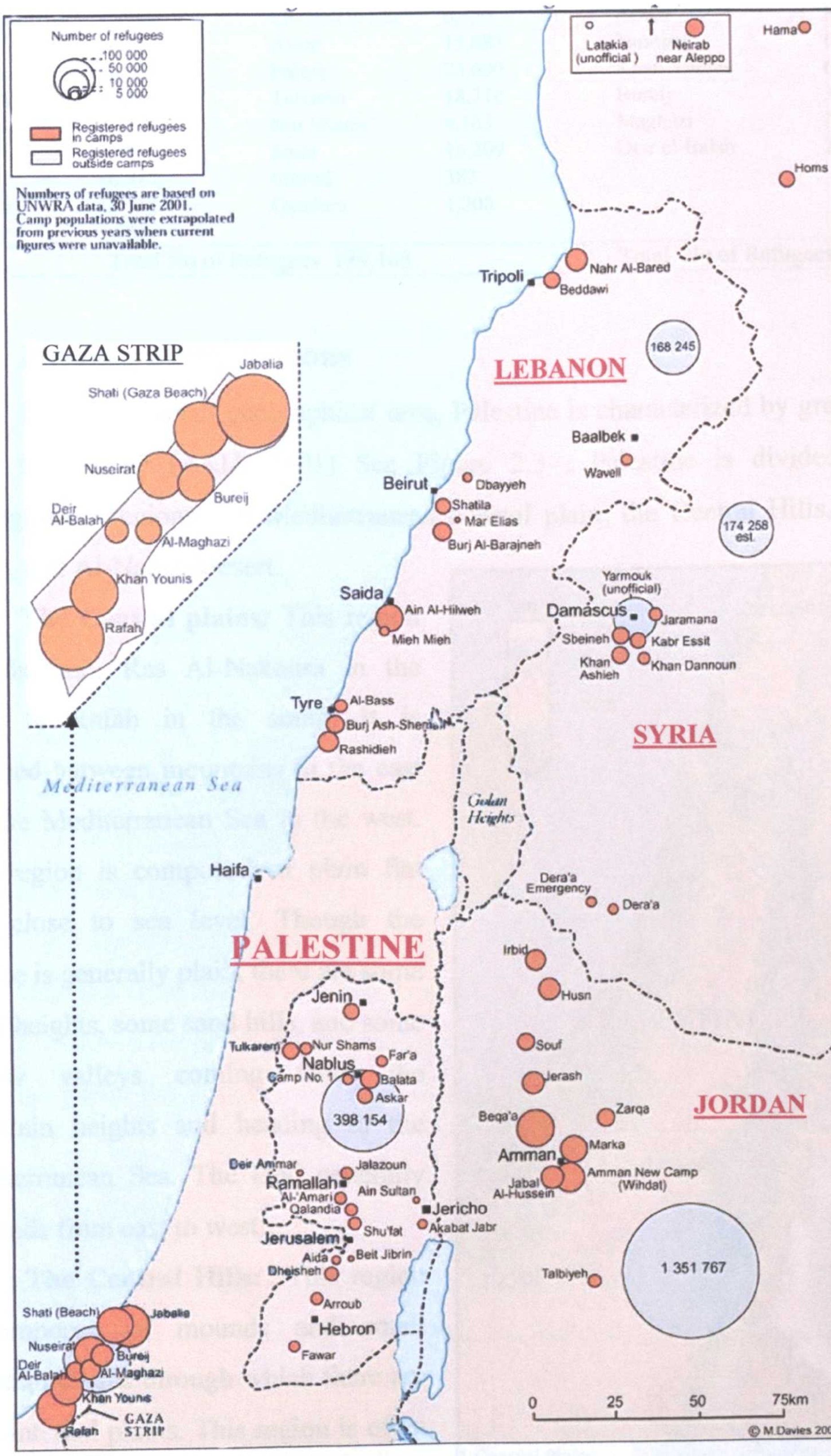


Figure 2.2: UNRWA map of Palestinian refugee camps, source: PMC, 2010

Table 2.2: Refugees Camps in Palestine, (UNRWA,2010)

Refugee Camps in the West Bank				Refugee Camps in Gaza Strip	
Camp	No of Refugees	Camp	No of Refugees	Camp	No of Refugees
Aqabat Jabr	6,403	Beit Jibrin	1,078	**Jabalia**	**107,590**
Ein el-Sultan	1,920	Far'a	7,632	Rafah	98,872
Shu'fat	10,936	Ein Beit el Ma	6,750	Beach	82,009
Am'ari	10,520	Askar	15,887	Nuseirat	62,117
Kalandia	10,981	Balata	23,600	Khan Younis	68,324
Deir Ammar	2,384	Tulkarm	18,310	Bureij	31,360
Jalazone	11,182	Nur Shams	9,163	Maghazi	23,981
Fawwar	8,066	Jenin	16,209	Deir el-Balah	20,753
Arroub	10,444	Silwad	382		
Dheisheh	12,954	Qaddura	1,208		
Aida	4,787				
Total No of Refugees 189,188				Total No of Refugees 494,296	

2.2.3 Physiographic Regions

Despite its small geographical area, Palestine is characterized by great variation in its topography (ARIJ, 2001) See Figure 2.3 . Palestine is divided into four physiographic regions: the Mediterranean coastal plain, the Central Hills, the Jordan Valley, and Al-Naqab Desert.

a. The Coastal plains: This region extends from Ras Al-Nakoura in the north to Rafah in the south. It is confined between mountains in the east and the Mediterranean Sea in the west. This region is composed of plain flat land close to sea level. Though the surface is generally plain, there are some small heights, some sand hills, and some narrow valleys coming from the mountain heights and heading to the Mediterranean Sea. The land generally descends from east to west.

b. The Central Hills: This region is composed of mounds and small mountain chains through which there are some internal plains. This region is often considered as the backbone of the Palestinian land and it stretches from the north to the farthest point in the south at

Figure 2.3: Palestine Topographic Map, reproduced from: Wikimedia, 2010

the Naqab desert. The height of the region land does not generally exceed 1,000 metres. The land gradually descends towards the plains in the west and more towards the east until it reaches the Jordan valley. Most of the valleys found in this area are dry or seasonal and flood with water immediately after rainfall.

c. **Jordan Valley:** In Palestine, this valley is the lowest point on the land surface, down to over 300m below sea level. The area lies in the eastern part of Palestine, on the border with Jordan and Syria and it stretches from the Sheik Mountains in the north to the Aqaba Gulf in the south. The River Jordan runs through this area from north to south. The length of the Jordan valley is more than 420 km long, and the width varies from 5 km to 35 km. This area has good soil but very few water resources. Agriculture there depends on irrigation, either from local streams or from the River Jordan.

The Jordan Valley is among the depressions that attract great attention all over the world. This is because the Dead Sea is located there, which is the lowest spot below sea level in the entire world.

d. **The Southern Desert (Al-Naqab):** This region comprises almost half of Palestine land. The area is characterized by a totally arid desert climate, contrasting with the semi-arid Mediterranean climate of the central and northern part of Palestine. This region is composed of a desert mound that extends along the south of Palestine and takes the form of a triangle whose base connects the southern part of the Dead Sea and Gaza on the Mediterranean Sea and whose head is located at the Gulf of Aqaba. This mound is considered to be a junction between the mound of Jerusalem and Hebron to the north and the mound of the semi-island, Siena, to the south. The surface shapes of the mound vary from the mountain chains and small mounds to the closed and small plains. It is low on the north but gets rougher in the area of middle Naqab to the south of Beer Sabe, where the heights increase to more than 1,000 metres above sea level (ARIJ, 2001).

2.2.4 Metrological data

Climatic conditions of Palestine are extremely diverse despite the country's small size. Palestine is located in a transitional climatic zone between the Mediterranean and the arid tropical zones. As it is affected by sea and desert, the climate of Palestine fluctuates between the climate of the Mediterranean Sea and the desert climate. Although the climate of the sea is prominent, Palestine's climatic conditions vary widely from one place to another. Palestine could be divided into four climatic zones:

(1) the coastal climate, (2) the hilly areas, (3) the Jordan valley, and (4) the southern desert, Al-Naqab.

Climatic behaviour in each of these regions is often diametrically opposed from the other ones. The coastal is hot and humid during the summer and mild during the winter. In the hilly areas, cold winter conditions and mild summer weather prevail. The climate in the Jordan valley is hot and dry in summer and warm and humid during the winter. In the southern desert, Al-Naqab, summer daytime-temperatures are often the highest in Palestine, at times reaching 44 to 46 °C.

The daily average temperatures in the coastal areas are 25°C and 15°C in summer and winter respectively. In the hilly areas, temperature is usually less by 1–3°C than in the coastal areas, while it is always higher in the Jordan valley. Temperature in the Jordan valley can rise in summer to 45°C with an annual average of 24°C. Rainfall is limited to winter and spring months, notably between October and April (ARIJ, 1997).

In Palestine, there are about 60 overcast days, 150 partly cloudy days, and the rest are clear with variable amounts of haze. Solar insolation in Palestine has an annual average of 5.4 kWh/m^2.day which fluctuates significantly during the day and all over the year, and approximately 2860 mean-hour sunshine throughout the year (PEA, 2010). The measured values in the different areas show that the annual average insolation values are about 5.24 kWh/m^2.day, 5.63 kWh/m^2.day, and 5.38 kWh/m^2.day in the coastal area, the hilly area, and the Jordan valley respectively. The following figure shows the annual monthly averages solar radiation amounts in three climatic zones.

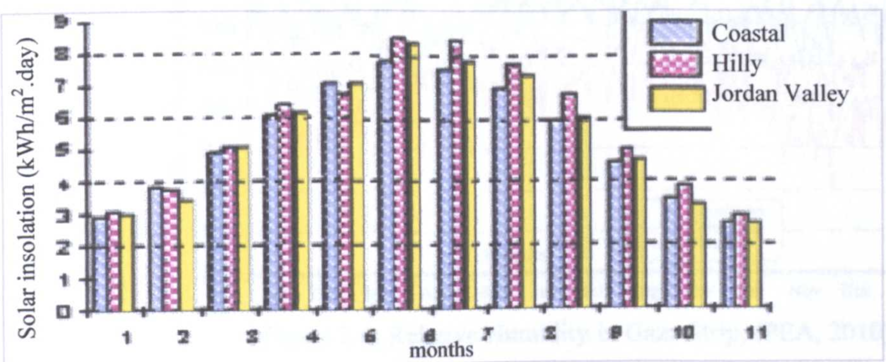


Figure 2.4: Annual monthly average solar radiation in three climate zones in Palestine, (PEA, 2010)

Climatic Analysis of the Coastal Region

The analysis of climate is the starting point for a design that maximizes comfort and minimizes the energy consumption for heating and cooling. The following is analysis for one of the climatic zones in Palestine which is the coastal Plain as the selected camp for this study is located in the Gaza Strip.

1- Air Temperatures: The average daily mean temperature ranges from 25°C in summer (May-August) to 15°C in winter (December-February). Average daily maximum temperatures range from 32°C to 19°C and minimum temperatures from 21°C to 11°C, in the summer and winter respectively (see figure 2.5). January is the coldest month of the year, in which the lowest recorded monthly mean was 14.2°C. July is the hottest month of the year in which the highest recorded monthly mean was 28.4°C (PEA, 2010).

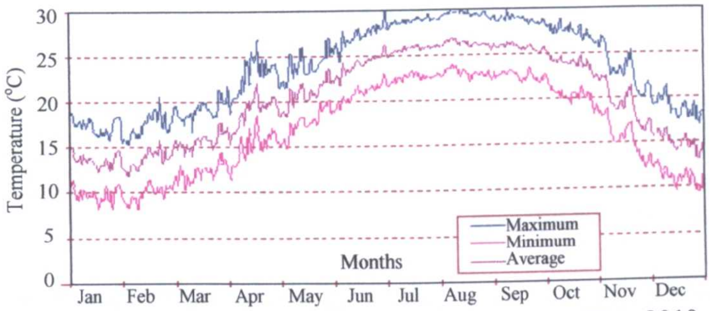


Figure 2.5: Air temperature in Gaza Strip, source: PEA, 2010

2- Relative Humidity: Relative humidity is high throughout the year for the whole region. The daily relative humidity fluctuates between about 63% in the daytime and 83% at night in the summer, whereas between 52% in the daytime and 81% at night in winter. Relative humidity data is complied from meteorological sources where it is measured twice daily, at 06:00hrs and at 18:00hrs (See figure 2.6). The data indicates that the mean of relative humidity, the highest value was 77% and registered for June while the lowest value was 64% in March (PEA, 2010).

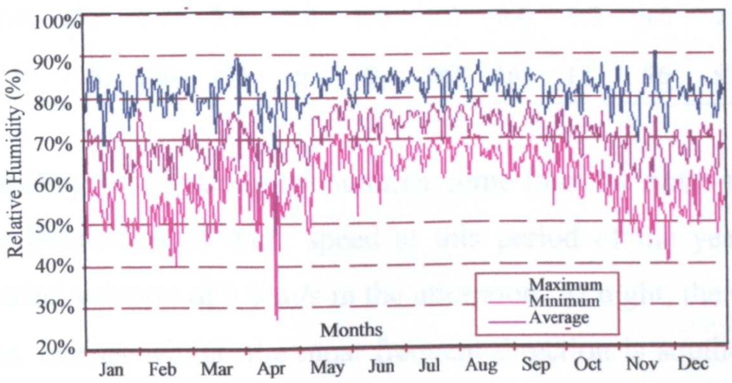


Figure 2.6: Relative Humidity in Gaza Strip, (PEA, 2010)

3- Solar Radiation: Gaza Strip has a relatively high solar radiation. It has approximately 2861 annual sunshine-hour throughout the year, which covers about 310 days. The highest duration of sunshine was registered for July with a value of 10.7 hr/day while the lowest was for December with a value of 4.5 h a day (ARIJ, 2001). Figure 2.7 presents the duration of sunshine.

The daily average solar radiation on a horizontal surface is about 222 W/m^2 (7014 MJ/m^2/yr). This varies during the day and throughout the year. Figure 2.8 illustrates the variation in the monthly daily average in total insolation on horizontal surface for each month.

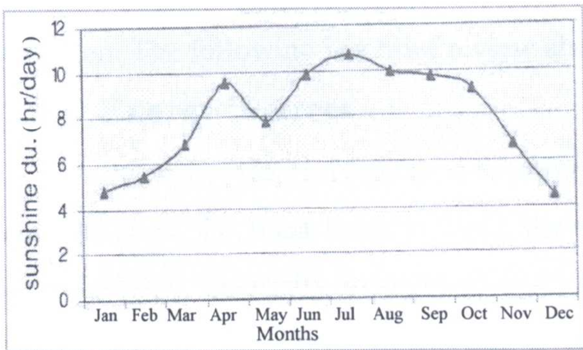


Figure 2.7: Sunshine duration in the Gaza Strip, (PSBC, 2010).

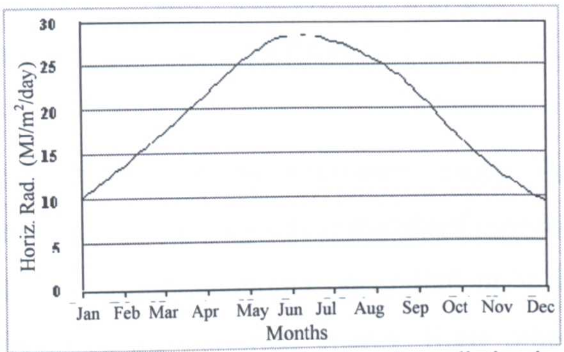


Figure 2.8: Annual variation in solar radiation in the Gaza Strip, (PEA, 2010).

4- Precipitation: The annual mean of rainfall in the Gaza Strip is 241mm with January has the highest rainfall quantity. The summer has no rainfall. The highest daily quantity is 30mm. The data indicate that the mean quantity of evaporation decrease in January and increase in July. The highest quantity of evaporation is 208 mm at July while the lowest quantity 77mm at February (see table 2.3).

Table 2.3:Rainfall and Evaporation in the Gaza Strip, source: PEA, 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Ave.
Rainfall Quant. mm	86.2	38.1	74.6	0.0	2.3	0.0	0.0	0.0	0.0	9.0	6.0	25	241
Max. Daily Rainfall mm	30.0	21.0	25.9	0.0	2.0	0.0	0.0	0.0	0.0	9.0	6.0	25	
Evap. Quant. mm	80.0	77.0	118	156	179	191	208	183	165	127	96	93	1672

5- Winds: The prevailing winds during the summer come from the north-west. There is a pronounced daily fluctuation of wind speed at this period of the year, with daily average maximum wind velocity of 3.9 m/s in the afternoon. At night, the wind speed is only half this figure. During winter, the most frequent direction is south-west and the average wind velocity is about 4.2 m/s. Nevertheless, storms have been observed in winter with a maximal hourly wind speed of up to 18 m/s mainly from the south-west (see table 2.4).

Table 2.4: Wind speed and direction in the Gaza Strip, source: PEA, 2010

Month	wind speed at noon m/s	most frequent wind direction 12:00-15:00hr	max. hourly wind speed m/s
January	4.2	SW	18
April	3.9	NW	13
July	3.9	NW	7
October	2.8	N	11

2.3 ENERGY SITUATION IN PALESTINE

In all countries, energy is of great importance because of its impact on the economy, people's well-being, and the quality of life. In Palestine, energy is even more crucial due to the country's high population density, lack of natural resources and unstable political situation. The following is a brief review about energy situation in Palestine.

2.3.1 Energy Sources

Palestine has no cheap or easily exploitable energy resources. Since the occupation of the West Bank in 1967, the occupation authority has maintained control over fuel and electricity in order to keep the Palestinian economy dependent upon it (ARIJ, 2001). Therefore, Palestinian is dependent on imported energy from other neighbouring countries like Jordan and Egypt or through the occupation companies. For instance, about 95 percent of electricity consumed is imported and all petroleum products are imported too. Furthermore, the gap between supply and demand is growing rapidly as economic activity increases.

In general, there are many different sources of energy, but in Palestine, they are limited and include the following:

- ***Electrical Energy:*** A diesel (gasoil) based power plant with electric generation capacity of some 140MW is located in the Gaza Strip. This power plant is the only major power generation facility in Palestine and which generates about 40% of the electric power consumed in the Gaza Strip. However, fuels, which are used in Gaza Power Plant, are imported. On the other hand, although generation of electricity through fuel is critical for life, it is also one of the most environmentally damaging activities, if air pollutant emissions are not controlled.

It is worth to mention that, Gaza Power Plant has received extensive damage since 2006 as a result of frequent air strikes by the occupation forces.

- ***Petroleum Products:*** In 2000, two fields of liquefied petroleum gas LPG was discovered in the Mediterranean Sea near the coast of Gaza Strip in Palestine at large quantities. One of the fields which is called Gaza Marine; is located 35 kilometres off the coastal range, and the depth of water in the region between 530-680 meters. Analysis of the discovered Gas beneath the Gaza Strip's coast was proven to be of good quality without sulphur compounds, but this has not yet been exploited because of political instability in the region.

- ***Biomass Products:*** Palestine is an agricultural country and several biomass products are used as energy sources such as; charcoal, wood, wood cake (Jefit) which is the reject of olive oil pressers, and other agricultural wastes. These biomasses are used in households for heating, baking and cooking specially in rural area. 76,000 tons are the annual average of olive mills solid waste (OMSW) which is produced by 265 olive mills in Palestine (Hafeetha, 2009).

- *Wind Energy:* Based on topographical features and available data, Palestine can be considered as a country of moderate wind speed. The annual wind speed is expected to be in the range of (4-6) m/s in the Hilly regions. In the Coastal region and the Jordan valley region, the wind speed is very low (ARIJ, 2007).

- *Solar Energy:* Solar energy represents a major energy source that is available in most Palestine regions with an average of 5.4 kWh/m^2.day solar radiation, and 2860 sunny days a year (see section 2.2.4). The most feasible application of solar energy used in the residential sector is the solar water heater SWH (more details is presented later in section 2.3.4). Other applications of solar energy include Photovoltaic, solar heating and cooling, solar drying, and Greenhouses for agricultural purposes.

2.3.2 Energy Consumption

Palestinian energy consumption is increasing rapidly due to the increasing rate of development as well as population growth. Figure 2.9 shows Total Palestinian Energy consumption by Fuel through (2001-2005). Even so, the total annual energy consumption in Palestine is lower than neighbouring Arab countries (PEC, 2010).

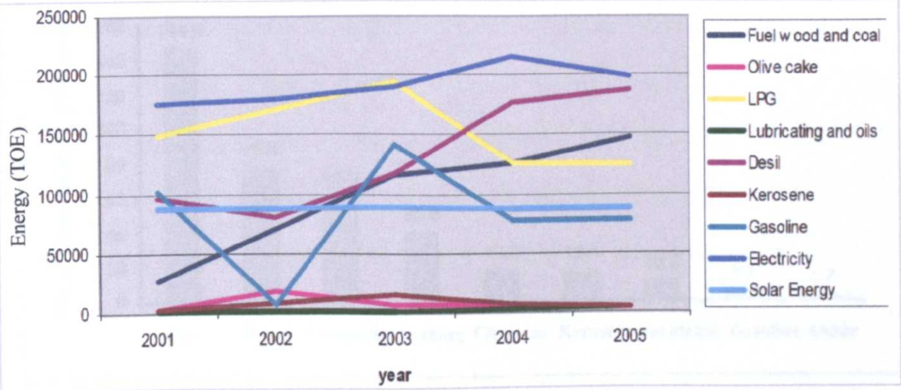


Figure 2.9: Total Palestinian Energy Consumption by Fuel through (2001-2005), Source: (PCBS, 2008a)

Statistics for energy consumption by sector show the role of domestic sector as the main energy consumer, with 64% of total consumption in 2005(See figure 2.10). The transportation sector is the second greatest consumer of energy while the industrial sector comes in the third place with 8% (PCBS, 2008a).

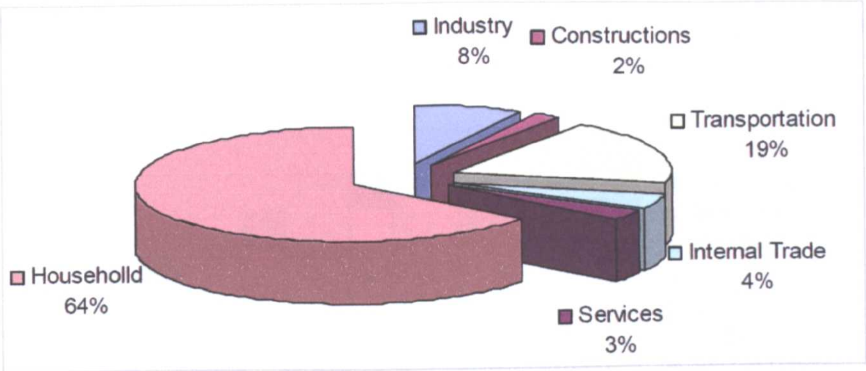


Figure 2.10: Energy consumptions by Sectors in Palestine, (PCBS, 2008a)

The average household electricity consumption differs per region and type of locality. The average was about 239 kwh in urban areas, 191 kwh in rural areas, and 229 kwh in refugee camps. The overall average per capita electricity consumption in Palestine during July 2006 was 35.8 kwh (PCBS, 2008a). Meanwhile 24.5% of households use Gas as a main source of energy for heating (36.3% in the West Bank and 1.2% in the Gaza Strip). In addition, kerosene is used as an energy source for heating in winter. Actually, 7.1% of households in Palestine (0.7% in the Gaza Strip and 10.3% in the West Bank) use kerosene as a main source of energy for heating (PCBS, 2008a). Figure 2.11 shows the number of households in the West Bank according to types of energy used for heating. It is clear that the highest number of households use Gas for heating, the Wood is the second while the electricity is the third.

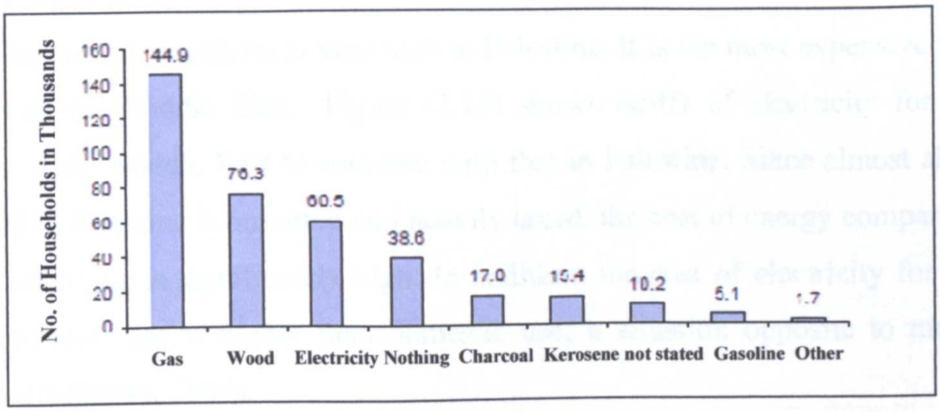


Figure 2.11: Number of households by source of energy used for heating in the west bank, reproduced from PCBS, 2010.

Charcoal usage is scarce and restricted in Palestine and it is used for heating in winter, while in some rural areas, it is used for cooking. Solar energy, on the other hand, is widely used for heating water for domestic and commercial usage. While oil products are used as fuel for transportation, heating and cooking, as well as for some industries. Figure 2.12 shows energy consumption in domestic sector by fuel for the years 2001 to 2005, where the Gas consumption represents the highest consumption of fuel in this sector. Most of the households in Palestine, about 99.3%, use Gas for cooking (PCBS, 2010).

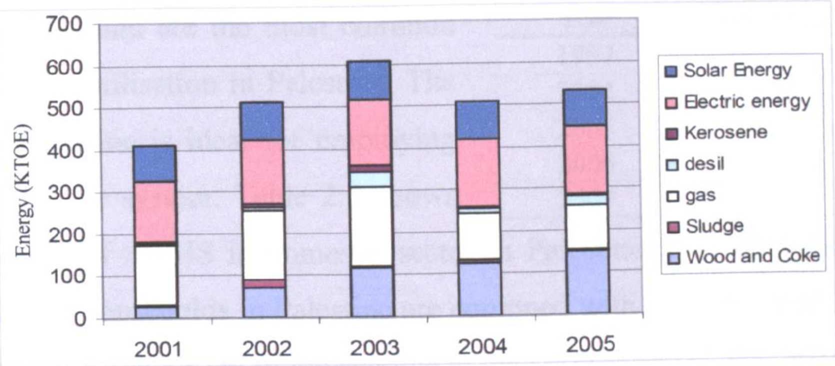


Figure 2.12: Energy Consumption in domestic sector by fuel (2001-2005), (PCBS, 2008a)

On the other hand, the availability of central heating in domestic sector in Palestinian is rare. According to Palestinian Central Bureau of Statistics, in 2007, 1.7% of households have central heating; however, none of households in refugee camps has any. (See table 2.5 for other selected years)

Table 2.5: Percentage of households by availability of central heating in Palestinian , (PCBS, 2010)

Year	Percentage of Households
1997	1.5
2004	4.1
2005	1.8
2006	2.1
2007	1.7

2.3.3 Electricity Prices

The cost of electricity is very high in Palestine. It is the most expensive in all the countries in the Middle East. Figure (2.13) shows tariffs of electricity for selected countries in the Middle East to compare with that in Palestine. Since almost all energy consumed in Palestine is imported and heavily taxed, the cost of energy compared to the standard of living is significantly high. In addition, the cost of electricity for industry and commercial use is higher than domestic use; a situation opposite to most other countries (Hafeetha, 2009).

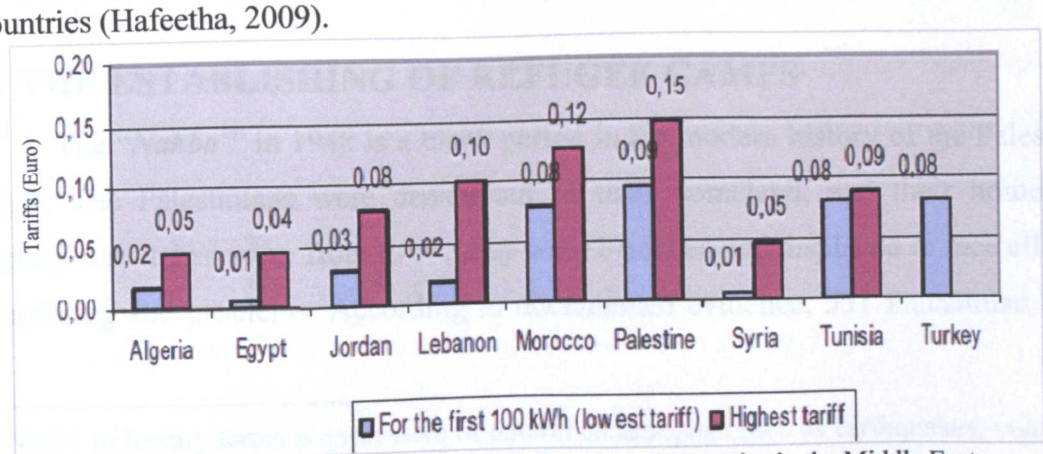


Figure 2.13: Tariffs of electricity in EURO for selected countries in the Middle East, Reproduced from PEC 2010

2.3.4 Solar Water Heating System

Table 2.6: Availability of SWHS in domestic sector in Palestinian, (PCBS, 2010)

Year	Percentage of Households
1997	61.2
2004	72.6
2005	69.4
2006	70.9
2007	73.2

Solar water heating systems (SWHS) are widely used and are the most common feature of solar utilisation in Palestine. The climate in Palestine is ideal for employing such sort of solar system. Table 2.6 shows the availability of SWHS in domestic sector in Palestine. It is obvious that, in 2007, about 73.2% of households in Palestine are equipped with SWHS; 59.6% of households in the West Bank and 82.1% of households in the Gaza Strip (PCBS, 2010).

More than 90% of SWHS are manufactured locally by Palestinians in the West Bank and Gaza. There is a 15-manufacturing workshop for local solar water heating system (10 of them in West Bank and 5 in Gaza Strip) with annual production rate about 26,000 units. However, the raw material is usually imported from other countries in Europe (Hafeetha, 2009). According to Palestinian Energy Authority PEA (2010), the average cost for typical flat plate solar collector is about 300 $ and the system payback period based on the electricity price, is less than 2 years (about 1.3 years). These systems operate at an annual average efficiency of approximately 50%. Therefore, such a unit can save about 2,000 kWh per year in electricity costs. The unit raises the temperature of the water by approximately 30°C above its starting point on an average day. Hence, most days of the year there is no need to operate the electrical heater. SWHS have proved to be feasible in providing energy compared with other alternatives, thus, their application is widespread in Palestine.

Hafeetha (2009) stated that, one of the most common solar water heating systems is thermosyphonic open circuit system which allows using hot water directly by consumer. This system consists of 2 or 3 flat-plate collectors, each measuring 1.7 m^2, a rating of 2750 kcal/ day (iron collector) as a yearly average output.

2.4 THE ESTABLISHING OF REFUGEE CAMPS

The "*Nakba*[1]" in 1948 is a black period in the modern history of the Palestinian people. The Palestinians were driven out of their homeland, and their homes and property were taken away from them; they were banished and displaced to face all kinds of suffering and problems. According to documented evidence, 531 Palestinian towns

[1] A Nakba in literary terms is expressive of natural catastrophes such as earthquakes, volcanoes, and hurricanes

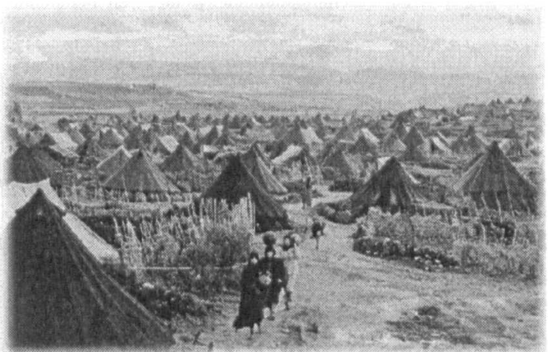
and villages were destroyed and 85% of the Palestinian population, more than 800,000 were banished and displaced (Palestineremembered.com). More than three quarters of Palestine was occupied in the ***Nakba*** of 1948. The Occupation forces committed atrocities include more than 70 massacres against Palestinians and killed 15,000 Palestinians during the ***Nakba*** period (Ibid.). The expulsion of the Palestinian from their country and the expropriation of their land and properties were to establish a Jewish State. The ***Nakba*** of Palestine was an ethnic cleansing process as well as destruction and banishment of an unarmed nation to be replaced by another nation. Contrary to natural catastrophes, the Palestinian ***Nakba*** was the result of man-made military plans and a conspiracy of states that unfolded a major tragedy for the Palestinian people.

Most of the Palestinian refugees took refuge in surrounding towns and villages in Palestine itself and in neighbouring countries like Jordan, Syria and Lebanon (see figure 2.14). The immediate humanitarian needs for the refugees were met first by private voluntary organization (PVOs). In 1949, the United Nations (UN) created the United Nations Relief and Works Agency (UNRWA) for Palestine Refugees in the Near East to take over relief operations of the PVOs (Schiff, 1995).

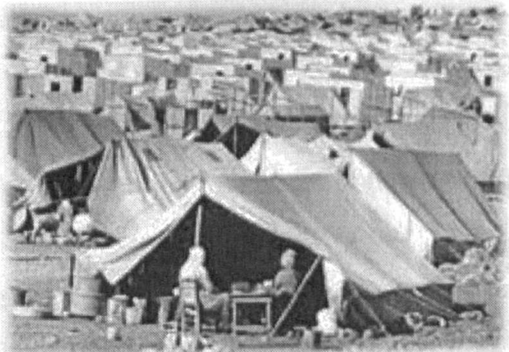
Figure 2.14: The Expulsion of Palestinians in 1948, source: Palestineremembered.com

The Agency was concerned with meeting the refugees more immediate desperate needs in the five fields of its operation, Gaza strip, West Bank, Jordan, Lebanon and Syria. The UNRWA started to establish the refugee camps and the tents were distributed to accommodate homeless refugees (see figure 2.15). Sites were located and several camps were established on government lands or on lands rented by the UNRWA from local residents. "*A camp, according to UNRWA's working definition, is a plot of land placed at the disposal of UNRWA by the host government to accommodate Palestine refugees and to set up facilities to cater to their needs........... The plots of land on which camps were set up are either state land or, in most cases, land leased by the host government from local landowners*" (UNRWA, 2010).

Each camp is divided by a main road and had sub-roads to facilitate the movement of UNRWA's cars while providing services to refugees on both sides of the roads. UNRWA clustered tents into straight rows with a divider space of several meters between them. The size of the area allocated to refugees correlated with the size of the family. Tent with one post was allocated to small size families (less than five members) while the relatively big size families were given tent with three posts. UNRWA`s installations were also housed in big size tents situated in one designated area opposite to the refugees` tents.



Nahr El-Bared Refugee Camp



Hson Refugee Camp

Figure 2.15: Tents for housing Palestinians refugees in camps, (UNRWA, 2010)

Afterwards, the UNRWA started to replace tents with shelters and by mid-1950s, all tents had been removed (see figure 2.16). The plot of land on which a shelter was constructed did not exceed 100 m^2 and the shelters were composed of one or two rooms as follows (Elkahlout, 2001): “A units”- 3×3m for 1-5 member families, “ B units”- 4×3.75m for 6-9 member families, “C units”- 4×4.45m for 9-11 member families, “AA units”- space 6x3m includes two rooms connected with an inside corridor housing 11-12 member families, and “BB units”- space 8x4m includes two rooms with an inside corridor housing more than 12 members families.

On this land, occupants were permitted to erect additional rooms as the family expanded through birth and marriage, and were permitted to grow vegetables as well. There were large spaces of land and wide alleys inside the refugee camps. This is attributed to the fact that the housing units were small, composed of one or two rooms. Outside the shelters, the UNRWA established communal water points and constructed public latrines. In addition, during the same period, the UNRWA constructed schools, clinics, distribution centres and offices of the camp service officers. These primitive conditions had a severe effect on the refugee community, especially during bad winter weather.

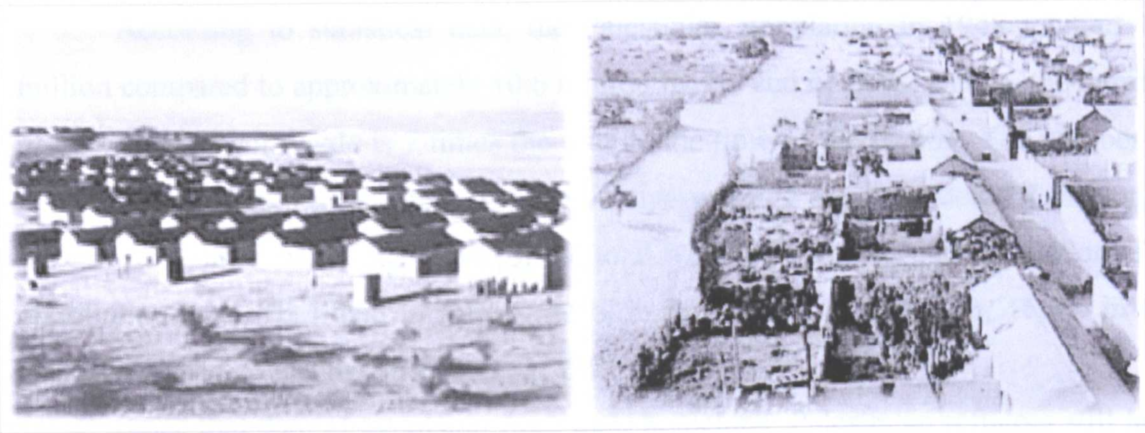


Figure 2.16: UNRWA replaced the tents with shelters by mid-1950s, (UNRWA, 2010)

By the turn of 1967, when the rest areas of Palestine was occupied, the number of refugees had increased dramatically, and more shelters were built by the UNRWA. The refugees started to construct additional rooms next to their units as the families expanded. Refugees refrained from doing so at the beginning because of their belief that living in camps was for short period as a temporary solution, until they would return to their original homes. Supported by the UNRWA, they also built additional shelters with simple utilities and gave up using the communal latrines. With improving the economic conditions of the refugees, due to the availability of job opportunities, they expanded their shelters using vacant land. At the beginning, refugee families took over as much as possible of adjacent plots of land and established a wall to preserve their entitlement. By the turn of the 1980s, most of the shelters became stabilised in terms of space and the alleys inside the refugee camps became narrower. Due to natural growth, Palestinian refugees had grown in number and part of them had to leave the camps due to overcrowding and lack of housing. While part of them had to expand vertically and started to reconstruct their shelters to build multi-storey concrete shelters (see figure 2.17).

Figure 2.17: Jabalia Refugee Camp in 2009

According to statistical data, the Palestinian population in 1948 totalled 1.4 million compared to approximately 10.6 million by the end of 2008. Hence, the number of Palestinians worldwide is 7 times the total at the time of the ***Nakba***. The number of Palestinian registered refugees in UNRWA's five working areas totalled 4.7 million at the end of 2008, constituting 44.3% of the total worldwide Palestinian population. The distribution is 41.8% living in Jordan, 9.9% in Syria, 9.0% in Lebanon, 16.3% in the West Bank, and 23.0% in Gaza Strip (PCBS, 2009).

Since that date of expulsion from their homeland, Palestinian refugees still lack access to durable solutions to their plight based on international Law and relevant UN resolution.

2.5 URBAN STRUCTURE OF REFUGEE CAMPS

The urban structure of refugee camps is a result of a complex interaction of many influences over time, such as, political, economical, social, and environmental influences, along with topography and construction material. Density, land-use, and road networks are the most important issues in defining the pattern of urban form.

What is noticeable in the context of the Palestinian camps is that their architectural and social urban structure have been spontaneously produced and developed by the refugees themselves. Overcrowding has been a common phenomenon and density remains high in all camps. Density varies from one camp to another. The refugee camps in the Gaza Strip have one of the highest population densities in the world exceeds 77,000 persons per kilometre square. Increases in population, coupled with rapidly deteriorating economic conditions, had forced refugees in camps to resort to the upgrading land expansion of existing shelters, both vertically and horizontally until the urban environment of the camps becomes overcrowded. The height of the buildings ranges from one to five or six floors without any planned or organized distribution (see figure 2.18). Therefore, the loss of daylight, sunlight and solar gain due to obstructions is an important feature of the Palestinian refugee camps.

Within the camp, the residential area is the dominant land use pattern with combined commercial uses on the ground floors and residences on the second floor along some of the main streets. The open spaces in refugee camps are uncommon. There are no water surfaces or public parks in refugee camps and the vegetation is so little. However, there are still some narrow courtyards distributed inside shelters.

Figure 2.18: Buildings heights in refugee camps

The streets in refugee camps are grid system divided into two levels. The first level consists of straight streets comparatively wide enough for traffics movement while the second level consists of very narrow alleys for pedestrians (see figure 2.19).

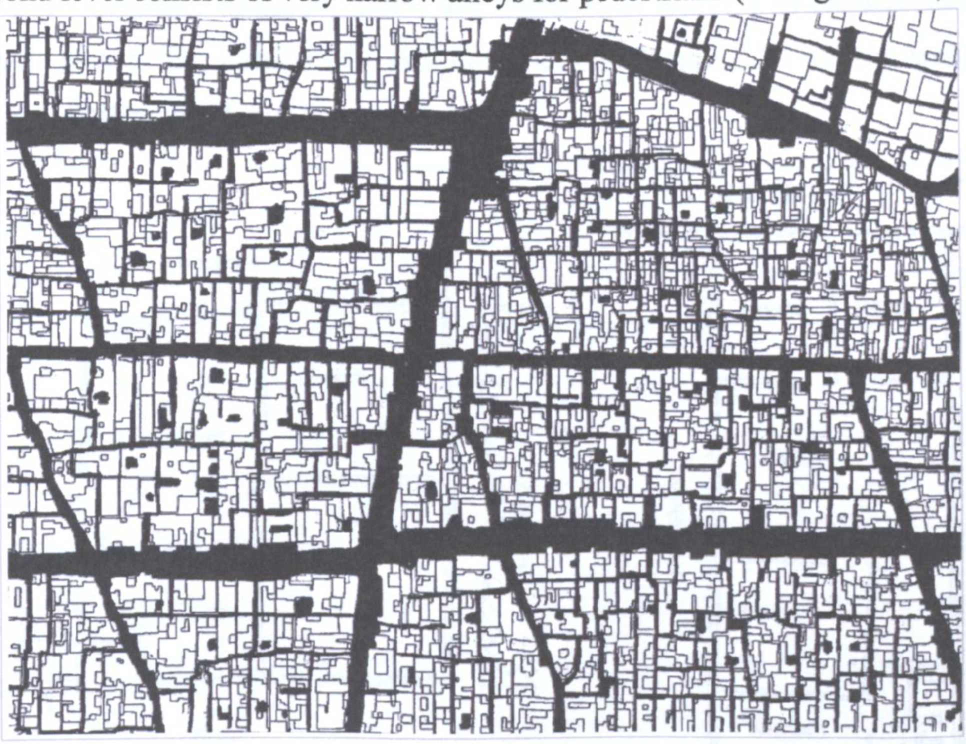


Figure 2.19: Urban form of refugee camps

Palestinian refugee camps characterise with high urban density, lack of land and space, and absence of green areas and open spaces (Zeidan 1999; Farah 2000). These characteristics are the key factors that limit achieving comfort indoor conditions as the shelters can experience poor ventilation, lack of natural light and solar radiation, and noise problems.

2.6 SHELTERS IN REFUGEE CAMPS

There are several factors influencing housing patterns. The most significant are the nature of the climate, the land, the topographical location, customs and social traditions as well as political conditions. As it is explained in section 2.4, all the shelters in refugee camps were constructed as small houses (single-story) in such a way that allow erecting additional rooms but didn't allow for vertical expansion. Afterward, there has been a trend toward the construction of multi-storey units as a solution in restricted areas such as camps, where there is a little land available. As a result, more than one-half of the shelters in refugee camps were reconstructed since 1990 with 45% of them were reconstructed after 1995 (PCBS, 2010). According to statics in 2006, more than one-half of the refugees live in houses (about 59%), while 38 % of households live in apartments in multi-story buildings. However, refugees living in apartments in the same building are almost extended families.

The size of plot in refugee camps is small and the shelters mainly consist of 3.3 rooms in average, kitchen and bathroom with closet (Ibid). No separate guest room or living room is usually included. There are numbers of shelters in refugee camps still have open courtyards, particularly asbestos shelters. Figure 2.20 shows examples of layouts for shelters in refugee camps.

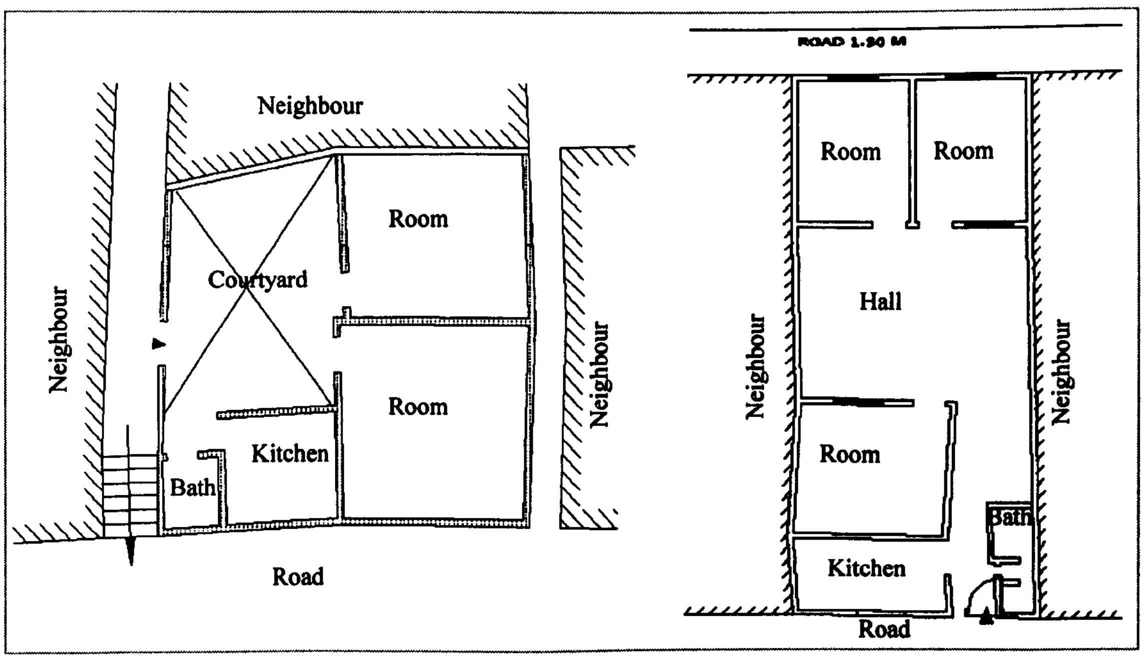


Figure 2.20: Layouts of shelters in refugee camps, (field survey 2010)

The building materials of the shelters differ amongst camps. However, the most common types of building material in the camps are cement blocks. Other types of construction material for the external walls are showed in Table (2.7). For roofing, the most common materials in refugee camps are asbestos, corrugated iron, and concrete slaps. As explained above, the original shelters were built of asbestos roofs, which made refugees incapable of vertical expansion, while recently reconstructed shelters are reinforced-concrete shelters.

Table 2.7: Construction material of external walls in refugee camps, (PCBS, 2010)

Camp location	Percentage distribution of construction material of external walls							Total
	cleaned stone	stone & concrete	concrete	cement block	adobe clay	old stone	other	
Palestine	1.3	1.6	0.8	**95.6**	0.5	0.1	0.1	100
West Bank	3.5	1.4	3.0	**89.9**	1.8	0.4	0.0	100
Gaza Strip	0.4	1.7	0.0	**97.8**	0.0	0.0	0.1	100

2.7 SUMMARY

Climatic conditions of Palestine are extremely diverse despite the country's small size. Palestine could be divided into four climatic zones; the coastal climate, the hilly areas, the Jordan valley, and the southern desert "*Al-Naqab*". Climatic behaviour in each of these regions is often diametrically opposed from the other ones. Climatic conditions of the coastal region, which is hot and humid, are analysed in this chapter.

Energy status in Palestine is explicated and different sources of energy are reviewed. In general, Palestine has no cheap or easily exploitable energy resources and it is dependent on imported energy from other neighbouring countries. The cost of energy is very high in Palestine. It is the most expensive in all the countries in the Middle East. However, solar energy represents a major energy source that is available in most Palestine regions. Solar water heating systems (SWHS) are widely used and are the most common feature of solar utilisation in Palestine.

The refugee camps in Palestine have one of the highest population densities in the world exceeds 77,000 persons per kilometre square. The alleys inside the camps are narrow, sometimes only a 0.6 metre wide. The shelters` plots are small and around quarter of households in refugee camps suffer from a high occupancy density. There are two types of shelters inside camps; asbestos shelters and reinforced concrete shelters. Most of the concrete shelters were constructed recently after 1990 in order to allow for vertical expansion. The most common types of external wall materials in the camps are cement blocks, while for roofing materials; asbestos, corrugated iron, and concrete slaps are generally used.

CHAPTER 3

INDOOR ENVIRONMENT

3.1INTRODUCTION

There are many factors, which influence the comfort of a human being in a building, some are universal comfort parameters and some are unique to buildings. They include; thermal environment, visual environment, acoustic environment, tactile environment, air quality, aesthetic considerations, vibration, control over the environment, and air movement (Alder et al., 1984). Many characteristics of the indoor environment may influence health, satisfaction, and productivity of buildings' occupants. Therefore, it is important for the designer to be able to control the indoor environmental conditions which include heat, light and sound (Szokolay, 2008). All building elements should be designed whenever possible to respond to the environmental conditions as priority and to provide delightful living conditions for occupants (Fitch, 1999).

Grjffiths (1991) have found that temperature is the most important factor determining human comfort; yet, many things other than the thermal conditions affect his comfort in a space. Visual comfort is important and has implications for other aspects of building performance. Britten (1977) reports that electric light is the most important household feature in making a house "fit to live in". Griffiths (1991) found daylight or suitable artificial light to be the second most important comfort factor after room temperature. The quality of the indoor environment depends also on several aspects of sound. Noise discomfort has greatly increased in the modem world which originates from both internal and external sources. Further, there is quite strong evidence that indoor air quality have great health effects.

Heat is the most substantial as the thermal behaviour of a building has the greatest effect on energy use and sustainability (Szokolay, 2008). Likewise, Hoof (2008) reported that thermal comfort plays a major role among other indoor environmental parameters.

This chapter looks at indoor environments including visual environment, acoustic environment, and other environmental factors such as indoor air quality, adequacy of space and building security. However, thermal environment, which is the major focus of this study, is separated in the next chapter. The importance of indoor environment is presented in this chapter followed by investigation of the visual environment including visual comfort and visual amenity. Design strategies for daylight are clarified. Principles of sound environment are explicated later to help identifying noise control approaches. In addition, sources of indoor air pollutants and methods to reduce them inside buildings are elucidated followed by review for security in buildings and adequacy of space.

3.2 THE IMPORTANCE OF INDOOR ENVIRONMENT

Continuous threats to human health are being posed in the built environment by increasing industrialization, high rate of energy utilization, and overcrowding of buildings and activities. The quality of buildings, including their performance in a range of indoor environmental attributes, is influential to the living quality of habitants. The quality of the environment within buildings is a topic of major importance for public health. Special efforts are therefore needed to maintain and enhance natural and man enhanced environmental features, which afford positive support to health. Chianga and Laib (2002) stated that the indoor environment is complex and made up of many factors. It is necessary to take various aspects of those environmental factors into consideration, when dealing with the influence of built-environment on occupants. Chen et al. (1998) mentioned that indoor environment is important for people's health and welfare, because up to 90% of a typical person's time is spent indoors.

According to the World Health Organisation (1990), the health of the occupants and their satisfaction on their homes can be affected by multifaceted environmental performance of a building, in respect to the quality of indoor thermal, visual and acoustics environments and indoor air quality. The influences of such composition of indoor environment parameters have determined human performance, productivity, as well as physical and intellectual capability. Furthermore, the causation of specific diseases is strongly influenced by indoor environment conditions. For instance, problems in indoor air quality and short-term exposures to highly elevated concentrations of carbon dioxide can cause brain damage or death while lower concentrations can cause chest pain among people with heart disease (NRC 1981). There is also evidence that a decrease in the amount of flicker in light, i.e., the magnitude of the rapid cyclic change in illuminance over time, may be associated with a decrease in headache and eyestrain (Wilkens et al. 1988).

As a consequence, it is essential for building designer, as a major responsibility, to provide appropriate indoor conditions for effective human visual and aural perception in conditions of thermal comfort in order to attain healthy, productive, effective, creative, and social acceptable lifestyle in buildings. Achieving optimum indoor conditions for building occupants should be also parallel with energy saving and natural resources protection in order to achieve green indoor environment compatible with greening of the wider environment. A good indoor environment is important to the success of a building, not only because it will make its occupants comfortable, but also because it will decide its energy consumption and thus influence its sustainability in terms of energy (Humphreys and Nicol, 2002a).

3.3 VISUAL ENVIRONMENT

Every visible thing that surrounds us could be referred as Visual Environment and sometimes called light or illuminance environment. The visual environment is provided through the eyes to the human brain, where it is subsequently further processed. So, when man is deprived of light, he is seriously deprived of visual information about his environment. In this section, human visual comfort and visual amenity will be explained followed by building design strategies for daylight. However, in order to understand these concepts and strategies, some selected light principles will be viewed and clarified firstly.

3.3.1 Principles And Definitions

a. **Daylight Sources:** Daylight sources could be categorized as direct light (sunlight and skylight) and indirect light. ***Direct sunlight***, which arrives directly from the sun, is too intense to be used directly for task illumination and sometimes is consider undesirable for lighting purpose because of its associated thermal content. However if direct sunlight is effectively distributed through building design, it will introduce less heat per lumen comparing with electric lights , so it could be an attractive strategy for reducing cooling loads in buildings. ***Direct skylight*** is diffuse light from the atmosphere and its illuminance level depends on sky conditions, clear or overcast, with range about 500-2000 fc, while illuminance level for direct sunlight ranges from 6000 to 10,000 (Moore, 1993). ***Indirect light*** is resulting from reflective or translucent diffusers that are originally illuminated by other sources.

b. **Transmission & Reflection of Light:** When Light strikes a surface, it is reflected, absorbed or transmitted. ***Reflectance*** is the ratio of reflected light to incident light, while ***absorbance*** conversely, is the ratio of absorbed light to incident light. Light ***transmittance*** is the ratio of transmitted light to incident light. For any surface, the value of these three properties, reflectance (r), absorbance (a), and transmittance (t) are equal one. For opaque surfaces, transmittance (t) is zero, so (r + a) equal one (Koenigsberger, et al., 1973). The reflectance of a surface is dependent on the angles of incidence and the surface's diffusion characteristics.

There are two types of reflection of light; regular reflection (specular reflection) and irregular reflection (diffuse reflection). In specular reflection, the reflected rays are parallel to each other (e.g. mirror or water surface); while in diffuse reflection, the incident light is reflected in different directions (e.g. a wall or wood). Non-opaque surfaces can transmit light either specularly (e.g. clear glass) or diffusely (e.g., frosted glass).

c. **Daylight Factor:** Daylight Factor (DF) is the ratio of the interior horizontal illuminance to the simultaneous external horizontal illuminance. It is used in daylighting design and was developed for overcast sky conditions.

DF = (Ei/Eo) × 100%, where Ei = illumination indoors, at the point taken; Eo = illumination outdoors from an unobstructed sky hemisphere.

And for any point P indoors:

DF(P) = SC(P) + ERC(P) + IRC(P); where; (SC) sky component, (ERC) externally reflected component, (IRC) internally reflected component (Goulding, et al., 1992).

Because interior daylight illuminance changes as a function of outdoor lighting conditions, which are highly variable, measurements of illuminance are not directly indicative of actual building performance. However daylight factor could be used to describe the daylighting performance of a building (Baker, et al., 2005)

3.3.2 Visual Comfort

Koenigsberger, et al. (1973) stated that the purpose of lighting is to facilitate the performance of a visual task, ensure visual comfort and to create certain emotional effects as well. In order to carry out visual tasks comfortably, attention should not only be paid to light levels, but also to luminance ratios, light colour, and colour rendering index (Hoof et al., 2010).

According to International Energy Agency IEA (2000), visual comfort could be achieved by a sufficient amount of light for the required visual task, uniform distribution, the absence of glare, and adequate spectral content to render colours accurately when required. These parameters of visual comfort are discussed blew.

a. **Lighting Requirements:** When specifying artificial lighting, illuminance standards can be met quite precisely. However, due to the variability of the sky as a light source, ensuring adequate illuminance under daylighting conditions is more complex. For some countries, an absolute illuminance level is used in a systematic evaluation. For other countries, particularly those that are dominated by cloudy sky conditions, the daylight factor DF, is used as a measure of light quantity.

However, because of the variability of daylight available from the sun and sky, daylighting systems are evaluated based on the quantity of illumination provided at a task over time. The required light level depends on; the visual task, the contrast, the fineness of detail, and the speed at which the view changes. According to Moore (1993) and Szokolay (2008), occupants` age should be considered while selecting lighting level and it is advisable to provide better illuminance for older people as visual efficiency of people reduces with age. Furthermore, surface properties of the room should be taken into account by determining higher illuminance values when the surfaces has low reflectance. Goulding, et al. (1992) stated that people`s attitude towards artificial and natural light is very different and the amount of light they need is to some extent a function of the mood of the moment. Recommended illuminance values also depend on socio-cultural as well as economic factors.

In addition to select the lighting requirements as a quantity, light distribution, colour appearance, colour rendering, and amount of glare should be considered as qualitative requirements of lighting.

b. **Glare:** *"Glare is a very subjective phenomenon - depending very much on human expectation, adaptability and even on mood"* (Koenigsberger, et al., 1973). Glare could result from a light source itself and be referred as 'direct glare'; or could result from reflective illuminated surfaces and be referred as 'indirect glare'. Depending on the magnitude of glare effects, glare could also be classified into two types; disability glare and discomfort glare. Disability glare is caused when intraocular light scatter occurs within the eye, the contrast in the retinal image is reduced (typically at low light levels), and vision is partly or totally impeded. Experts agree that this disability glare is affected by the total intensity of the glare source; not just by the brightness or area alone. However, there are no known satisfactory models to predict and evaluate this condition (IEA, 2000). According to Szokolay (2008), disability glare can normally be avoided, but discomfort glare is more of a problem.

Discomfort glare is a sensation of annoyance caused by high or non-uniform distributions of brightness in the field of view. The contrast relation between object luminance and surrounding luminance depends on the absolute height of the surrounding luminance and thus on eye adaptation; the higher the surrounding luminance, the lower the subjectively perceived brightness of an object luminance (Eicker, 2003). If the luminance ratio (L_{max}/L_{min}) within a visual field is greater than about 15, visual efficiency will be reduced and discomfort glare may be experienced (Szokolay, 2008).

Santamouris (2001) stated that discomfort glare can be reduced by:

- decreasing the luminance of the light source;
- diminishing the area of the source;
- increasing the background luminance around the source.

Szokolay (2008) illustrated that if the luminance of the visual task on a desk is taken as 100%, its immediate surrounding should not be more than 50% and the rest of the visual field not more than 20% and by this glare is reduced.

Different indexes have been proposed in order to define the comfort conditions inside a building; such as the Visual Comfort Probability (VCP) and The Unified Glare Ratio (UGR). The VCP value represents the percentage of people who probably will not complain about the glare produced in the space while UGR is calculated parameters in the field of view. Discomfort is then evaluated in position on a scale of discomfort.

c. **Distribution and Direction:** The luminance distribution is a measure of how lighting varies from point to point across a plane or surface. Some degree of uniformity across the task plane is required for visual efficiency. Visual discomfort may be experienced if the eye is forced to adapt too quickly to a wide range of light levels. The ratios of "maximum to average" illuminance or "average to minimum" illuminance are used to determine lighting uniformity.

Distribution in daylighting depends on windows and reflective surfaces. However, evaluation of daylight distribution is complicated by a number of parameters. For instance, the sun is a variable-position light source and sunlight could be redirected. Consequently, determining the location, the size, and the intensity of bright areas of sunlight will be a hard part to simulate and measure illuminance distribution. Furthermore, the luminance of exterior obstructions (e.g., opposing semi-reflective buildings) or the ground varies with task location and solar conditions. Occupants, nevertheless, may accept much greater luminance variations when spaces are lit by daylight than when they are artificially lit.

Sufficient directionality of light is required also for some tasks to model and evaluate three-dimensional objects and surfaces. The greater the amount of diffuse light, the less shadowing occurs, reducing an occupant's ability to evaluate the depth, the shape, and texture of a surface. A balance between diffuse and directional light enables an occupant to evaluate the smoothness, the nap, the grain, and other properties of a surface. There are no standard performance parameters to evaluate the direction and diffusion of light (IEA, 2000). Direct sunlight is typically directional with sufficient diffuse light from the sky to balance out the contrast of a three-dimensional object. Some daylighting systems can redirect diffuse daylight in the same way, so some directional effects appear even in diffuse daylight.

3.3.3 Visual Amenity

Visual amenity includes the human responses to the visual environment that go beyond pure visibility criteria, taking account of psychological features. Light affects people's behaviour and their impressions of an environment. Cognitive factors such as attention, expectation, and habituation will affect an occupant's ability to recognize objects and distinguish details.

a- Outside view

Provision of views and connection to outside has become a predominant function for windows in building design in addition to provide adequate daylight, sufficient sunshine and ventilation to interiors. Occupants will not feel isolated when they are psychologically connected to outside environment as they will be able to get visual information about surrounding activities, weather conditions and time of day. However, preference for being connected to outside varies with quality, types and contents of views. Most of people may like view of nature because this is an innate response for humans to be in contact with nature or because it can reduce stress or improve attention. Sometimes, if the window provides pleasant views, the limitations of daylight and ventilation may be more readily accepted.

On the contrary, an unpleasant outside view is always regarded as a negative externality and it will not be favoured by a majority of individuals. With unpleasant views, individuals may not even prefer to have window of any size unless required.

b- Visual Privacy

Visual Privacy preferences can diverge from one person to another, as what feels to be personal to some people may feel to be not private to others. Visual privacy is a subjective phenomenon depending very much on people`s culture and thoughts. Visual Privacy requirements may also vary for different types of buildings and for different functions of a space. Achieving visual privacy in interior design depends on the relative brightness of the interior compared to the exterior. Selecting the size, the sill height, the location, and the glazing materials of the windows will significantly affect visual privacy. Reflective glass, for example, will yield complete privacy during the daytime with completely clear views. At night, when the relative brightness is reversed, the glazing from the interior is completely reflective yet affords no privacy.

Designers should consider the level of privacy desired for the building application and the occupants` preferences, select suitable glazing, and provide opaque operable shades where privacy is critical.

3.3.4 Building Design For Daylight

Koenigsberger, et al. (1973) reported that, in lighting design the designer must ensure light which is both adequate and suitable for the visual task. Suitability in this context, as clarified in (section 3.3.2) would include freedom from glare, light distribution and colour of light. The larger the number of hours per year that daylight system is able to meet, but not grossly exceed the design illuminance level, the more successful the design (IEA, 2000). Daylighting design starts with the selection of a building site and continues as long as the building is occupied.

a. Building Site and Obstructions

It is necessary to determine the availability of daylight on building site in order to be utilized in building design. Surrounding objects such as other buildings, trees, and landforms all act as daylight obstructions by blocking either direct sunlight or portions of the sky dome as visible from the building location. Studying the obstructions at a construction site help determine the daylight potential of the building's facades and allow the designer to shape the building and to allocate windows with respect to daylight availability. In selecting daylighting strategies, a designer should also consider the degree to which the new building will create an obstruction for existing buildings which reduces their access to daylight. For high density built environment, daylight-redirecting systems can improve the distribution of light to interior spaces.

Various methods are available to analyse any obstructions around the site and to establish the extent and duration of overshadowing. Figure 3.1 shows shadows for different times of the day in a large-scale urban housing area using a physical model in an artificial sky.

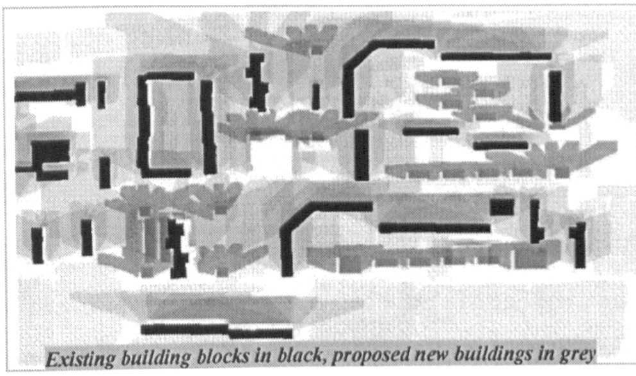


Figure 3.1: shading study in buildings site, (IEA, 2000)

b. Design Strategies

Daylight may be introduced into a building using a variety of techniques and daylighting systems, which provide usable daylight for a particular climate and building type for a significant part of the year, and which allows electric lighting to be offset by natural daylight. Figures 3.2 to 3.4 show examples of various daylighting systems. In addition, Building shape has a primary effect on daylighting performance, since narrow plans are preferable for providing adequate amount of daylight as well as good ventilation. In contrary, in deep plans, depending on artificial lights could be higher due to the increased distances to the exterior walls. Moore (1993) stated that, narrow plan is recommended to keep work areas within 30 ft of the exterior in order to utilize daylighting effectively in buildings.

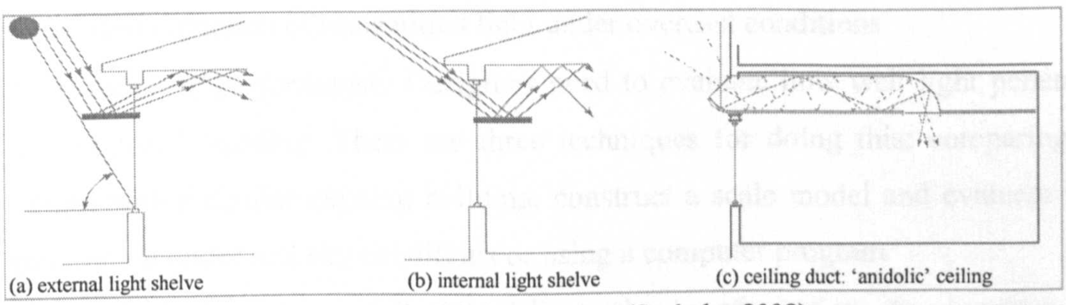


Figure 3.2: daylighting systems, (Szokolay 2008)

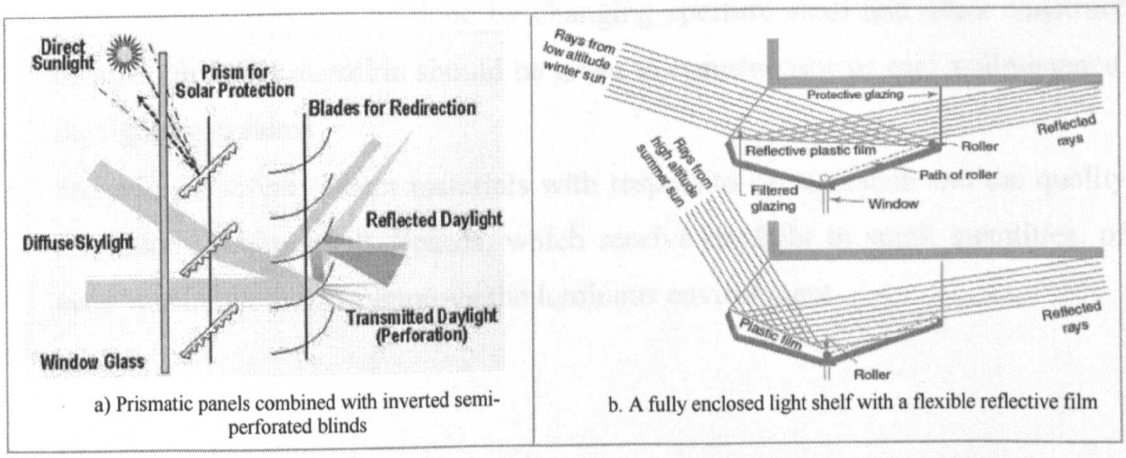
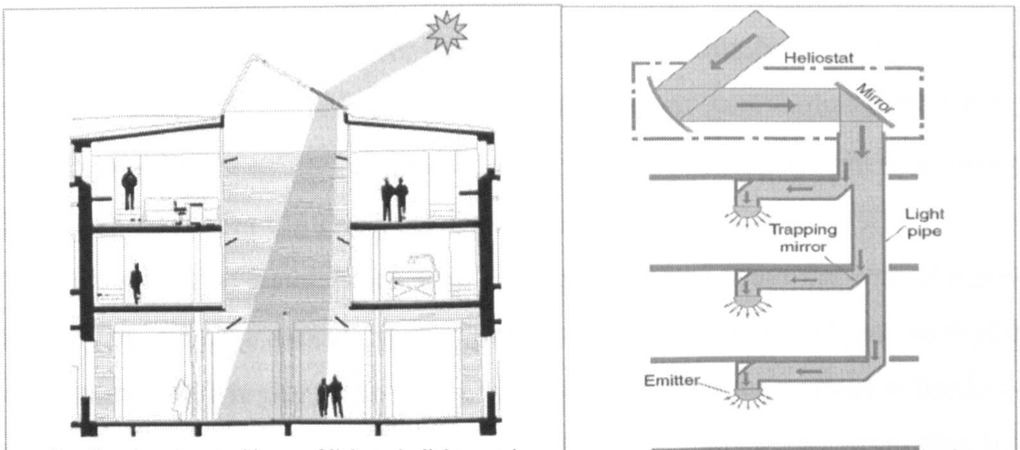


Figure 3.3: a. Prismatic panels, b. A fully enclosed light shelf, source: IEA, 2000



a. Sun-directing glass used in a roof-light to daylight an atrium

b. Beam sunlighting by heliostat and light pipes

Figure 3.4: a. Sun-directing glass b. heliostat and light pipes, (IEA, 2000 & Szokolay 2008)

Goulding, et al., (1992) reported the following checklists which help building designer to achieve efficient daylighting design.

- *Site analysis:* Identify the directions with the most interesting and pleasant views. Consider sunlight availability on the site. Select appropriate orientation for the building and its facades.
- *Organization of indoor spaces:* Organize the indoor spaces with respect to daylighting requirements, giving priority to those needing most daylight.
- *Aperture distribution:* Distribute and size apertures with respect to the volume of the indoor spaces to be lit.
- *Sunlighting:* Design solar shading devices with precision, keeping in mind the associated reduction of transmitted light under overcast conditions
- *Verification of performance:* Designers need to evaluate how well light penetrates the proposed building. There are three techniques for doing this; comparing the design with a similar existing building, construct a scale model and evaluate light penetration under real sky conditions or using a computer program.
- *Detailed performance analysis:* Adjust the configuration to improve the performance. This can be done by changing aperture sizes and other construction details. Particular attention should be given to ensuring low or easy maintenance for daylighting systems
- *Material selection:* Select materials with respect to performance and the quality of the indoor environment. Spaces, which receive daylight in small quantities, often need warmer colours to improve the luminous environment.

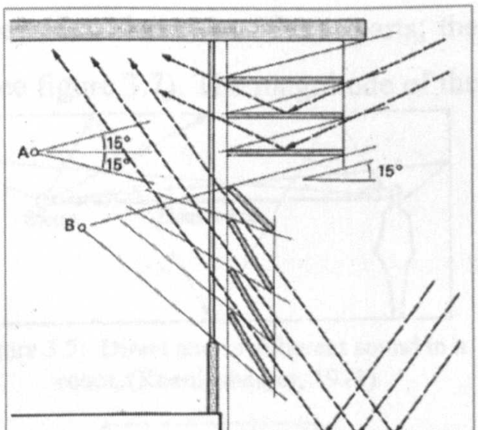
- *Electric Lighting:* Take care over the location and the number of lamps connected to each light switch. Evaluate the possible benefits of task lighting as well as the automatic control of overall electric lighting with respect to daylight availability.

c. Climatic Influences On Daylight Design

It is not easy to generalize across different climates about the correct daylighting strategies. The starting phase in proposing recommendations about daylighting in various climates and regions should be to analyse the broad strategies needed in the context of local climate, and then to assess how to apply these strategies to select appropriate daylighting design solutions (WHO & UNEP, 1990).

In warm climates, due to the accompanying thermal radiation with sunlight, excess of daylight would mean overheating which would consequently cause much greater discomfort than that resulting from lack of daylight. Furthermore, a slightly under-lit room would be psychologically more acceptable, as light is mentally associated with warmth but reduced lighting is associated with coolness. This requires great skill in daylight design in hot climates, partly to ensure an adequate illumination for the necessary visual efficiency and partly to avoid creating a gloomy effect. Buildings in these climates have to be with large openings to ensure cross-ventilation and air movement, and are recommended to be with wide overhanging eaves or other shading devices. Koenigsberger, et al. (1973) summarised the task and the problems of daylighting in hot humid climates as follows:

- Provide adequate daylight, even if the windows are protected by louvers or grilles for thermal reasons
- Exclude excessively bright surfaces from the visual field, which would cause glare; such as bright ground, sunlit blade or louver surfaces.
- Permit view of sky and ground near the horizon only, within about $\pm$ 15^0 (up and down).
- Daylight is to be reflected from ground and blades up to the ceiling, which itself should be of a light colour. Figure 3.5 shows an example of daylighting system suitable for this kind of climate.



Two critical points (nearest to window) are taken as:
A: standing– 1.7m height , 1.1m to window
B: sitting – 1.2m height, 0.8m to window

Figure 3.5: A special louver system, source: Koenigsberger, et al. (1973)

3.4 ACOUSTIC ENVIRONMENT

The science of sound (acoustics) can be broadly divided into two major fields. The first field is the handling of wanted sound, i.e. creating of the most favourable conditions for listening to a sound we want to hear (room acoustics). This area is out of the scope of this study. The second field of acoustics is the handling of unwanted sound, i.e. the control of noise, which is reviewed in this section. However, before that a brief review of sound reflection and transmission and noise standards will be necessary in order to have clearer understanding of noise problems and the means of noise control.

3.4.1 Reflection and Transmission of Sound

Sound incident on the surface, such as a wall, is either reflected (r), absorbed (a) (converted into heat), or transmitted (t) to air on the opposite side, and the sum of the three components is unity; i.e. r + a + t =1 (see Figure 3.6)

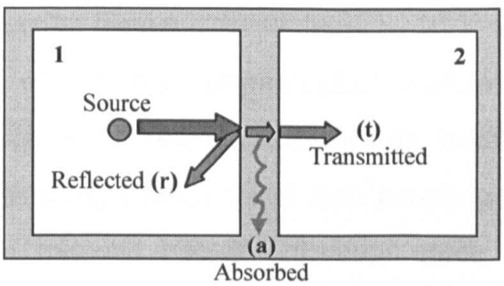


Figure 3.6: Airborne sound transmission, (Adapted from Koenigsberger, 1973)

The reflected part of the incident sound will reinforce the sound within the space and the remainder will be lost for the system. In an enclosed space, there will be a complex pattern of inter-reflected sound, which is referred to as (reverberant sound). Thus at any point in the space the total sound received will consist of two parts; the direct component and the reverberant component (see figure 3.7). The magnitude of the reverberant component depends on the absorbent qualities of room surfaces. The more absorbent these surfaces are, the lesser the reverberant component will be.

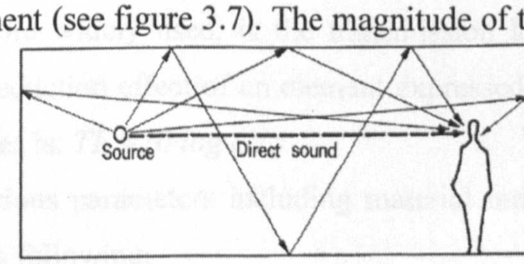


Figure 3.7: Direct and reverberant sound in a room, (Koenigsberger, 1973)

The transmitted part of the incident sound will induce a vibration of material`s molecules. This vibration will spread in the body as "structureborne sound" and then re-emits to air in adjacent space. Figure 3.8 shows some possible sound paths from a

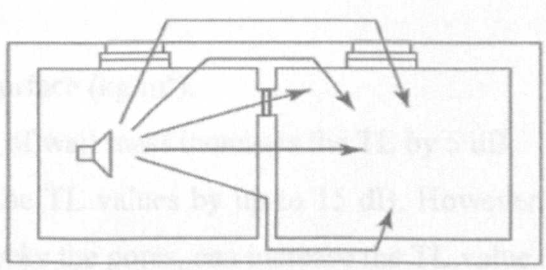


Figure 3.8: Sound transmission paths, (Szokolay 2008)

source in one room to a listener in another room.

The absorbed part of the incident sound will dissipate in the molecules of material. However, according to ASHRAE (2009), absorbed sound is defined as the part of incident sound that is transmitted through the surface and either dissipated or transmitted into the adjoining space. This means that absorbed sound indicates all the sound that not reflected. Depending on this definition, the absorption coefficient is calculated by the equation: ($\alpha = I_{abs}/I_{inc}$), where; I_{abs} is the intensity of absorbed sound and I_{inc} is the intensity of sound incident on the surface.

3.4.2 Noise Standards

Noise is the term used for any unwanted sound. Thus, the definition of noise is subjective; one person's enjoyable sound may be another's noise. The average person can hear frequencies from about 20 to 16000 Hz (Hertz), but this range is reduced with age and other subjective factors.

A variety of different physiological studies have led to classification of permissible and tolerable maximum noise levels, which form the basis of establishing hygienic norms. Szokolay (2008) stated that, people generally judge the noisiness of a given situation as follows: NR 20–25: very quiet, NR 30–35: quiet, NR 40–45: moderately noisy, NR 50–55: noisy, and NR 60 and over: very noisy, where NR is noise rating

3.4.3 Sound Insulation

One form of expression used to describe the noise insulating qualities of an element is the transmission coefficient (t) which is a decimal fraction expresses the proportion of sound energy transmitted. Another form, more widely used, is the transmission loss (TL) or sound reduction index which is the reduction effect of an element expressed in dB. The relationship between the two quantities is: $TL = 10 \log (1/t)$

The value of TL is affected with various parameters including material mass, porosity of material and frequency of sound as following:

a. ***Material mass***: For solid, homogeneous, non-porous elements, an approximate value of the TL can be obtained from the formula:

$TL = 18 \log M + 8$; where M is mass per unit surface (kg/m^2).

Szokolay (2008) reported that every doubling of wall mass increases the TL by 5 dB.

b. ***Porosity of material:*** Porosity can reduce the TL values by up to 15 dB. However, using a surface film such as paint, which blocks the pores, can increase the TL value.

c. ***Frequency of sound:*** When the resonant frequency, or natural frequency, of an element is at or near the frequency of sound, coincidence occurs and the TL is reduced by up to 10 dB. However, the application of some coating with a vibration dampening effect such as rubber or plastic foam would reduce the coincidence dip.

3.4.3.1 Structureborne sound insulation

As mentioned earlier, when airborne sound impinges on a building surface, some vibrations would generate in the fabric, i.e. structureborne sound. In these cases, it would be of negligible level. However, when structureborne sound is generated by mechanical impacts such as vibrating machinery, footsteps or dropping objects in the floor, its effect would be significant. The way to reduce structureborne transmission is to prevent the spread of vibrations by resilient linings and by introducing structural discontinuity, i.e. a physical separation or flexible connections (Koenigsberger, 1973). Figure 3.9 shows some arrangements for 'floating floors', where a resilient layer would isolate the floor surface from the structural floor below it. It is worth to mention that some building regulations prescribe the use of such floors between separate occupancies such as flats.

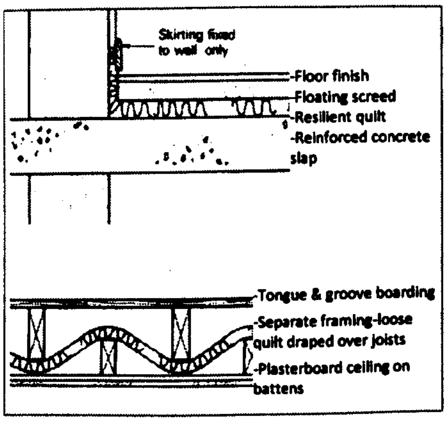


Figure 3.9: Some Floating Floor arrangements, (Koenigsberger, 1973)

3.4.4 Sound Absorbers

Absorbents could be classified into four types as following (see fig 3.10):

a- ***Porous Absorbents***: they have open cell structure such as mineral wool, glass wool, fibreboard or plastic foams. They are best in the higher frequencies and if they are fixed at some distance from a solid surface, it will have almost the same effect as a thicker absorber.

b- ***Membrane Absorbents:*** they are flexible sheets stretched over supports, or rigid panels mounted at some distance from a solid wall. Most such absorbers are best effective in the low frequency range.

c- ***Resonant Absorbers:*** they are air containers with narrow necks. They are best in a very narrow frequency band.

d- ***Perforated Panel Absorbents:*** they combine the mechanisms of porous membrane and resonant absorbers.

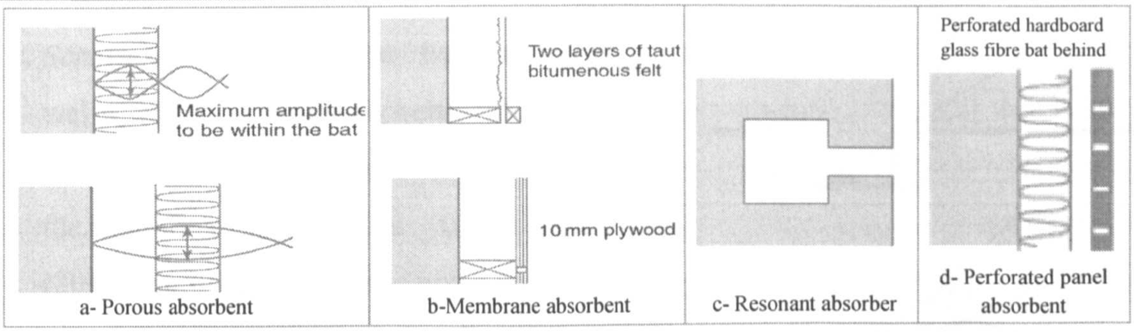


Figure 3.10: Types of sound absorbers, (Szokolay, 2008)

Skilful use of absorbent surfaces will greatly help in reducing noise. Absorbers could be used on the critical surfaces of construction elements, e.g. walls or ceilings, to reduce the reverberant noise. The most likely surface to receive absorbent treatment is the ceiling for two reasons:

- Especially in low and extensive spaces, the ceiling would cause multiple reflections of the sound, thus it is the most critical surface.
- Most absorbents are rather vulnerable, and the surface least exposed to mechanical damage is the ceiling.

Moreover, an absorbent material could be placed inside the cavity of multilayer construction in order to reduce the build-up of reverberant sound within the cavity, thus it would further improve the transmission loss value.

3.4.5 Noise Control In Buildings

In order to control noise in buildings, the first step is to determine noise sources to be controlled whether they are external or internal noises and then to select the appropriate means for control. The following means could be used to control external noise:

a. ***Planning:*** Separating areas which are not noise-sensitive and placing them on the side of the building nearest to the noise source. Thus, these areas would provide screening and protection to the more critical areas. The difference in noise exposure between the two sides can be as much as 30 dBA (Szokolay, 2008). Furthermore, the plan shape can be adjusted to provide additional protection.

b. ***Distance:*** If a site is given on which the positioning of a building is subject to the designer's choice, it is recommended to place the building as far from the noise source as possible since every doubling of the distance will reduce the noise level. This reduction is also affected by noise frequency, air temperature and air humidity. The area between the building and the noise source could be heavily vegetated.

c. ***Screening and Barriers:*** Barriers such as walls, fences plantation belts, etc., can be utilised to reduce the external noise reaching the building (see figure 3.11). Szokolay (2008) reported that for any noise barrier to be effective, it should have a surface density of not less than 20 kg/m. In addition, barriers should be positioned in such a way as to fit in with any advantageous effects of local topography.

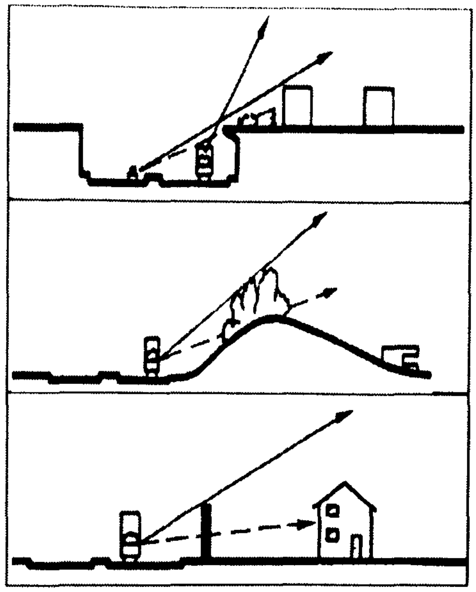


Figure 3.11: screening effects of barriers, (Koenigsberger, 1973)

According to Koenigsberger (1973), barrier will also be most effective when it is as near to the source as possible, while placing it near the building is the second best position. The barrier would be least effective half-way between the source and the building. The efficiency of the barriers will increase with shorter noise wavelengths and higher barriers as well (Szokolay, 2008).

d. ***Noise Insulating Building Envelope:*** Noise insulation can only be spoken of in relation to a fully enclosed space. The primary requirement is air-tightness. Under tropical conditions (especially in warm-humid climates) full enclosure and air tightness can only be achieved with air conditioning. In non-air conditioned buildings openings must be left for ventilation. Therefore, this mean could not been used in naturally ventilated building in hot humid climates. Therefore, other means of noise control should be greatly utilised.

e. ***Openings:*** Windows are the weakest point in the building envelope for noise penetration. Their position and orientation should be away from the noise source as much as possible. Their performance can, however, be improved by:

- Ensuring airtight closure by using gaskets
- Using double or triple glazing, where each pane with its frame is independent
- Placing absorbent material on the reveals, which should be at 150 mm, but preferably 200 mm to be effective

In some cases ventilating ducts are used which may pierce the noise insulating airtight envelope. This can be indirectly ameliorated by the use of absorption, basing on the following principles:

- The air is passed through not only an opening but a length of duct with minimum length one meter.
- The duct is curved or shaped in such a way that there is no direct straight line path left for the sound.
- As the shape induces multiple sound reflections within this duct, all internal surfaces are lined with a highly absorbent material.
- To further increase the number of reflections and the total absorbent surface available, absorbent baffles can be placed inside the duct. Figure 3.12 shows some typical arrangements.

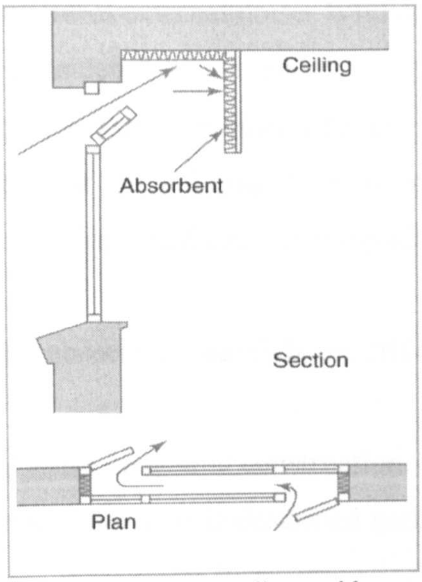


Figure 3.12: Ventilator with absorbent baffles, (Szokolay, 2008)

However, in naturally ventilated building in hot humid climates, with large openings, the methods described above could not be completely adequate. In such cases, it is recommended that surfaces from which sound may be reflected through the openings into the building must be identified and made absorptive. Figure 3.13a shows an example where street noise is reflected into the room from ceiling near the window. Absorbent lining is used to reduce the reflected noise. Other approaches, which could be applied to reduce external noise entering buildings through openings, are louver systems with absorptive surfaces. Figure 3.13b shows a louver system, on a ground floor opening. A sound of horizontal direction will be reflected twice; once from the top and once from the underside of a louver blade. By making the underside absorptive, an effect similar to the above may be achieved. Z-shaped or S-shaped blades could also improve the effectiveness of a louver system for noise reduction (Figure 3.13c)

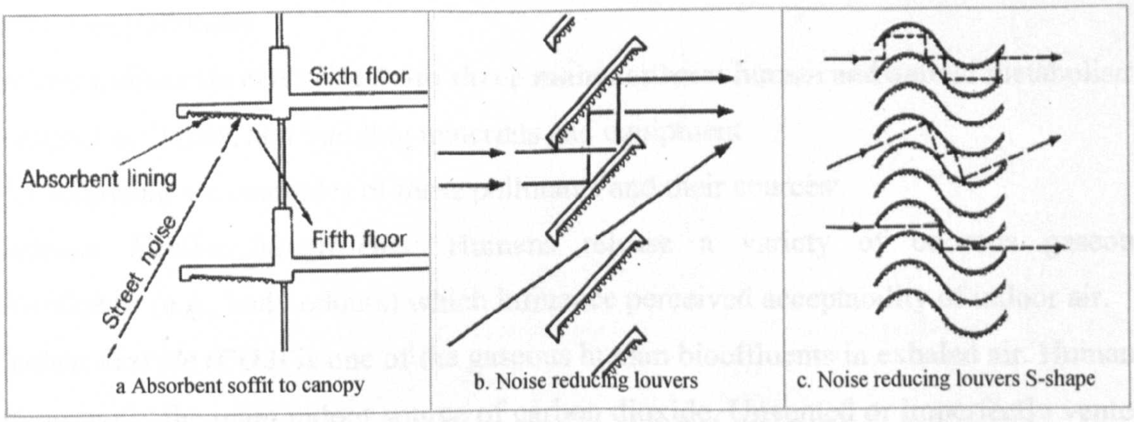


Figure 3.13: Noise reducing strategies in natural ventilated buildings, (Koenigsberger, 1973)

The means described above could be applied to control external noise. Whilst, to control internal noises, the following means should be considered (Hyde, 2008):

a- Separating noisy spaces from quiet ones and placing indifferent areas in between
b- Placing noisy equipments in the most massive part of the building such as in a basement and reduce their impact noises by covering surfaces with resilient materials
c- Reduce noise in the space where it is generated by absorbent materials on critical surfaces of the room.
d- Reduce airborne sound transmission by airtight and noise insulating construction.
e- Reduce structureborne sound transmission by discontinuity as it is described earlier in section 3.4.3

3.5 OTHER INDOOR ISSUES: AIR QUALITY, SECURITY, AREA

3.5.1 Air Quality Environment

Indoor air quality is considered an important parameter influencing the performance and the efficiency of the indoor environment. Strategies to control air quality in buildings are clarified in this section. A brief review of sources and types of indoor air pollutants is presented to have clear understanding of controlling means.

a. Indoor Air Pollutants Sources

There are a large number of indoor air pollutants that can influence occupant health and the perceived acceptability of indoor air. Sources of indoor pollutants are both outdoor and indoor and they either may have a natural origin or may be produced from human activities.

Major outdoor sources are: Industrial emission, traffic pollution, nearby sources, and soil-borne pollutants

Indoor pollutants can arise from three main sources: human and animal metabolism, occupant activities, and building materials and equipment

The following are examples of these pollutants and their sources:

Gaseous human bioeffluents: Humans release a variety of odorous gaseous bioeffluents (e.g., body odours) which influence perceived acceptability of indoor air.

Carbon dioxide (CO2) is one of the gaseous human bioeffluents in exhaled air. Humans are normally the main indoor source of carbon dioxide. Unvented or imperfectly vented combustion appliances can also increase indoor CO_2 concentrations.

Carbon monoxide (CO) and nitrogen oxides (NOx): Indoor unvented combustion, such as , unvented space heaters, failures in the combustion exhaust vent systems of vented appliances, leakage of air from attached parking garages into the building and Tobacco smoking are sources of CO and NOx.

Volatile organic compounds (VOCs): they are emitted indoors by building materials (e.g., paints, pressed wood products, adhesives, etc.), furniture, equipment (photocopying machines, printers, etc.), cleaning products, pest control products, and combustion activities (cooking, unvented space heating, tobacco smoking) (Steinemann, 2004). Humans also release VOCs as a consequence of their metabolism and use of personal products such as perfumes. New building materials and furnishings generally emit VOCs at a much higher rate than older materials. The outdoor air entering buildings also contains VOCs.

Radon: The primary source of radon in most buildings is the surrounding soil and rock. Radon enters buildings from soil as soil gas is drawn into buildings and also enters by diffusion through the portions of buildings that contact soil. Earth-based building materials and water from wells can also be a source of radon.

Moisture is not a pollutant but it has a strong influence on indoor air quality. Water vapour is generated indoors due to human metabolism and human activities involving water use, as well as due to unvented combustion activities and by humidifiers. Moist soil may be a source of moisture in indoor air and in the flooring materials that contact the soil. Condensation of water on cool indoor surfaces such as windows, may promote the growth of microorganisms. Water leaks, such as roof and plumbing leaks, and exposure of building materials to rain during building construction are a frequent source of growth of microorganisms.

Fibres in indoor air include those of asbestos and man-made mineral fibres such as fibreglass, and glass wool. The primary indoor sources are building materials especially insulation products.

b. Control Indoor Air Quality

The indoor air quality depends on; the outdoor pollutant concentration, the indoor pollutant generation rate, and on the total rate of pollutant removal by ventilation, air cleaning, and other removal processes. Consequently indoor air quality could be achieved by the following strategies:

- ***Building Location:*** When possible, buildings should be located in areas with acceptable outdoor air quality.

- ***Ventilation:*** ventilation has a key role in providing an optimum indoor air quality in a building. Two types of ventilation in buildings could be applied; natural ventilation and mechanical ventilation. Natural ventilation is relatively inexpensive and required minimum level of maintenance; however, it is not suitable for noisy and highly polluted locations (Santamouris, 2001).

- ***Openings Orientation:*** windows should not be located near strong sources of pollutants such as combustion stacks, exhausts from fume hoods, sanitary vents, busy streets and parking garages.

- ***Ventilation Rate:*** ventilation with outside air must be provided at an adequate rate for all occupied spaces.

- ***Airflow Pattern:*** A floor-to-ceiling indoor airflow pattern can reduce pollutant concentrations in the breathing zone while a short-circuiting airflow pattern at ceiling level can increase pollutant concentrations in the breathing zone.

- ***Pressure Differences***: In the case of air conditioning building, maintaining pressure differences between different indoor spaces can limit the rate of pollutant transport between these spaces. For example, bathrooms are often depressurized so that pollutants generated within these spaces do not leak into the surrounding rooms.

- ***Local Exhaust Ventilation*** is recommended to be used in rooms with high indoor air pollutant or odour sources.

- ***Maintaining and Cleaning***: Air Cleaning Systems in HVAC systems require regular maintenance to limit odour emissions and microbiological growth.

- ***Isolating of Equipment:*** Equipment with high emission rates of pollutants or odours should be isolated in rooms, such as copy machine rooms or kitchens, with high air exchange rates with air exhausted directly to outdoors

- ***Separating Parking Garages:*** Parking garages should be physically separated from occupied spaces and maintained under negative pressure relative to the adjoining occupied spaces

- ***Building Materials, Furnishings and Equipment*** with low VOC and odour emission rates should be selected.

- ***Eliminating Water leaks & Drying Construction Materials:*** Water leaks from plumbing and the building envelope should be eliminated. Building materials that become wet should be dried rapidly or removed and replaced. Construction materials, including concrete, should be dry before they are covered or enclosed in a wall cavity.

- ***Using Moisture barriers and thermal insulation***: Condensation of water vapour inside the building envelope and on interior building surfaces must be limited by controlling indoor humidity, and proper use of moisture barriers and thermal insulation in the building envelope (IPMVPC, 2001). Condensation is much more likely in high humidity climates, so specific requirements will vary with climate.

3.5.2 Security For Building Occupants

The design and construction of secure buildings continues to be a primary goal for owners, architects and engineers. In recognizing concern for acts of crimes and violence, the design team must take a multi-hazard approach towards building design that accounts for the potential hazards and vulnerabilities. Designing buildings for security requires practical strategies that predict hazards and then protect the building occupants by avoiding any attack to occur. The selection of these strategies will depend on; the security requirements, the acceptable levels of risk, the impact of these approaches on the design, and the use of the building. The first step in this process is to understand the various possible threats and the risks that occupants pose.

Security approaches could include several types of methods; operational methods (i.e. guards), technical methods (i.e. camera), and physical methods (i.e. high fences) (WBDG, 2010). The following security measures could be applied in residential buildings:

- Control perimeter such as Fences and anti-ram barriers
- Remote controlled gates
- Multi lock doors and windows
- Barrier protection for man-passable openings such as windows barrier especially for ground floors spaces.
- Perimeter intrusion detection systems such as Alarms.

It is worth to mention that security measures should be considered together with other design objectives in order to achieve quality high performance buildings.

3.5.3 Adequacy Of Space

Adequacy of space is one of the most frequently requested aspects of the evaluation of indoor environment in residential buildings, in particular low cost housing where the efficiency of spaces, which occupants make use in this type of buildings, is considerably associated with financial values. Adequacy of space could be also considered as a significant aspect of the functional requirements and aesthetics objectives of building design.

The architect's conception of the activities that will take place within each room has always been fundamental of building design, as this implies what size each room needs to be and where it should be positioned relative to the others. This is a complex task for the architects, illustrated by the fact that sufficient amount of space depends not only on the identifiable activities but also on people`s culture, which should be taken into consideration. Number of users, in addition to activities, has significant impact on determining the sufficient amount of space through building life.

Furthermore, interior design plays a major role in the measure of space adequacy, since it concerns with more than just the visual or ambient enhancement of an interior space; it seeks to optimize and harmonize the activities to which the spaces will be designed.

3.6 SUMMARY

Enhancing indoor conditions have great valuable impacts on both health aspects and energy utilization. Visual comfort as one of essential indoor features could be achieved by sufficient amount of light, uniform distribution, and absence of glare. Several strategies presented in this chapter, could be applied in building design for daylight considering building type, location, and climate, followed by clarification for sound physics and number of approaches to control internal and external noise in buildings. Further, indoor air pollutants and methods to eliminate them in buildings are illustrated. Finally, security in buildings and adequacy of space as required aspects of indoor environment evaluation, are reviewed. Next chapter will concentrate on thermal environment which plays the major role among other indoor conditions in human comfort and energy consumption and which is the main focus of this study.

CHAPTER 4

THERMAL COMFORT & BUILDING THERMAL PERFORMANCE

4.1 INTRODUCTION

All human capacities would be generally at their peak when they are in the most comfortable periods and they will decrease in the unfavourable seasons; and this is one of the inducements for creating thermal comfort in built environments (Auliciems & Szokolay, 2007). Thermal comfort is also considered as an important feature in the evaluation of the building performance and energy savings. Therefore, exploring buildings' thermal behaviour is necessary; to predict occupants' comfort, to identify energy consumption, and to examine alternate enhancements for achieving better indoor thermal environments and energy efficient buildings.

Parameters that could affect thermal comfort are explicated in this chapter to help identifying the methods of prediction thermal comfort, which are elucidated later. In addition, the thermal comfort conditions preferred by the people in hot-humid climates are investigated. The major categories of building thermal models are also reviewed with focus on the limitations of each one. The chapter also highlights different types of thermal insulation including, resistive, reflective and capacitive insulation and their application. Glazing properties related to heat transfer are then presented combined with parameters impact windows' thermal behaviour. The chapter finally explicates main aspects of selection materials in hot humid climates.

4.2 FACTORS AFFECTING THERMAL COMFORT

There are different controversial definitions of thermal comfort; one of these is stated by the ASHRAE as *"that condition of mind which expresses satisfaction with the thermal environment"* (ASHRAE, 2009). Referring to this definition, the phrase "condition of mind" could be the result of a perceptual process, a state of knowledge, or a general feeling and attitude (Heijs, 1994). This means that comfort is a subjective mental state and it is continuously changing depending on various factors. These factors, which affect thermal comfort, could be classified under three main categories; environmental, personal and secondary factors. The effect of each of these factors on thermal comfort is explained below.

4.2.1 Environmental Factors

The environmental factors; such as air temperature, mean radiant temperature, relative humidity and air velocity, have a direct influence on the rate in which the body loses or gains heat to or from its surroundings and are discussed as follows;

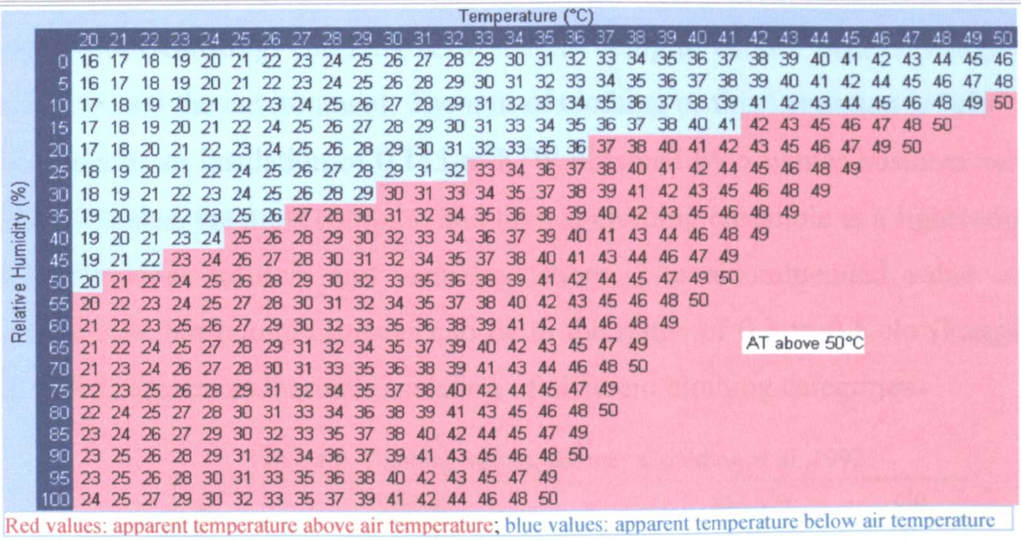
a. Air temperature: Air temperature is considered as the most significant ambient factor which affects level of human comfort. It affects the rate of heat exchange between the skin and surroundings, as when air temperature approaches skin temperature or exceeds it, both convective and evaporative heat loss decrease or even cease.

b. Mean Radiant Temperature (MRT): Objects in the space affect human thermal comfort, even if they are not in a direct contact with the human body. These objects absorb or emit heat, depending on their thermal properties and temperature difference between them and the surrounding air. When the mean radiant temperature is lower than the body surface temperature, body heat loss by radiation takes place. When the temperature of the surrounding surfaces and subsequently the main radiant temperature are higher than the body surface temperature, heat gain to the body by radiation takes place.

MRT has a significant effect on human thermal comfort. In winter, increasing MRT can compensate the low value of air temperature. In summer, and for passive cooling, increasing air velocity helps removing the undesired heat emitted by the ambient surfaces. Szokolay (2008) stated that the effect of MRT depends on clothing; for instance, in warm climates (with light clothing, the effect of MRT is twice as considerable as the dry bulb temperature (DBT), while in winter (with heavy clothing) it has about the same influence as the DBT.

c. Relative Humidity (RH): When the relative humidity is high, people tend to feel hotter than the actual temperature of the environment due to slow evaporation rate. This appears in the "Heat Index" which is an index that combines air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature - how hot it actually feels (see figure 4.1).

The high relative humidity in hot-humid regions is a typical climatic problem in this sort of regions. This could be solved by increasing the air movement to allow evaporation to take place as thermal balance can still be effectively maintained through evaporative cooling at different levels of relative humidity.



Relative Humidity (%) \ Temperature (°C)	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
5	16	17	18	19	20	21	22	23	24	25	26	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	44	45	46	47	48
10	17	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34	35	36	37	38	39	41	42	43	44	45	46	48	49	50
15	17	18	19	20	21	22	24	25	26	27	28	29	30	31	33	34	35	36	37	38	40	41	42	43	45	46	47	48	50		
20	17	18	20	21	22	23	24	25	26	28	29	30	31	32	33	35	36	37	38	40	41	42	43	45	46	47	49	50			
25	18	19	20	21	22	24	25	26	27	28	29	31	32	33	34	36	37	38	40	41	42	44	45	46	48	49					
30	18	19	21	22	23	24	25	26	28	29	30	31	33	34	35	37	38	39	41	42	43	45	46	48	49						
35	19	20	21	22	23	25	26	27	28	30	31	32	34	35	36	38	39	40	42	43	45	46	48	49							
40	19	20	21	23	24	25	26	28	29	30	32	33	34	36	37	39	40	41	43	44	46	48	49								
45	19	21	22	23	24	26	27	28	30	31	32	34	35	37	38	40	41	43	44	46	47	49									
50	20	21	22	24	25	26	28	29	30	32	33	35	36	38	39	41	42	44	45	47	49	50									
55	20	22	23	24	25	27	28	30	31	32	34	35	37	38	40	42	43	45	46	48	50										
60	21	22	23	25	26	27	29	30	32	33	35	36	38	39	41	42	44	46	48	49											
65	21	22	24	25	27	28	29	31	32	34	35	37	39	40	42	43	45	47	49												
70	21	23	24	26	27	28	30	31	33	35	36	38	39	41	43	44	46	48	50												
75	22	23	25	26	28	29	31	32	34	35	37	38	40	42	44	45	47	49													
80	22	24	25	27	28	30	31	33	34	36	38	39	41	43	45	46	48	50													
85	23	24	26	27	29	30	32	33	35	37	38	40	42	44	45	47	49														
90	23	25	26	28	29	31	32	34	36	37	39	41	43	45	46	48	50														
95	23	25	26	28	30	31	33	35	36	38	40	42	43	45	47	49															
100	24	25	27	29	30	32	33	35	37	39	41	42	44	46	48	50															

AT above 50°C

Red values: apparent temperature above air temperature; blue values: apparent temperature below air temperature

Figure 4.1: Heat index, (AGBM, 2010)

d. Air movement: Air movement has great influence on the body heat loss by both convection and evaporation. An increase in air velocity would generate a greater heat loss by both processes. However, evaporation is restricted in high humidity; thus, even air movement cannot adequately increase the cooling effect (Szokolay, 1980). Natural cooling is therefore in some cases difficult to achieve.

In hot humid climate, high air velocities help enhancing evaporative heat transfer over skin surface as drier ambient air replaces the saturated air near the skin and it increase convective heat loss as long as the temperature of the moving air is less than the skin temperature. However, air velocity should be kept below its allowed upper limit in building design.

4.2.2 Personal Factors

Personal factors, activities and clothing, are comfort factors determined by the occupants. Moore (1993) stated that these factors are beyond the control of the designer but they have an indirect effect on building design.

a. Occupant activity/ metabolic rate: Body's activity determines the metabolic rate of heat production. A higher level of activities requires cooler conditions to reduce the thermal stress. This heat production is measured in metabolic or met unit, which is "the metabolic rate of a seated person when relaxing, i.e. 58 W/m^2 (Goulding et al., 1992). The metabolic rates for some activities are shown in the table 4.1.

Table 4.1: Metabolic Rate , source: EN ISO 7730:2005

Activity	Metabolic rate	
	W/m2	met
Reclining	46	0.8
Seated, relaxed	58	1
Sedentary activity (office, dwelling, school, laboratory)	70	1.2
Standing, light activity (shopping, laboratory, light industry)	93	1.6
Standing, medium activity (shop assistant, domestic work, machine work)	116	2
Walking on level ground: 2 km/h	110	1.9

b. Occupant clothing: Clothing helps human being to control heat exchanges between their body and the environment. The unit of clothing or this insulation is "clo", which is equivalent to an insulation of 0.155 m^2K/W obtained by a winter business suit. In hot-humid climates, the most common and logical clothing ensemble is a lightweight cotton shirt with loose trousers and ventilated shoes. The recommended value of thermal insulation for hot-humid climates can be in the range of 0.3 to 0.5 clo (Fanger, 1982). Table (4.2) illustrates thermal insulation of different clothing categories.

Table 4.2: Clothing values, source: Goulding et al.,1992

Clothing	m2 k/w	clo
Nude	0	0
Light summer ensemble	0.08	0.5
Typical indoor winter ensemble	0.16	1.0
Heavy business suit	0.23	1.5

4.2.3 Secondary Factors

Air temperature, air velocity, humidity of the surrounding environment, and personal parameters are main factors that influence human thermal comfort. Other factors that may indirectly affect thermal comfort of a person are discussed in this section.

a. Age: Because metabolism decreases slightly with age, many have stated that comfort conditions for young subjects cannot be used for other age groups. However, studies have revealed that at a given activity and clothing level the thermal environments preferred by older people do not differ from those preferred by younger ones (ASHRAE, 2009). Nevertheless, this does not necessarily mean that they are equally sensitive to cold or heat. The lower metabolism in older people is compensated for by a lower evaporative loss (CIBSE, 2006). Despite this, older people generally require higher temperatures because their activity level is usually lower.

b. Sex: Women have slightly slower metabolic rates and therefore prefer an average of 1°C higher compared to men (Koenigsberger, 1973 and Olgay, 1992). A field survey conducted by Wang (2006) verified that the neutral operative temperature of males is 1°C lower than that of females. However, experiments carried out by Fanger (1982) indicated that; at the same activity and clothing levels, men and women prefer almost the same thermal environments. The reason that women often prefer higher ambient temperatures than men may be partly explained by the lighter clothing normally worn by women (ASHRAE, 2009). A series of laboratory experiments carried out by Parsons

(2002) revealed that; for identical clothing and activity, there are few gender differences in thermal comfort responses for neutral and slightly warm conditions but women tend to be cooler than males in cool conditions.

c. Adaptation: There are three main types of adaptation; physiological adaptation, psychological adaptation and behavioural adaptation (Yao et al, 2009). There are two sub-categories included in physiological adaptation: genetic adaptation (from generation to generation) and acclimatization (within one generation). Psychological adaptation is an altered perception of, and reaction to, sensory information due to subjective past thermal experiences and expectations (de Dear and Brager, 2002). Repeated exposure to a specific thermal environment would diminish the sensitivity of the human body to this environment. Behaviours such changing clothing level, switching on/off a fan, opening/closing of windows, and taking in hot/cold drinks, can be considered as behavioural adaptation because these behaviours will affect the heat balance of the human body (Singh et al., 2011).

The studies by Fanger (1982) on the effect of geographical locations on thermal comfort sensation suggest that there is no significant effect upon preferred temperatures. These results indicate that people cannot adapt to preferring warmer or colder environments, and therefore the same comfort conditions can likely be applied throughout the world. On the other hand, field experiments have shown that occupants of naturally ventilated buildings in warm climates could accept higher temperatures (EN ISO 7730, 2005). Adaptation plays a particularly important role in determining a human's thermal sensations in free-running buildings (de Dear and Brager, 2002).

4.3 PREDICTION OF THERMAL COMFORT

It is possible to measure the environmental variables at a suitable number of points in the occupied zone in a given space, but these measurements should be interpreted in order to predict the comfort level in that zone. Due to the number of interacting factors affecting human comfort, including personal preferences, the prediction of thermal comfort is not an easy task. Several models have been developed to predict comfort which most of them are based on survey data of large numbers of people under many different conditions. Of this range of models, only two are selected to be discussed here which are the predicted Mean Vote (PMV) model and the Adaptive Model.

4.3.1 The Predicted Mean Vote (PMV)

The theory of Predicted Mean Vote (PMV) associated with the index of Predicted Percent of Dissatisfied (PPD) is originally derived by Fanger (1970) and later is adopted as an international standard ISO 7730 since the 1980s. As explained by Awbi (2003), the well-known Fanger's model (the PMV) is the most comprehensive model for thermal comfort assessment up to date. Hoof (2008) stated that Fanger's PMV model is still used as the number one method for evaluating thermal comfort. The original data were collected from large number of subjects who had been exposed to well controlled environments. Therefore, the PMV index could be defined as the mean value of the votes of a group of persons, exposed to the same environment with identical clothing and activity (CIBSE, 2006). PMV is given by the equation:

$$\begin{aligned} PMV= & [0,303.\exp(-0.036.M + 0,028].\{(M-W) - 0,00305\,[5733 - 6,99.(M-W) - p_a] \\ & - 0,42.[M-W-58,15] - (1,7.10^{-5}).M.(5867 - p_a) - 0,0014\,.M.(34 - t_a) - (3,96.10^{-8}) f_{cl} \\ & .[(t_{cl} + 273)^4 - (t_r + 273)^4] - [f_{cl}\,.(h_c\,.(t_{cl} - t_a)]\} \end{aligned} \tag{4.1}$$

Where,

M: metabolic rate, (W/m^2)
W: effective mechanical power, (W/m^2)
f_{cl} : clothing surface area factor
t_a: air temperature, (°C)
t_r : mean radiant temperature, (°C)
p_a: water vapour partial pressure, (Pa)
h_c: convective heat transfer coefficient, $W/m^2.K$
t_{cl}: clothing surface temperature, (°C)

The PMV predicts the mean value of the votes of a large group of persons on the 7-point thermal sensation scale, values range between (-3) and (+3). Negative values indicate an uncomfortable feeling due to a cold sensation where; (-1) slightly cool, (-2) cool, (-3) cold. Positive values indicate an uncomfortable feeling due to a hot sensation where; (+1) slightly warm, (+2) warm, (+3) hot. Zero is the neutral point, representing comfort.

Humphreys and Nicol (2002b) found that the more thermal conditions moved away from neutral, the larger the bias in PMV. According to EN ISO 7730:2005, The PMV index should be used only for values of PMV between (-2) and (+2), and when the six main parameters are within the following intervals:

Metabolic rate	0,8 - 4 met	Mean radiant temperature	10 - 40 °C
Clothing insulation	0 - 2 clo	Relative air velocity	0 - 1 m/s
Air temperature	10 - 30 °C	Water vapour partial pressure	0 - 2700 Pa

Association with PMV, the Predicted Percentage of Dissatisfied (PPD) can be determined by the following equation;

$$PPD = 100 - 95\,.\exp(-0,03353\,.PMV^4 - 0,2179\,.PMV^2) \tag{4.2}$$

PPD index provides information on thermal discomfort or thermal dissatisfaction by predicting the percentage of people likely to feel too warm or too cool in a given environment; where dissatisfied here is defined as anybody not voting (-1), (+1), or (0). However, to insure a comfortable indoor environment, PMV should be kept (0) with a tolerance of ±0.5 scale unit (EN ISO 7730:2005). The relationship between PMV and PPD is illustrated in figure (4.2), which shows that with PMV equal to zero, about 5% of the people remain dissatisfied as it is very difficult to achieve thermal comfort for all people in a space.

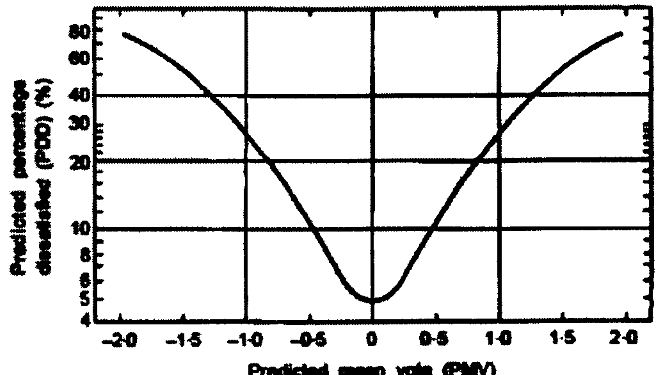


Figure 4.2: PPD as function of PMV, (CIBSE, 2006)

4.3.2 The Extended Predicted Mean Vote (PMVe)

The PMV model is flexible tool includes all the main parameters that affect thermal sensation. It is widely used and accepted for design and field assessment of comfort conditions (ASHRAE, 2009). The PMV index is derived for steady-state conditions, however, it can be applied with good approximation at relatively minor fluctuations of one or more of the environmental variables (Fanger & Toftum 2002, and EN ISO 7730:2005).

On the other hand, various field studies in hot climate, particularly in natural ventilated buildings, have shown that the PMV is higher than the Actual Mean Vote by the occupants (ASHRAE, 2009). Fanger and Toftum (2002) clarified that; this difference is related mainly to the expectations of the occupants in warm environments and the estimated activities. The influence of these two major factors on PMV is explained below

a. The expectations of the occupants: People who have been living in hot climates through generations believe that it is their destiny to live in this sort of climate where they feel warmer than neutral and will judge the hot environment as less unacceptable than those from temperate and cold climates or those who are used to live in air conditioning. As a result, an extension for the PMV model is adapted by multiplying PMV with expectancy factor (e) to reach the actual meant vote of the occupants in naturally ventilated buildings in hot climates. The factor (e) is estimated to range between 1 and 0.5 where 1 is for air-conditioned buildings (Fanger and Toftum, 2002). The expectancy factor (e) depends mainly on the duration of the hot weather over the year and the proportion of air-conditioned buildings in the region. For instance, in naturally ventilated buildings in region where the weather is warm only during summer and no or few buildings have air conditioning, the expectancy factor (e) may be 0.7-0.8 (see table 4.3).

Table 4.3: Expectancy factors for non-air-conditioned buildings in warm climates, (Fanger & Toftum, 2002)

expectation	classification of non-air-conditioned buildings location	warm periods
high	in regions where air-conditioned buildings are common	occurring briefly during summer
moderate	in regions with some air-conditioned buildings	summer season
low	in regions with few air-conditioned buildings	all seasons

b. The Estimated Activity (Metabolic Rate): When people feel warm, they unconsciously tend to slow down their activity decreasing their metabolic rate to adapt to the warm environment. However, in many field studies, the mechanistic approach to estimate the metabolic rate on the basis of a questionnaire (identifying the percentage of time the person was sedentary, standing, or walking) does not acknowledge the people adaptation. Accordingly, metabolic rate should be reduced when calculating the PMV.

4.3.3 Adaptive Models

Adaptive models do not actually predict comfort responses but they almost verify the conditions under which people are not feeling warm nor cold. They assume that, if changes occur in the thermal environment to produce discomfort, then people will make various adjustments to themselves and their surroundings to reduce discomfort and physiological strain. Adaptive adjustments are typically conscious actions such as altering clothing, posture, reducing activity levels, rate of working, diet, or even opening a window for ventilation. Humphreys and Nicol (1998) remarked that; through occupants` adaptive actions in residential buildings, an acceptable degree of comfort is possible over a range of air temperatures from about 17.2 to 31.1°C (ASHRAE, 2009).

The main input of the adaptive models is the monthly mean outdoor temperatures T_{out}, and then comfort temperatures T_c or ranges of T_c could be determined. Since adaptive models are based mainly on human behaviour and outside weather conditions, they are usually based on extensive surveys of thermal comfort in a wide range of buildings, climates, and cultures. According to adaptive models, the comfort temperature t_c could be determined by the following equations (ASHRAE, 2009):

$$t_c = 75.6 + 0.43(t_{out} - 71.6)\exp - \left(\frac{t_{out} - 71.6}{61.1}\right)^2 \tag{4.3}$$

For climates and buildings where cooling and central heating are not required, the operative comfort temperature t_{oc} is determined by the equation:

$$t_{oc} = 66 + 0.142\,(t_{out} - 32) \tag{4.4}$$

In general, the main value of the Adaptive Models is to expand the range of comfortable conditions that designers can follow, particularly in naturally ventilated buildings where the occupants have a greater degree of control over their thermal environment (source: Squ1.org).

4.3.4 Adaptive Predicted Mean Vote (aPMV)

The visible shortcoming of the Adaptive Models is that they do not include the personal factors nor the four environmental factors, that have a well known influence on human body heat balance and therefore on thermal comfort (Fanger and Toftum, 2002). The Extended Predicted Mean Vote (PMVe) is only suitable for hot climate. Yao, Li, and Liu (2009) developed an Adaptive Predicted Mean Vote (aPMV) model which has explored the relationship between the findings from experimental studies and field studies. The aPMV model set up the relationship of the (aPMV) and the Predicted Mean Vote (PMV) in free-running buildings by involving the adaptive coefficient (λ) which reflects a human's adaptive functions such as behavioural and psychological adaptation. The determination of the value of the adaptive coefficient (λ) is based on the field study taking into account local climate, culture and social backgrounds.

The (aPMV) model can be described as: aPMV = PMV/ [1+ (λ x PMV)]

When the adaptive coefficient (λ) is equal to zero, the aPMV is equal to PMV, which is the lab-based condition with no adaptive action. In hot conditions, the adaptive coefficient (λ) is greater than zero; consequently, the aPMV will be less than the PMV. In cool conditions, the adaptive coefficient (λ) is less than zero; consequently, the aPMV will be greater than the PMV. The aPMV model will be useful to apply the PMV method in various buildings in both hot and cold environments with consideration of the local climate, culture and social backgrounds, and behaviour habit etc (ibid).

4.4 COMFORT ZONE

"*The range of conditions within which at least 80% of the people would feel comfortable*" can be termed 'comfort zone' (Koenigsberger, et al., 1973). Since thermal comfort is dependent on a variety of variables, as explicated earlier in section 4.2, several attempts have been made to determine the range of acceptable comfort conditions in order to express comfort zone boundaries with the combined effect of these variables, particularly the environmental and personal ones. However, according to Olgyay (1993); the comfort zone does not have real boundaries since the situation of comfort subtly turns to a slight degree of stresses and from this to situations of discomfort as diverging from the centre of the comfort zone. Furthermore, the comfort zone could not be the same under different location or various conditions. The following is presenting of selected studies where comfort zones are determined with combined with various parameters.

Houghten and Yagloglou in 1927 produced the 'effective temperature index' figure (4.3). The index shows comfort zone (shaded quadrangle) in terms of dry bulb temperature, wet bulb temperature and air velocity for people wearing business clothing (1 clo). The comfort zone is indicated by the effective temperature range 22 °C and 27°C and by the air velocity range 0.15 and 1.5 m/s, which found to be suitable in most tropical climates (Koenigsberger et al, 1973).

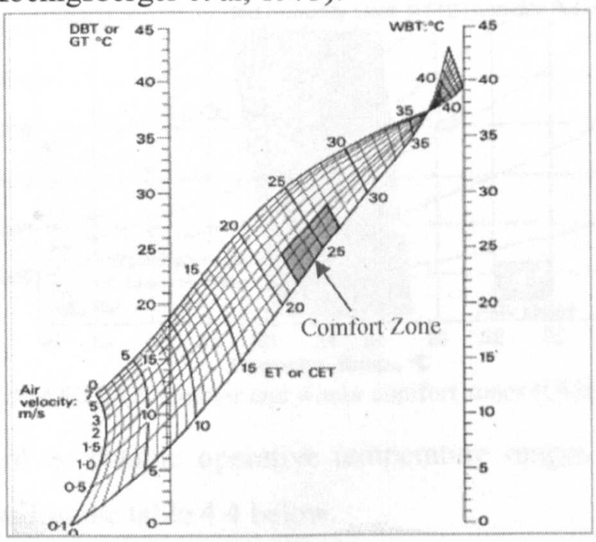


Figure 4.3: Effective temperature Index, source: Ogunsote, et al., 2002

Olgyay 1953 introduced the 'bioclimatic chart" (figure 4.4) which shows human comfort zone (the aerofoil shape in the middle) in terms of dry bulb temperature on the vertical axis , and relative humidity on the horizontal axis for people with ordinary indoor clothing. Curves above show how air movement can extend the upper limits and lines below it show the extension by radiation. The desirable comfort zone indicated lies between 30% and 65% relative humidity (Olgyay, 1992). It is worth to mention that comfort zone here is directly applicable to inhabitants of the temperate zone of approximately 40° latitude.

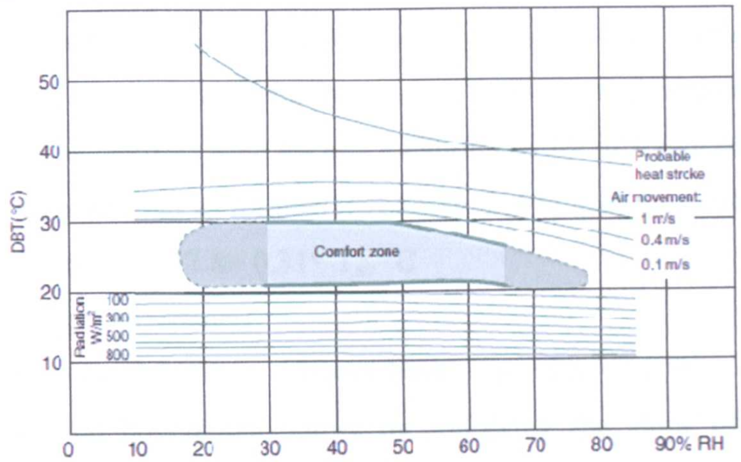


Figure 4.4: Olgyay 's bioclimatic chart, source: Szokolay, 2008

ASHRAE Standard55-2004 determines summer and winter comfort zones as relating to operative temperature and humidity at air speed ≤ 0.2m/s for people with clothing 0.5 and 1.0 clo and activity level ≤ 1.1 met (see figure 4.5). The upper recommended humidity is 60% RH with no lower humidity limit (ASHRAE, 2009).

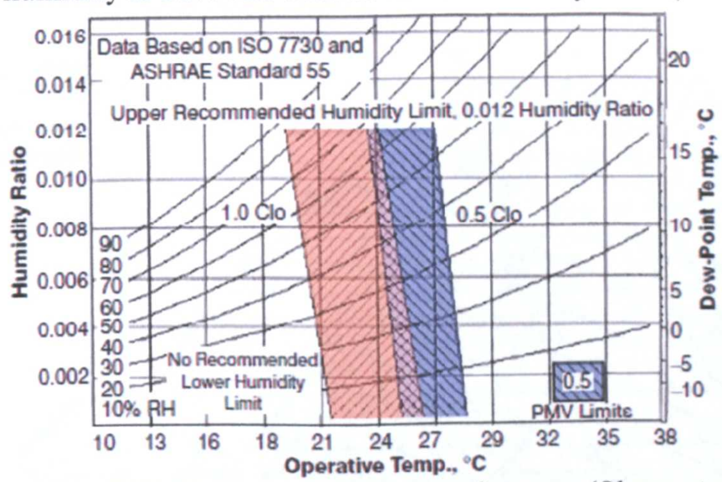


Figure 4.5: ASHRAE summer and winter comfort zones (Olesen, et al., 2004).

Examples of acceptable operative temperature ranges based on comfort zone diagrams are showed in the table 4.4 below.

Table 4.4: Examples of acceptable operative temperature ranges based on comfort zone diagrams in ASHRAE Standard-55-2004, (Charles, et al., 2005)

Conditions	Acceptable operative temperatures °C	°F
***Summer** (clothing insulation = 0.5 clo)*		
Relative humidity 30%	24.5–28	76–82
Relative humidity 60%	23–25.5	74–78
***Winter** (clothing insulation = 1.0 clo)*		
Relative humidity 30%	20.5–25.5	69–78
Relative humidity 60%	20–24	68–75

Szokolay (2008) stated that the Standard Effective Temperature SET is the latest comfort index now generally accepted. The SET combines the effect of temperature and humidity and is defined as *"the equivalent air temperature of an isothermal environment at 50% RH in which a subject, wearing clothing standardized for the activity concerned, has the same heat stress (skin temperature Tsk) and thermoregulatory strain (skin wettedness w) as in the actual environment."*(ASHRAE, 2009, P9.21). The comfort zone for any location and for different month can be plotted on the Psychrometric chart as follows (Szokolay, 2008): (see figure 4.6)

Neutral temperature $Tn = 17.8 + 0.31 * T_{av}$ °C (4.5)

(where T_{av} is average temperature)

Lower limit: $T_L = Tn - 2.5$ °C, Upper limit: $T_U = Tn + 2.5$ °C

For the side boundaries, either by following the slope of SET lines on the Psychrometric chart or constructing the corresponding sloping SET lines by determining the X–axis intercept from:

$$T = T_L + 0.023 * (T_L - 14) * AH_{50} \quad (4.6)$$

$$T = T_U + 0.023 * (T_U - 14) * AH_{50} \quad (4.7)$$

(Where AH_{50} is the absolute humidity (g/kg) at the RH 50% level at the T_L and T_U)

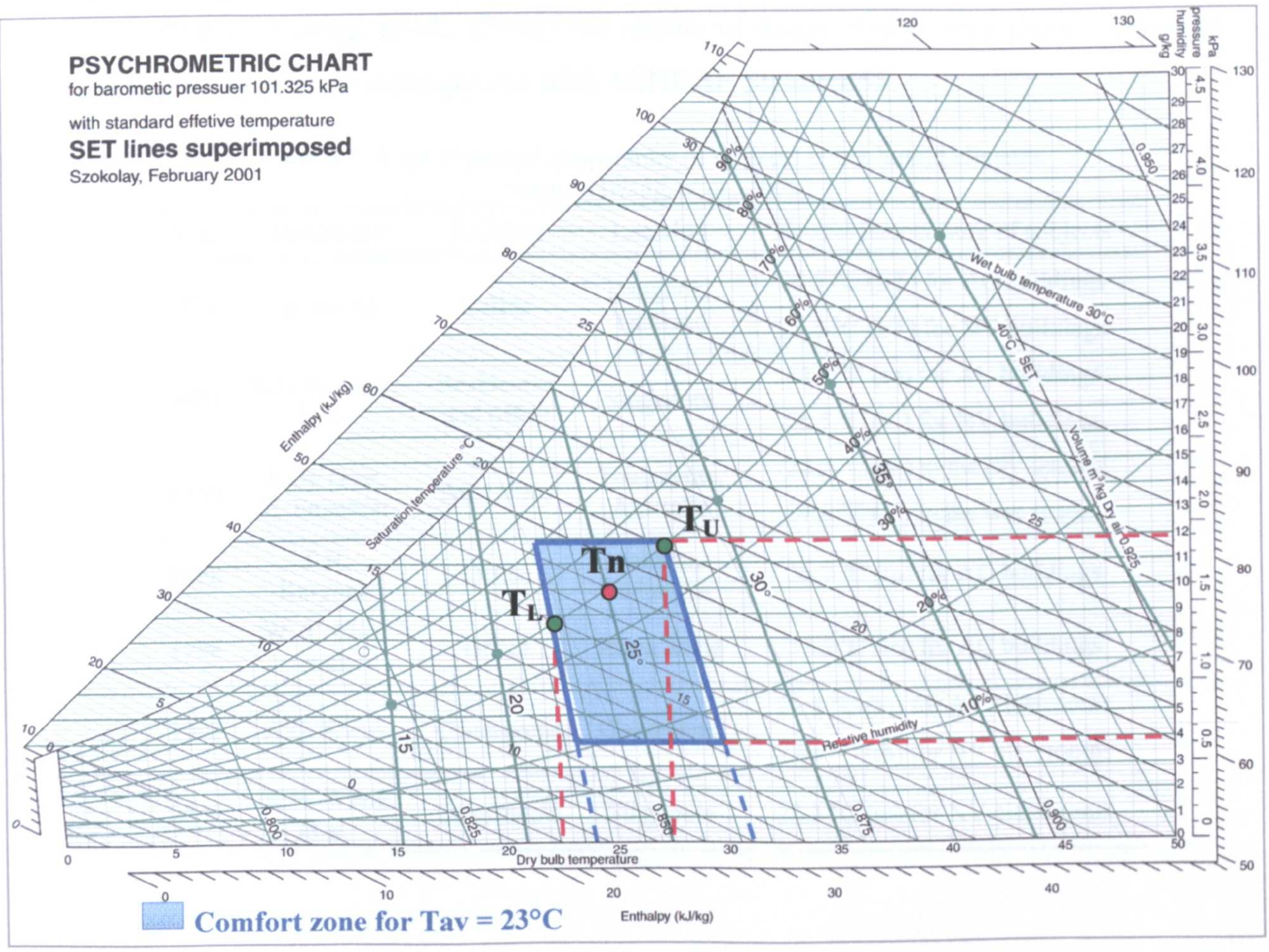


Figure 4.6: Psychrometric chart. Source: Szokolay, 2008

4.4.1 Thermal Comfort In Hot Humid Climate

Many comfort studies have been carried out in different countries with different climate zones and geographical locations. The hot humid climate regions consist of a wide range of topographical and physical features. Thus, the determination of thermal comfort of the people in hot humid climates may vary slightly from place to place. According to Wong, et al., (2003), the first attempt to observe and analyze thermal comfort in hot humid climate was done by Webb in 1949– 1950. In his research, he reported that the effective temperature (ET) for a Singaporean is 25.94 $\pm$ 0.42 °C. Among the earliest researches conducted in hot humid climates also, is the comfort survey by Ellis 1953 on Europeans and Asians subjects in Singapore; focusing on the effect of race, gender, and age on thermal comfort. He concluded that the levels of thermal comfort were similar for acclimatized European and Asian men and women (Wong & Khoo 2003).

There are also several works done by building researchers to determine the thermal comfort conditions in both naturally ventilated and air conditioned buildings located in hot humid regions. For the purpose of reference, a review on various studies is provided in (Wong & Khoo, 2003), (Hwang, et al., 2006), and (Daghigh, et al., 2009). According to Hwang, et al., (2006) the results of many studies like those viewed in (table 4.5) were often incompatible with ASHRAE Standard55.

Table 4.5: A list of neutral temperature of subjects in hot-humid climates
Source: Hwang, et al., 2006

Year	Researcher	Building	Location	Neutral temperature of subjects
1990	J.F. Busch	Office	Bangkok, Thailand	24.5 °C (ET) for AC buildings 28.5 °C (ET) for NV buildings
1991	R.J. De Dear, et al.	Residential and office	Singapore	24.2 °C (to) for AC buildings 28.5 °C (to) for NV buildings
1994	J. De Dear, E. Fountain	AC Office	Townsville, Australia	24.2 °C (to) in the dry season 24.6 °C (to) in the wet season
1998	T.H. Karyono	Office	Jakarta, Indonesia	26.7 °C (to) for AC buildings
1998	W. T. Chan et al.	Office	Hong Kong	23.5 °C (to) for AC buildings
1998	A.G. Kwok	Classrooms	Classrooms	26.8 °C (to) for AC classrooms 27.4 °C (to) for NV classrooms
2003	N.H. Wong et al.	Classrooms	Singapore	28.8 °C (to) for NV classrooms

4.5 BUILDING THERMAL MODELS

Heat transfer in building can occur through heat pathway through its components including; walls, windows, roofs, and floors. A building can be considered as a thermal system, with a series of heat inputs and outputs (see figure 4.7). When the sum of all heat flow terms is zero, thermal balance exists, while when it is greater than zero, the temperature inside the building is increasing, or if it is less than zero, the building is cooling down. The following equation express heat transfer in any buildings:

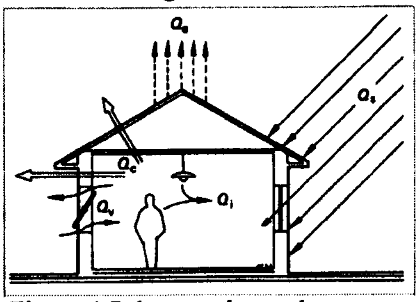


Figure 4.7: heat exchange between a building and its environment, (Szokolay, 1980)

$$Qi + Qc + Qs + Qv + Qe = \Delta S \qquad (4.8)$$

Where: Qi: internal heat gain, Qc: conduction heat gain or loss, Qs: solar heat gain, Qv: ventilation heat gain or loss, Qe: evaporative heat loss, ΔS: a change in heat stored in building.

Modelling the heat transfer through the building envelope is a key starting point in the prediction of the indoor conditions, the thermal comfort, and the energy consumption in a building. There exist numerous modelling methods to analyze and predict buildings thermal performance, varying significantly in both ease of implementation and comprehensiveness. The desirable degree of detail in the analysis of a building depends on the design stage. For instance, in conceptual design or the very early stages of design, a steady-state model is often satisfactory while, for preliminary design more detail is required, taking into account all objectives of thermal design and the specific characteristics of the system considered (Athienitis, et al., 2002). The following is a brief review of the major categories of building thermal models with focus on the characteristics, the benefits, and the limitations of each one.

4.5.1 Steady State

Steady-state thermal analysis techniques calculate the overall building loads using the U-values of the building components. Traditionally designers have relied on this simple steady state concept to estimate peak heating loads for preliminary sizing of heating systems. Such methods can also be used to determine temperatures, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Any changes in parameters such as; solar radiation, internal sources, long-wave radiation exchange, or plant operation are not considered in analysis calculation. Steady-state analysis ignores the dynamic aspect of fabric behaviour as the U-value has no role as a predictor of fabric thermodynamic performance. The approach does not preserve spatial integrity since different constructional arrangements will perform differently even though each may have the same U-value (Clarke, 2001). As a result, these methods are being replaced by dynamic theories and play a diminishing role even at early design stages.

4.5.2 Response Factor

The Response Factor Method was first proposed by Stephenson and Mitalas in 1967 (Underwood, et al., 2004). In this method a series of equations that govern the flow of heat within the building fabric is set up to define the response of each surface to changes in temperature. By solving this series as conditions change, modelling the dynamic response of a building is achieved and hourly heat flows are provided. There are two main approaches of this method:

a. Time-domain response function: It is capable of handling both periodic and non-periodic flux and temperature time-series. For this reason perhaps, this method has enjoyed wider application, especially in North America, than the frequency-domain method (Clarke, 2001). It use recorded hourly weather data as input and calculate hourly internal conditions as output.

b. Frequency-domain response function: The fundamental assumption underlying the frequency domain method is that weather time-series can be represented by a series of periodic cycles. In this way, the weather's influence can be represented by a steady state term accompanied by a number of sine wave harmonics with, in general, increasing frequency and reducing amplitude. Such methods use a number of surface factors for each material that characterize its dynamic response in either domain (Autodesk, 2010).Three separate response factors have been identified: decrement response, surface response, and admittance response.

- *The decrement response factor* which is the ratio of the cyclic flux transmission to the steady state flux transmission and is applied to fluctuations (about the mean) in external temperature or flux impinging on exposed opaque surfaces.

- *Surface response factor* which is the ratio of the heat flux re-admitted from a surface, usually internal, to the total flux absorbed.

- *Admittance response factor* which is the ratio of the energy entering an internal surface to the corresponding temperature swing. It is used to represent enclosure response and give the equivalent swing in temperature about the mean value due to a cyclic heat load on the enclosure (Clarke, 2001).

Another deviation of Response Factor methods is the Admittance Method induced by the UK Chartered Institute of Building Services Engineers. It assumes that all internal and external load fluctuations can be represented by the sum of a steady-state component and a sine wave with a period of 24 hours and by this steady cyclic conditions are achieved (Davies, 2004). The admittance procedures use the admittance of a surface, which is essentially a dynamic U-value, as well as thermal lag and decrement factors, to define the surfaces dynamic response. According to CIBSE 2006, the admittance method does not consider the effects of rapid load changes nor long-term storage. Therefore, it is not suitable for determining the performance of buildings with a large thermal capacity or the effects of rapid changes in load.

4.5.3 Numerical Methods

These methods are characterised by systems that subdivide every material into multiple equidistant layers or surfaces into multiple smaller segments of a 3D grid. The heat flows between each layer of each material over the whole building fabric are calculated in relatively small time increments. Numerical techniques can sort out complicated flow-path interactions and can be used to handle problems of almost any degree of complexity (Clarke, 2001). There are two main approaches of this method; Finite difference and Finite element

Finite difference techniques are adopted in most building energy simulation programmes that are based on numerical methods (Underwood, et al., 2004). While, Finite element methods are more often used in industrial and smaller scale processes (Autodesk, 2010).

In the context of design tools intended to provide an early indication of performance trends, the response function and numerical modelling approaches are equally. Both can handle the dynamic interactions occurring within buildings. However, Numerical methods, with the linearity and invariability assumptions, are largely acceptable in terms of tool purpose (Clarke, 2001). In general, response factors are favoured in the USA and finite differences are favoured in Europe (CIBSE, 1999).

4.6 THERMAL INSULATION

Thermal insulation is the use of a material to reduce the flow of heat. Various materials can be used for the purpose of thermal insulation, but basically there are three main types of insulation effects; resistive, reflective, and capacitive. These three types are clarified below.

4.6.1 Resistive Insulation

Resistive insulation, often referred to as bulk insulation, uses air gaps in the fabric material to resist conduction and convection through the material. The best ones have a fine foam structure, consisting of small closed air cells separated by very thin membranes or bubbles, or consist of fibrous materials with entrapped air between the fibres (Szokolay, 2008). The most often used insulating materials are expanded or extruded plastic foams, such as polystyrene or polyurethane or fibrous materials in the form of batts or blankets, such as mineral wool, glass fibres. Loose cellulose fibres or loose exfoliated vermiculite can be used as cavity fills or poured over a ceiling. Second class insulators include wood wool slabs (wood shavings loosely bonded by cement), wood fibre soft boards and various types of lightweight concrete; either using lightweight aggregate or autoclaved aerated concrete.

Resistive insulation controls the heat flow in both directions; it is particularly important in very cold climates, heated buildings, or in very hot climates, air-conditioned buildings. In naturally ventilated buildings, it is important for elements exposed to solar radiation, such as roofs.

- **Interstitial Condensation**

Condensation occurs whenever moist air is cooled to or comes into contact with a surface below the dew point temperature DPT. The cross-section of an external element, such as a wall, has a temperature gradient between the warm surface inside and the cold surface outside. Vapour will permeate the envelope fabric, driven by the indoor–outdoor vapour pressure difference. When the vapour reaches a layer of temperature at or below the DPT, interstitial condensation will occur within the pores of the material (see figure 4.8).

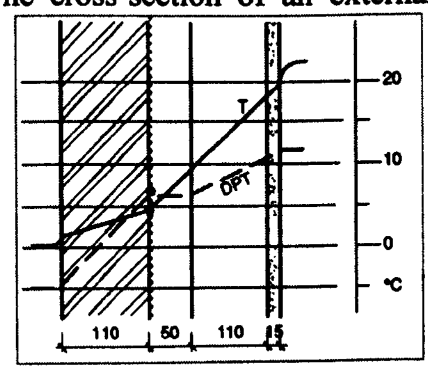


Figure 4.8: interstitial condensation, (Szokolay, 2008)

The interstitial condensation is more difficult to handle than outer surface condensation as it can cause rotting or corroding for thermal insulation and reduce its performance and even it could make the insulation layers saturated and therefore ineffective. The causes of condensation are:

- Increased humidity of the internal air
- Lack of ventilation, which means that the vapour generated stays in the room.
- Inadequate heating and poor insulation can produce very cold inside surface temperatures. According to Clarke (2001), the risk of interstitial condensation is greater in the case of internally located insulation since a portion of the construction may fall below the dew point temperature of moist air permeating through the construction in the absence of an effective vapour barrier.

The following procedures could help avoiding interstitial condensation:

- Place the insulation on the external side of the element, e.g. roof or wall, to ensure that the internal side of the element is around the internal temperature of the heated space.
- Ventilate the cavity on the inside of the outer wall so that the moisture will run down the inner face of the external wall, and not touch the insulation on the outer face of the inner leaf (Roaf, et al, 2007).
- Incorporate polythene vapour barriers or damp proof membranes on the inside of the insulating layer (Harriman, et al, 2009)
- Use a vapour-based breathing construction that is airtight but vapour permeable. In this type of construction, the vapour resistance of the inner layer must be at least five times the vapour resistance of the outer layer, so that any water vapour that condenses within the construction will find its way to the outside (SIG, 2010).
- Control the internal humidity such using passive dehumidification or reducing internal vapour production.
- Integrate adequate ventilation system.

4.6.2 Reflective Insulation

Reflective insulation materials should have high reflectance, such as aluminium foil, to face into a cavity where the heat transfer is primarily radiant. Foil has a low absorptance and an extremely low emissivity and thus radiant heat transfer between the walls of the cavity is much reduced. It affects downward heat flow more than the upward flow as the downward heat transfer is mostly radiant while the upward flow is mainly convective. It will be effective only if it is facing a cavity as it does not itself have low resistance, but it modifies the R-value of the cavity. The best performance is achieved if the double-sided foil is suspended in the middle of a cavity, so that both the high reflectance and low emissivity are utilised (Szokolay, 2008). Its Performance as a reflective insulator is compromised if the face of the foil is in contact with another material as conduction of heat is then allowed. The amount of heat a material can radiate depends on its surface emissivity, i.e. how easily it allows heat to move through its surface, and the temperature difference between its surface and that which it is radiating to. Its thickness is irrelevant (Roaf, et al, 2007). Deterioration in time (e.g. dust deposit) should be considered, so a foil under the roof skin face down is better than one on top of the ceiling face up.

A white and a shiny metal surface may have the same reflectance, but the white would have an emissivity similar to a black body at terrestrial temperatures whilst the emissivity of the shiny metal is practically negligible. Thus if heat dissipation is the aim, a white surface would be preferred. Table 4.6 shows the radiation properties of some materials as examples.

Table 4.6: Radiation properties of some materials, source: Szokolay 2008

	Materials	For 6000°C solar radiation Absorptance & emissivity	Reflectance	At 50°C Absorptance & emissivity
Brick	Brick White, glazed	0.25	0.75	0.95
Roofs	White tiles	0.4	0.6	0.5
	Aluminium, oxidized	0.3	0.8	0.11
	Bright aluminium, chrome, nickel	0.1	0.9	0.05
	Bright (new) aluminium foil			0.03
Paint	White	0.3	0.7	0.92

It can be concluded that in hot climates, to reduce downward heat flow through roof, it is very effective to apply aluminium foil under roof surface facing down relying on its low emissivity. However, if it is applied on top of roof facing up, it will not permit for heat dissipation during the night. So, the top surface of the roof should have high reflectance to reflect solar radiation during the day and at the same time it should have high emissivity to allow for heat escape during the night. In cold climates, the foil is useless in reducing upward heat flow as the heat flow is dominantly convective, unaffected by the foil.

4.6.3 Capacitive Insulation - Thermal Mass

Capacitive insulation, which is often described as thermal mass, is material of a high thermal capacity (i.e. heavyweight construction) affects the magnitude of heat flow and its timing (Davies, 2004). The difference between capacitive insulations and other types of insulations, such as reflective and resistive insulation, is that the later respond to temperature changes instantaneously, while capacitive insulations affect the timing of the heat flows. So in the case of reflective and resistive insulations, as soon as there is a heat input at one face, a heat output on the other side will appear, even though at a controlled rate. Not so with thermal mass as it has a dampening and stabilising effect. The boundaries of heavyweight and a lightweight construction are shown in table 4.7.

Table 4.7: boundaries of heavyweight and a lightweight construction, (Szokolay, 2008)

three boundaries	kg/m^2	two boundaries	kg/m^2
Light	< 150	Light	≤ 250
Medium	150–400		
Heavy	> 400	Heavy	> 250

Thermal mass has a positive effect on occupant comfort. High-mass buildings prohibit high wall temperature variations and sustain a more steady overall thermal environment. This increases comfort, particularly during large air-temperature changes, high solar gain, and in areas with large day-night temperature swings. Common materials used as a thermal mass include adobe, mud, dense concrete, and stones.

4.6.3.1 Mechanism of Thermal Mass

To achieve the best possible results of thermal mass application, general guidelines and appropriate actions that fall within the overall procedure of energy-efficient building should be considered. It is important, though, to understand the mechanism of thermal mass performance in order to achieve the best possible results. Figure (4.9) illustrates outdoor and indoor temperature fluctuations as a result from applying thermal mass. The orange line is the outdoor temperature fluctuation and the green line is the indoor temperature fluctuation. The indoor temperature curve is delayed behind the outdoor temperature curve by some time. This delay of the peak of the green line curve behind the peak of the orange line curve is referred to as the time-lag (φ) measured in hours.

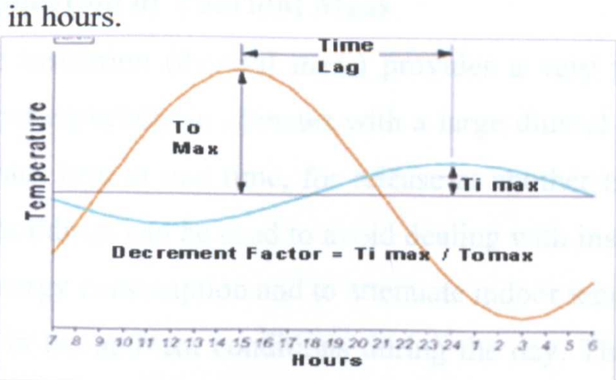


Figure 4.9: Thermal mass introduces time lag and decrement factor, (CLEAR, 2010)

The reduction in cyclical temperature on the inside surface compared to the outside surface is knows and the decrement factor. Thus, a material with a decrement value of 0.3 which experiences a 20 degree diurnal variation in external surface temperature would experience only a 6 degree variation in internal surface temperature.

4.6.3.2 Parameters Influencing Thermal Mass Effectiveness

The rate of heat transfer through building materials and the effectiveness of thermal mass is determined by a number of parameters and conditions. Optimization of thermal-mass levels depends on the thermal characteristics of the building materials, the building and facade orientations, the thermal insulation, the potential ventilation provided and its characteristics, the climatic conditions and use of an auxiliary cooling or heating system, and the occupancy patterns.

Heat is conducted through the solid material of the wall and the rate of the heat flow depends on the conductivity of the material the wall is made of, its thickness, and the difference in temperature between the air on the two different sides of the wall (Roaf, et al, 2007). For the wall material to store heat effectively, it must exhibit a proper density, a high thermal capacity, and a high thermal conductivity value, so that heat may penetrate through all the wall material during the specific time of heat charging and discharging. As a result, a wall with a low value of density, thermal capacity, and conductivity will have a low heat storage capacity, even though it may be quite thick. The admittance of the element, which is the measure of its ability to pick up and release heat from the indoors as the temperature changes, has also a strong influence on thermal mass performance. Further, for multilayer elements, the sequence of these layers with respect to the direction of heat flow affects the time lag and the decrement factor of the element and consequently, affects the performance of thermal mass.

4.6.3.3 The Application of Thermal Mass

Capacitive insulation (thermal mass) provides a very powerful control of the timing of heat input especially in climates with a large diurnal temperature swing as it can store the surplus heat at one time, for release at another time, when it is needed. Thermal mass in buildings can be used to avoid dealing with instantaneous high cooling loads, to reduce energy consumption and to attenuate indoor temperature swings, caused by rapid changes in the ambient conditions during the day. The benefits of capacitive insulation, or mass effect, will be greatest in hot-dry climates, with a large diurnal variation, where the temperature varies over the daily cycle between too high and too cold, where the day's mean is within the comfort zone. Massive construction may provide the full solution, as it may ensure comfortable indoor conditions without any mechanical cooling or night heating.

Santamouris & Asimakopoulos in 1996 proposed that the effectiveness of thermal storage is acceptable where the diurnal variation of ambient temperatures exceeds 10K. Likewise, Szokolay (2008) stated that some sources propose that a mean range (the range between monthly mean maximum and minimum, averaged for the 12 months) of 10K would require massive construction; others put this limit at 8K.

In addition to outdoor condition, Occupancy patterns of buildings should be considered for thermal mass application. The mass effect provided by a heavy construction is beneficial in a continuously occupied building, e.g. house, where it would allow the use of intermittent heating (in cold season) or cooling (in hot season), and still keep a stable temperature. In an intermittently used building, e.g. an office, lightweight insulated construction may be better since massive construction would have a longer heating up or cooling up period in the morning increasing energy load.

- ***Amount and Distribution of Thermal Mass:*** The amount of thermal mass in a building and its distribution in the envelope play an important role in the building thermal performance. Thermal mass must be properly distributed, depending on the orientation of the given surface and the desirable time lag. A surface with north orientation has little need for time lag, since it only exhibits small heat gains. For other orientations; such as east, west, and south orientations, it is desirable to have a very long time lag.

The roof, which is exposed to solar radiation during most hours of the day, would require a very long time lag. However, because heavy roofs will increase the structure dead load and consequently its cost, the use of additional insulation is usually recommended instead (Santamouris, et al., 1996).

4.7 GLAZING MATERIALS

4.7.1 Glazing Properties Related To Heat Transfer

Glazing materials are essential component of any building enclosure, in the form of windows, glass doors, skylights, sunspaces, atria, and even glass walls. Glazing in building envelope has a number of functions including achieving maximum view to the outside, increasing solar heat gain in winter, and providing adequate daylight. Incorporating glazing materials in building components should consider their impacts on all indoor environment conditions, including thermal environment, daylighting effectiveness, acoustic performance, and visual amenity.

Glass is a source of heat gain and heat loss which largely affects the thermal performance of building. Heat gain by solar or short-wave radiation is the main source of heat flow through glazing materials. The ordinary glass transmits a large proportion of the incident radiation where some part reflected and the remainder is absorbed within the body of the glass. The factors influencing solar heat gain through glazing materials are the coefficient of glass absorption, the coefficient of reflection, the coefficient of transmission, and the solar gain factor. While the U- value of the glass affects conduction heat flow through the glazing materials.

4.7.2 Glazing Types

Different parameters affect the thermal performance of windows including their size, position, orientation, glazing type, external shading devices, internal blinds, closing mechanism, and insect screens. Glazing type (single, double, multiple, and special glasses, heat absorbing or heat reflecting glasses) affect significantly conduction and solar heat flow. With the recent vast development in glass manufacture, different properties of glass have been enhanced including thermal, visual, and acoustics characteristics, as well as colour range and appearance. The following is brief review of some types with focus on those types with improvement related to heat transfer.

a. Insulated Glazing: One of the shortcomings of glass is its relatively poor thermal insulating qualities. Multiple panes of glass with air spaces in between improve the insulating value considerably. Relative to all other glazing options, clear single glazing allows the highest transfer of heat while permitting the highest daylight transmission. Double-glazing reduces heat loss by more than 50% in comparison to single glazing (Carmody, et al., 2004). Although U-value is reduced significantly, solar heat gain coefficient (SHGC) for double-glazed unit with clear glass remains relatively high. As expected, adding a third or fourth pane of glass further reduces the U-value of the window, but with diminishing effect. However, there are economic limits to the number of glass panes that can be added to a window assembly.

Another improving to the thermal performance of insulating glazing units involves reducing the conductance of the air space between the layers. This can be achieved by filling the space with a less conductive, more viscous, or slow-moving gas which minimizes the convection currents within the space, reducing conduction through the gas and the overall heat transfer between the interior and exterior.

b. Tinted glazing:

Glass is available in a number of coloured tints, which absorb a portion of the solar heat, reduce glare, and increase visual privacy but retain outward view. Every change in colour affects transmittance, solar heat gain coefficient and reflectivity. Tinted glazing is specially formulated to maximize their absorption across some or the entire solar spectrum and is often referred to as ***heat-absorbing.*** All of the absorbed solar energy is initially transformed into heat within the glass raising the glass temperature. Up to 50% of the absorbed heat may be transferred to the inside via radiation and convection. Thus, comparing with other glazing, there is only a modest reduction in overall solar heat gain. Heat-absorbing glass provides more effective sun control if used as the outer layer of a double pane window.

Tined glazing can decrease glare but it also diminishes the amount of daylight entering the room. To address this problem, glass manufactures have developed high-performance tinted glass that is sometimes referred to as ***spectrally selective***. This glass preferentially transmits the daylight portion of the solar spectrum but absorbs the near-infrared part of sunlight. The spectrally selective glazing has a light blue or light green tint and has a higher visible transmittance values than traditional bronze- or gray-tinted glass, but have lower solar heat gain coefficient.

c. Reflective coatings:

A reflective coating can be used to lower the solar heat gain coefficient by increasing the surface reflectivity of the material. These coatings (in various colours: silver- gold- bronze) usually consist of thin metallic or metal oxide layers and can be applied to clear or tinted glazing. The solar heat gain coefficient can be reduced by varying degrees, depending on the thickness and the reflectivity of the coating, and its location in the glazing system. Figure 4.10 shows solar energy transmission through three types of glass.

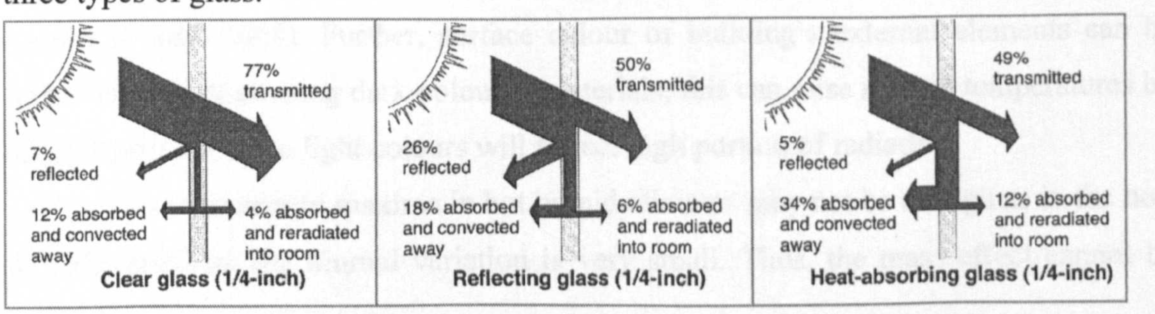


Figure 4.10: Solar energy transmission through three types of glass, (Carmody, 2004)

Several new technologies are emerging that further enhance the properties of windows. These include using various insulating materials between glazing layers to further improve thermal performance. In addition, a range of switchable glazing with dynamically changing properties is under development and has begun to appear in the market.

4.8 SELECTION OF MATERIALS IN HOT HUMID CLIMATE

Two key factors should be considered when materials are selected for buildings in hot climates; availability and performance (Konya, 1980). This implies to use local materials and to conceive along with the extent and the rate of deterioration. The environmental factors are a major influence and have a profound effect on the durability and the behaviour of materials and structure. The effect of weather on materials in hot climates is explained as follows;

1. High temperatures cause rapid deterioration for the surfaces of building elements.
2. High humidity causes moisture-associated breakdown, mould growth and erosion.
3. Maritime conditions enhance the rates of degradation and corrosion of metals
4. High dusty winds have physical effects such as sand erosion.

Fry & Drew (1982) suggested that the selection of materials should consider to resist the damage by insects and to promote conditions of health. Other considerations should include economical factors and the methods of construction. Furthermore, the type of material to be used should be determined by the nature of the spaces in the building (CLEAR, 2010).

In hot humid regions, high solar heat gain drives the need for insulation material. This approach should be applied through careful consideration of the environmental conditions surrounding the building. For instance, whether the roof or walls are shaded or unshaded and if the surrounding buildings reflect heat, will significantly affect the selection of insulation materials. This kind of analysis will determine the heat gains to the surfaces of the envelope and, consequently, the type and the level of insulation needed (Hyde, 2008). Further, surface colour of building's external elements can be significant, such as using dark-coloured materials; this can raise surface temperatures by heat absorption while light colours will reflect high portion of radiation.

The temperature maxima in hot humid climates may not be as high as in the hot-dry climates, but the diurnal variation is very small. Thus, the mass effect cannot be fully relied. According to Szokloay (2008), for daytime rooms (such as living, dining, and kitchen), a heavy construction may ensure indoor temperatures close to the day's minimum. Bedrooms should cool down quickly after sunset, therefore a lightweight construction and cross ventilation would be desirable.

Further, in hot humid regions, the roof receives very strong irradiation causing the mean radiant temperature to increase due to great solar heat input. Therefore, using reflective foil insulation for the underside of the roof skin is recommended to prevent the increase of ceiling temperature and to reduce downward heat flow. However, the top surface of the roof should be reflective to reflect solar radiation during the day and at the same time should have high emissivity to dissipate the heat during night. Achieving those two goals (solar reflection and heat dissipation) could be reached by using a light colour. Some resistive insulation in the roof would help to reduce solar heat gain, but a careful analysis is needed to determine its thickness and type since the increased resistive insulation will reduce night time dissipation of heat.

For walls facing the east and west, they should have few or no windows, to avoid heat input from a low-angle sun, and should be reflective and insulated since the sol-air temperature of these walls could be much higher than the air temperature.

4.9 SUMMARY

Thermal environment has significant effects on humans, especially on their productivity, health, physical and mental energy, and in the most comfortable periods, on improving intellectual, manual and perceptual performance. However, thermal comfort is continuously changing depending on various factors; environmental, personal, and secondary factors. The environmental factors are considered the most significant parameters which influence the comfort condition.

Due to the number of interacting factors affecting human comfort, including personal preferences, the prediction of thermal comfort is not an easy task. There are various models developed by researches to predict thermal comfort. The predicted Mean Vote (PMV) is concluded to be the most comprehensive model for thermal comfort assessment up to date since it is flexible tool includes all the main parameters that affect thermal sensation. However, PMV overestimates thermal sensation in hot climate, particularly in natural ventilated buildings. Because of that, some modifications to the original PMV model have been proposed and tested. The most promising application is the extension of the PMV model in which PMV is multiplied with expectancy factor (e) depending mainly on the duration of the hot weather over the year and the proportion of air-conditioned buildings in the region. The range of acceptable comfort conditions, which is expressed as the comfort zone, is presented with reference to several studies that attempt to determine it with combination of different parameters. It was clear that the comfort zone could not be the same under different location or various conditions.

Thermal behaviour of a building is then described by various types of heat transfers which include heat transfer through building fabric, windows, ventilation and internal gain. In hot climates, the use of insulation in the building envelope is primarily to reduce heat flow in order to lower solar heat gains. The main categories of thermal insulation materials are presented with clarifying of their application and parameters that affect their effectiveness. In addition, thermal characteristics of glazing materials including a number of their types are reviewed followed by explanation of the major aspects that affect the selection of the materials in hot humid climates.

CHAPTER 5

THE STUDIED SHELTERS AND FIELDWORK METHODOLOGY

5.1 INTRODUCTION

This chapter provides a description for the studied shelters, which are the Special Hardship Cases (SHC) shelters, along with an introduction to the SHC programme which has been conducted by the United Nation Relief and Works Agency (UNRWA) for Palestine Refugees in the Near East. A summary of the population and the economic situation of the SHC families is presented followed by analysis for the conditions and the physical aspects of the old shelters. Then, shelters reconstruction programme, which has been promoted by the UNRWA for SHC families, is discussed including; reconstruction scoring system, design criteria, and physical features of the new shelters.

Description of fieldwork procedure and stages are also provided along with highlighting for the flow and the administration of the work. Then, the criteria of selecting case studies for the computer modelling phase are addressed, followed by summarizing of the difficulties in conducting the fieldwork.

5.2 SPECIAL HARDSHIP CASE IN GENERAL

The Agency's Special Hardship Case (SHC) programme was introduced in 1978 to provide a cushion of support to the neediest families among the Palestinian refugee (UNRWA, 2009a). To qualify for aid, refugee families have to meet a number of established criteria, and they must be in economic distress. The majority of SHC families assisted fall within three categories: the elderly (A category), female-headed households (W category) and those unable to work due to chronic illness or disability (M category). The Agency also extends SHC assistance to low-income families headed by, or including; a male adult who is following a full-time course of post-secondary study (E), orphans (O), and families of those who are imprisoned (I). Those who do not fall under any of the previously mentioned categories, but are still in need are eligible under the "Z" category (Hejoj and Badran, 2006; UNRWA, 2007).

Under the SHC programme, eligible refugees receive food, blankets, clothing, small amounts of cash aid, cash grants for self-support projects, and assistance in the repair or reconstruction of shelters. Recently, the UNRWA began a major reform of its SHC Programme (now the Social Safety Net Programme), moving from a status-based approach to a poverty-based approach which uses focused analysis of refugee data to better identify who the poor are and to better determine family specific benefit levels (UNRWA, 2007, 2009a)

5.2.1 Population

Population patterns, such as family composition, age and sex structure are important indicators which, when combined with other social and economic indicators, contribute to a more nuanced picture of the living standard of SHC families.

SHC refugees account for 8.5% and 4.6% of all registered refugees in the Gaza Strip and the West Bank respectively (UNRWA, 2010b). In terms of distribution of SHC population by category (as indicated by Table 5.1), the majority of SHC families fall under the aged "A" category, which represents about one-third of the SHC beneficiaries in the Gaza Strip and one-half of those in the West Bank. In the Gaza strip, the medical category "M" (31.4%) comes the second in order followed by the widowed category "W" (16.9%). However, the percentages of the medical category "M" and widowed category "W" in the west Bank are approximately similar which represent 18.2% and 19% respectively (Hejoj and Badran, 2006).

Table 5.1: Distribution of SHC families by categories, reproduced from (Hejoj and Badran, 2006)

Category	A	E	I	M	O	W	Z	Total
West Bank	50.1	2	3	18.2	1.6	19	6.1	100
Gaza Strip	33.6	7.1	1	31.4	1.6	16.9	8.4	100

The average SHC family size in Gaza Strip (4.71 persons) is higher than non-SHC families, i.e., registered refugees (4.63 persons), where in the West Bank the SHC family size (3.45 persons) is lower than the average for registered refugees (4.57 persons) (ibid). This can be explained by the fact that; the majority of SHC families in the West Bank (50.1 %) are under the aged "A" category and the family size of this category is the lowest among all categories.

For all SHC categories, the male population is less than the female population, with variations across categories. In addition, the percentage of female-headed families among SHC families is almost four times higher than the percentage of female-headed families among the overall registered refugee population (UNRWA, 2009b). The high percentage of female headed families is directly related to the targeting criteria of the SHC programme.

5.2.2 Economy

The majority of SHC families are in hardship by definition and, in general, have low incomes. As indicated by a survey conducted by the UNRWA in 2006, more than

68% of SHC individuals have annual incomes of less than USD 600, with an average annual per capita income of USD 435. Transfer incomes are the major source of income for SHC families with transfers from the UNRWA account for 28.2% and 34.6% of annual income for SHC in the West Bank and the Gaza Strip respectively (Hejoj and Badran, 2006). Other sorts of transfer incomes include; support from family or relatives, transfers from governments, NGOs, and private organizations (see table 5.2).

Table 5.2: Distribution of annual per capita transfer income by source of income, reproduced from (Hejoj and Badran, 2006).

Income source	West Bank	Gaza
Support from family or relatives	37	20.8
Gifts in kind	6.2	5
Retirement pensions	0.7	0.9
Social security entitlements	1.4	0.1
Transfers from Government	18.2	27.9
Transfers from UNRWA	28.2	34.6
Transfers from NGOs	2.5	7.2
Transfers from Private organization	1.7	2.2
Transfers from Other (friend, neighbours, people of goodwill, etc)	3.1	0.9
Other Transfers	1	0.3
Total	100	100

In terms of expenditures, almost all (96.5%) of SHC individuals in Gaza have expenditure levels of less than USD 2 a day and around 70% have expenditure levels of less than USD 1 a day. The median family monthly expenditure is USD 154.7 in the West Bank and USD 109 in Gaza (UNRWA, 2009c). The distribution of the total expenditures by expenditure groups is presented in table 5.3. It reveals that about 47% of total expenditures is spent on food (Hejoj and Badran, 2006).

Table 5.3: Distribution of average monthly expenditures, ibid

	Rent	Electricity	Fuel	Food	Cloths	Education	Health	Transport.	Telecom.	others	Total
WB	2.6	10.4	6.7	45	9.3	6.1	8.5	6.6	1.9	2.8	100
Gaza	1.5	3.7	8.3	48.9	10.5	8.6	6.3	7.9	1.5	2.8	100

5.3 CONDITIONS OF OLD SHC SHELTERS

The SHC shelters in camps are generally crowded. This is due to the limited area of shelters, the shortage of land, and the large family size. However, the limited space and the family size are not the only factors that affect the overall living conditions of SHC families. In addition to these factors, the majority of shelters suffer from an unhealthy indoor environment; such as humidity, poor ventilation, and leakage during winter (Al-khatib, Arafat, and Musmar, 2005). Inadequate ventilation encourages mould and other microorganisms to grow. A survey conducted on 3000 SHC families indicated that about 32 percent of SHC families consider their shelters to be a health hazard

(Hejoj and Badran, 2006). The following two sections describe the physical features and the infrastructural facilities of the old SHC shelters.

5.3.1 Physical Aspects

The main types of SHC shelters which are found in refugee camps are houses and apartments with the majority of SHC families live in houses. The houses are almost attached on one, two, or three sides while apartments are included in detached buildings. The minority of SHC families live in huts and tents. SHC families occupy a limited space, with an average shelter size inside camps of 67 square meters (Al-khatib, Arafat, and Musmar, 2005). Table (5.4) presents the different types of SHC shelters in Palestine. As shown in the table, houses account for the majority of SHC shelters in the camps, while apartments are more found outside camps.

Table 5.4: Percentage of different types of SHC shelters, reproduced from (Hejoj & Badran, 2006)

	Location	Type of shelters				
		Apartment	House	Hut	Tent	Others
West Bank	Inside Camp	21.02	76.85	1.9	-	0.26
	Outside Camp	25.64	72.44	1.7	0.08	0.19
	Total	23.69	74.3	1.8	0.05	0.22
Gaza Strip	Inside Camp	11.7	80.92	7.4	-	-
	Outside Camp	30.79	59.92	9.1	0.18	-
	Total	20.95	70.74	8.2	0.09	-

The most common types of construction materials of SHC shelters are cement blocks for walls while the roofs are mostly asbestos, corrugated iron, or combination of them. Concrete slaps are found in few shelters as roofing materials for particular spaces (mostly for kitchens and bathrooms) in order to arrange the solar hot water panels on the top of them.

5.3.2 Infrastructure Facilities

Most SHC shelters in camps (99.8% of the shelters) benefit from access to drinking water that is piped directly into their shelters (UNRWA, 2010c). Also, almost all SHC families have access to electricity which is used primarily for lighting and appliances, but not for heating or cooking. In terms of heating in winter, Hejoj and Badran (2006) stated that almost 1 in 4 SHC shelters in the UNRWA's five fields of operation have no heating at all. However, it is worth to mention that, only parts of the shelters are kept warm in winter because the heating devices used are 'spot-specific' devices which warm only the immediate location around them. Therefore, family members have to cluster around the heating device to keep warm.

Nearly all shelters have independent kitchens and toilet facilities inside the shelter with about 87% of shelters connected to underground sewerage system (UNRWA, 2010c). Overall, the vast majority of refugee shelters have access to the essential amenities which is explained by services provided to the camps by the UNRWA. Although of the availability of the main infrastructure facilities, the indoor environment is not always comfortable and most of the shelters in the camps are unhealthy (Farah, 2000).

5.4 RECONSTRUCTION OF SHC SHELTERS

Based on the UNRWA reports, it was estimated that 25 % of shelters inhabited by SHCs are in need of rehabilitation (UNRWA, 1999, 2003). In their research paper, Al-khatib, Arafat and Musmar (2005) found that almost one-half of SHC shelters are substandard and inadequate to live in, and that most are certainly in need of restructuring to make them properly serviceable. According to a survey conducted by the UNRWA on 2006, more than one-third of SHC families in the five fields reported that all or part of their dwellings suffer from some sort of a structural defect and 42.5 % indicated that their shelters are in need of rehabilitation.

In order to improve refugees' living conditions in camps, the UNRWA had been promoting the Peace Implementation Programme (PIP). The primary objectives of this programme, as indicated in the UNRWA annual reports from 1994 to 2004 , was to effect the following changes: (1) rehabilitation of existing shelters, (2) providing better social and physical infrastructure, (3) creating employment opportunities and (4) supporting the needy and hardship cases. All funding received under PIP was earmarked by donors for specific projects to be undertaken by the UNRWA. Responding to the appalling shelter situation, the UNRWA identified the need for a programme of shelter rehabilitation. In 1993 and under PIP, the UNRWA established shelter rehabilitation department and started to construct shelters for SHC families whose original shelters had become dilapidated. The quality of the shelters constructed by the Agency under this programme is better than those constructed in 1950s. According to a technical scoring system adopted by the UNRWA, SHC shelters which did not meet specific criteria have been classified for repair or reconstruction. More cases have been added to the list of SHC because of the natural growth rate and the poor economic conditions. The focus of this study is on the SHC shelters that are entirely reconstructed by the UNRWA (i.e., repaired shelters are out of the scope). The following section deals with the reconstructed shelters (which are referred as new shelters) including the reconstruction scoring system and the design criteria in addition to description in details for the physical aspects of these shelters. Table (5.5) presents statistical information for SHC shelters reconstructed in refugee camps in different area of the Gaza strip since 2000

Table 5.5: General statistics for SHC shelters reconstructed in the Gaza Strip since 2000, (source: survey 2009)

<table>
<tr><th>Year</th><th>Area</th><th>No. of Families</th><th>Total no. of families</th><th>Donors</th><th>Budget ($)</th><th>Status</th></tr>
<tr><td rowspan="4">2000</td><td>North Area</td><td>38</td><td rowspan="4">142</td><td rowspan="4">Saudi</td><td rowspan="4">1,500,000.0</td><td rowspan="18">Completed</td></tr>
<tr><td>Middle Area</td><td>43</td></tr>
<tr><td>KhanYounis</td><td>30</td></tr>
<tr><td>Rafah</td><td>31</td></tr>
<tr><td rowspan="4">2001</td><td>North Area</td><td>42</td><td rowspan="4">127</td><td rowspan="4">USAID, 2nd Appeal, 3rd Appeal</td><td rowspan="4">269,835.0</td></tr>
<tr><td>Middle Area</td><td>47</td></tr>
<tr><td>KhanYounis</td><td>16</td></tr>
<tr><td>Rafah</td><td>22</td></tr>
<tr><td rowspan="4">2002</td><td>North Area</td><td>94</td><td rowspan="4">272</td><td rowspan="4">ECHO, 2nd Appeal, Irish, 3rd Appeal, 4th Appeal</td><td rowspan="4">2,215,298.0</td></tr>
<tr><td>Middle Area</td><td>79</td></tr>
<tr><td>KhanYounis</td><td>43</td></tr>
<tr><td>Rafah</td><td>56</td></tr>
<tr><td rowspan="3">2003</td><td>North Area</td><td>31</td><td rowspan="3">68</td><td rowspan="3">General fund, Belgium</td><td rowspan="3">584,855.0</td></tr>
<tr><td>KhanYounis</td><td>19</td></tr>
<tr><td>Rafah</td><td>18</td></tr>
<tr><td rowspan="4">2005</td><td>North Area</td><td>12</td><td rowspan="4">41</td><td rowspan="4">Belgium</td><td rowspan="4">643,660.0</td></tr>
<tr><td>Middle Area</td><td>16</td></tr>
<tr><td>KhanYounis</td><td>7</td></tr>
<tr><td>Rafah</td><td>6</td></tr>
<tr><td>2007</td><td>North Area</td><td>19</td><td>19</td><td>Saudi</td><td>861,503.0</td></tr>
<tr><td rowspan="4">2008</td><td>North Area</td><td>81</td><td rowspan="4">287</td><td rowspan="4">Japanese, Saudi</td><td rowspan="4">5,500,000.0</td><td rowspan="4">On-going</td></tr>
<tr><td>Middle Area</td><td>89</td></tr>
<tr><td>KhanYounis</td><td>56</td></tr>
<tr><td>Rafah</td><td>61</td></tr>
</table>

During the reconstruction process, the UNRWA rents houses for the families until the construction is completed. As it is obvious in the table above, reconstruction which started in 2008 are not completed yet because the basic materials used in construction, such as cement, wood, iron and others are totally banned from shipments to the Gaza Strip since the commencement of the blockade in 2007. Therefore those families whose shelters are not finished yet are still staying in rented houses and the UNRWA still pay the rent for them.

5.4.1 Reconstruction Scoring System

The shelter problems of the Special Hardship Cases in Palestinian refugee camps range from substandard to hazardous conditions, in particular, structurally unstable walls, inadequate ventilation, or limited space. The UNRWA had applied a rehabilitation scoring system in order to ascertain the SHC shelters which in need for reconstruction or repair. Social workers stuff in the UNRWA had the task to fill in a scoring sheet (for every SHC shelter) which consisted of three sections; (1) shelter condition, (2) type of shelter, and (3) number of rooms occupied relative to family size.

In shelter condition section; rooms, sanitary facilities and kitchen should be scored according to three scales (Non-existing, Structurally unsafe, or Unhygienic) with every point has different maximum score. Types of shelter have to be scored also in the second section according to five types which are Straw and mud, Zinc sheet, Wooden shelter, Cement brick shelter with Eternit sheet roofing, and Concrete house. The highest maximum score is for straw types and the lowest maximum score is for concrete house. In the third section of the scoring sheet, number of rooms relative to family size has to be scored with the highest maximum score for the most crowded shelter. For more details, see a copy of the shelter rehabilitation scoring sheet in Appendix (A).

Recently, the UNRWA applied a socio-economic and technical evaluation form which has been developed by the Engineering and Construction Service Department. This new scoring system is divided into two parts; ***Socio-economic Evaluation*** which has to be filled by the social worker and ***Technical Evaluation*** to be filled by the engineer. The *Social Evaluation* comprises aspects related to family size, members of family with disability or chronic disease, and social problems such as harassment, violence, dispute with neighbour, and separation. The *Economic Evaluation* deals with the financial status of the family and includes questions about the household's education degree, the property ownership and the income.

The *Technical Evaluation* comprises aspects related to the shelter itself such as its structure, amenities, dampness, hazards, and indoor conditions. The structural system as a whole has to be evaluated according to four scales (Collapsing, Very week, Week and Stable). In addition, structure defects in walls and roofs, such as cracks and deflection, have to be scored. Dampness indications are required to be determined in the evaluation form, and hazards which need immediate repair such as electric wires and severe flood are to be indicated by the engineer. The quality of ventilation and daylight in every space and in the shelter as a whole are rated into four grades (Good, Acceptable, Week, and Very week). For more details, see a copy of the socio-economic and technical evaluation sheet in Appendix (A).

5.4.2 Design Criteria

The objective of the shelter reconstruction program conducted by the UNRWA is to ensure that shelters meet the minimum requirements of the space, the health conditions, and the needs of the family (UNRWA, 1999). The UNRWA has reconstructed SHC shelters according to criteria, which have been developed by a team of architects and engineers to comply with international standard housing criteria, and in view of the UNRWA experience in the field of shelter rehabilitation in order to have adequate shelter provision (UNRWA, 2010). This shelter was defined as follows:

a) Structurally and environmentally safe.
b) No overcrowdiness.
c) Connected to basic infrastructure (drinking water, water network, electricity, and sewage network)
d) Provided with sanitary facilities, kitchen and toilet.
e) Properly lit and ventilated.
f) Has a suitable access.

The dwelling unit comprises a kitchen, a sanitary unit (shower and toilet) and bedrooms. The number of bedrooms and hence the built-up area depends on the size of the benefiting family. Table (5.6) presents guidelines for dwelling unit intervention and built up areas for various family sizes.

Table 5.6 : SHC dwelling unit intervention and built up area, source: survey 2009

Family Size	Dwelling unit intervention	Built-up Area(m2)
1-2	1 Bedroom + Kitchen + Bathroom	42
3-4	2 Bedrooms + Kitchen + Bathroom	60
5-7	3 Bedrooms + Kitchen + Bathroom	101
8 and above	4 Bedrooms + Kitchen + Bathroom + Toilet	124

One bedroom is added to a single parent living within the family. Individual room sizes may vary at the request of the benefiting family subject to staying with the total net area for the individual dwelling unit. The shelter should be restricted to a single storey construction except in cases where the plot area is smaller than the allowed built-up area. If a SHC family wish allowing a provision within the shelter area for a future staircase, then it could be provided. This allowance should always include sufficient space for an internal staircase and any required future structural alteration. Provision of actual staircases would only be included in shelters which have to be two storeys due to plot restriction. The space of the staircase would still be part of the overall entitlements.

By reviewing the above design criteria and the technical norms and guidelines for shelter reconstruction, it is obvious that they clearly focus on shelter`s area with its appropriation to family size while do not entail any technical details for indoor conditions, climatic issues, or energy conservation in such shelters. Even the quality of ventilation and light which is mentioned above as one of design criteria, it is applied by only ensuring that every space in the shelter is provided with a window opening to outside as it was stated by the UNRWA`s staff in the Design Department.

5.4.3 Description of New SHC Shelters

5.4.3.1 Site layout

The new shelters are constructed on the same plots of the old shelters; however the layouts of the new shelters almost differ from the old ones. The old shelters are almost attached with neighbouring buildings on more than one side as their windows may open to internal halls or courtyards. However, the new shelters are designed in such a way to make all spaces have windows opening to outside, consequently they are less attached with surrounding buildings. Since the plot area is almost small, the paths around the new shelter are almost narrow (in some cases only a 0.6 meter wide). Figure (5.1) shows an example of the layout of a shelter before and after reconstruction by the UNRWA.

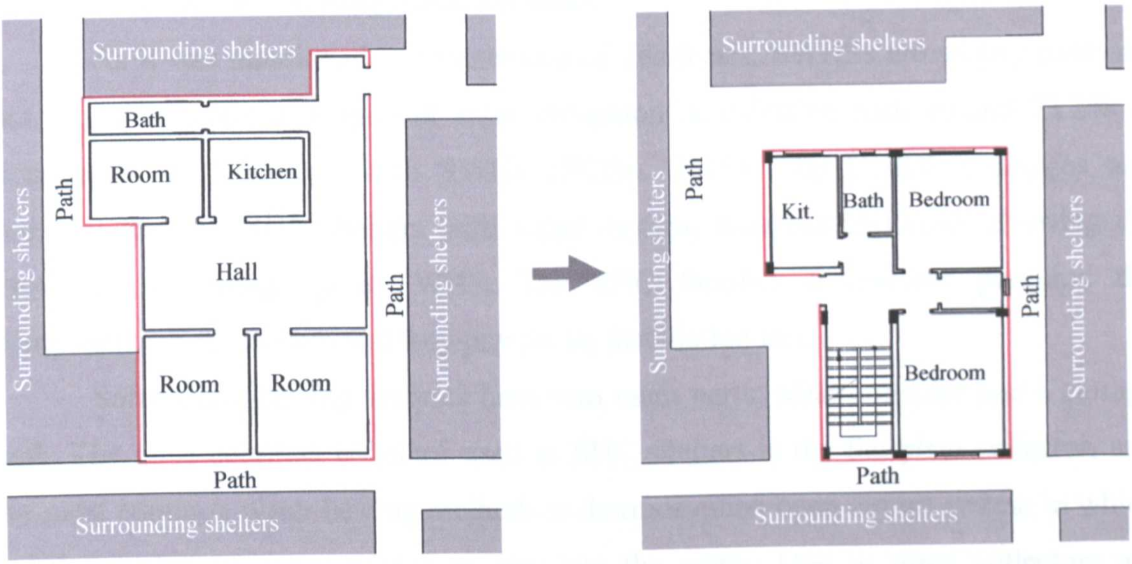


Figure 5.1: Site layout of a SHC shelter before and after reconstruction, survey 2009

5.4.3.2 Spaces arrangement

The new shelters mainly consist of one to four bedrooms, kitchen, and bathroom with closet. No separate guest room or living room is included. The entrance almost leads to a small hall or a corridor which directs to rooms arranged on one or two side depending on the dimensions of the plot area. If the shelter is composed of two storeys (where plot area is smaller than the entitled built-up area), the stair is located close to the entrance followed by the kitchen and some of the bedrooms. The rest of bedrooms are placed in the first floor, while bathrooms and toilets are located either in ground or first floors in accordance with the plot area.

5.4.3.3 Structure and envelope

All new SHC shelters are skeleton constructions which comprise reinforced concrete columns bear flat reinforced hollow concrete slaps. The external walls are

20cm hollow concrete block covered with two layers of external rendering followed with white painting (Bonderol and Supercryl) as exterior finishing. Floors are terrazzo and ceramic tiles (ceramic tiles in the bathrooms and the toilets while terrazzo tiles for the other spaces) installed over a 50 mm sand layer which placed on the concrete slap. On the other hand, roofs are reinforced hollow concrete slaps left without any insulation or finishing. The internal partitions are 10cm hollow concrete blocks finished with internal cement plaster and in some cases followed by white water-based painting.

Windows are hinged single-glazing with wooden frames and wooden louvered exterior shutters. The shelters which reconstructed recently, have sliding single-glazing windows with aluminium frames. In addition, glazing louvered windows are used for stair cases and bathrooms.

5.4.3.4 Solar Water Heating System SWHS

As it was mentioned in chapter one of this thesis, SWHSs are widely used and are the most common feature of solar utilisation in Palestine with around 73.2% of households are equipped with SWHS (PCBS, 2010). The UNRWA designs and provides the new SHC shelters with water system, both hot and cold, allowing the provision of setting up a SWHS. The SHC families themselves purchase the components of the system and they pay for its installation too.

Solar water-heating systems have two main parts; solar collector and a storage tank. The most common collector used in SHC shelters is the flat-plate collector, and the most common water heating methods is thermosyphon open circuit system in which no electrical pumps are needed to circulate the water. One to three collectors are generally used and a hot water storage tank with a capacity of 150-200 litres is almost utilised. All the components of this system are always mounted on the shelters' roofs and the cold water supply tanks are located generally above the hot water storage.

The hot water provided by SWHSs which are fitted in the SHC shelters is used only for bathing and washing purposes and not used for heating spaces.

5.5 FIELDWORK METHODOLOGY

As it was mentioned in chapter one of this thesis, a combination of techniques were utilized in this study to achieve research objectives including observations, interviews, questionnaires, and computer model. These methods have been chosen to suit the different aspects of the research. Field survey was practiced as a main tool to examine the indoor environment conditions; with focus on thermal comfort, and to assess the occupants' satisfaction in the SHC shelters. In addition, different types of interviews are carried out with UNRWA officials and key figures to gain deeper insights into the SHC programmes promoted by the UNRWA. Furthermore, fieldwork was conducted on the SHC shelters (both the old and the new shelters) to gather data related to their locations, surroundings, layouts, and construction materials. These data are essential for the computer model. The following sections present fieldwork methods and strategies and explain its administration and procedures.

5.5.1 Fieldwork Secondary Data

Secondary data related to the studied shelters are gathered from the UNRWA offices in the Gaza Strip. These data include project documents, reports of UNRWA, SHC general statistics, lists of SHC families, and the criteria of the SHC reconstruction programme. Informal and semi structure interviews are carried out with key figures in the UNRWA who through their position or role know a lot about the SHC shelters rehabilitation programme which developed by the Agency. Interviews techniques are particularly useful for getting the story behind a participant`s experiences and to pursue in-depth information around the topic (Haigh, 2008). The interviews provide a reasonable and efficient means of exploring the SHC shelters reconstruction features and the aspects which related to their scoring system and design concept.

5.5.2 Sampling

Since it would be impractical to collect data from the entire population being studied, it is necessary to pick a sample to represent that population (Hoxley, 2008). The first step to select a sample is to define the population. It was clarified earlier in chapter two of this thesis that; there are 29 recognised refugee camps in Palestine, 21 camps in the West Bank and 8 camps in the Gaza Strip. Besides, climatic conditions of Palestine vary widely from one place to another and are divided into four climatic zones; the coastal plain, the hilly areas, the Jordan valley, and the southern desert. This study focuses on the hot humid climate (i.e. the coastal plain) which indicates that the population of the survey is the SHC shelters in refugee camps located in the Gaza Strip.

Since all camps in Gaza strip are similar, the criteria of the SHC programme are applied on SHC shelters on all refugee camps, and this study has a short limited time, the survey was conducted on SHC shelters located in one camp. The selected camp is called Jablia camp, where the author of this thesis had lived. Jablia camp is located in the north of Gaza Strip and it is the largest of the Gaza Strip's refugee camps which covers an area of about 1.4 square kilometres. Overcrowding is a key concern for its residents, with approximately 108,000 registered refugees live in the camp (UNRWA, 2010).

Two groups of SHC shelters were investigated; SHC shelters reconstructed by the UNRWA (which are referred to as new shelters) and SHC shelters which are not reconstructed yet (which are referred to as old shelters). Studying the two groups of shelters, old and new, was to help assessing the value of the improvement that has already taken place by the UNRWA and to bring greater comprehension of indoor conditions that still needs more enhancements. The occupants of new shelters generally apply changes and extensions to their shelters consistent with their needs and families growth. For this reason, the most recent reconstructed shelters were selected for the investigation in order to get shelters with the fewest changes. 204 SHC families (94 of them live in new shelters and 110 live in old shelters) were surveyed with a response rate of about 74%.

5.6 FIELDWORK PROCEDURES

Face-to-face questionnaires were practiced as a main tool to examine the indoor environment conditions in SHC shelters. Data related to shelters` locations, their surroundings, and construction materials are gathered through the fieldwork. In addition, the physical dimensions for the SHC shelters were taken in the field to get scaled drawings for the shelters` sites and layouts; which are crucial input data for the computer model. A clear determination for the tasks, the sequence of procedures, and the survey materials was essential in order to carry out the fieldwork with the least effort and on the determined time. The importance of the timing in this survey is vital due to the fact that this survey is concerned with indoor conditions and human comfort in both summer and winter. Therefore, this survey had to be conducted once during spring or autumn period in order to avoid extreme seasons` effects. The fieldwork was conducted on three stages discussed below (see figure 5.2):

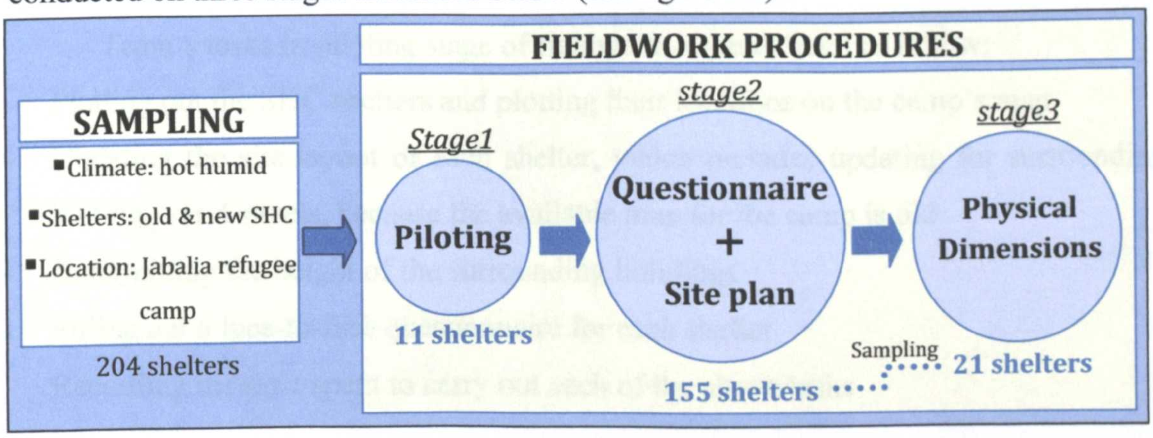


Figure 5.2: Fieldwork procedures

5.6.1 Fieldwork Stage one - Piloting

Designing, organizing, and conducting a questionnaire survey is not an easy task, so it requires good preparation. Two questionnaires are designed, one for the old shelters and another for the new shelters. The questionnaires are designed to evaluate the indoor environment with focus on the thermal environment; and are utilized to gather information about the materials of shelters` envelope which is used later as variables to select cases for thermal simulation. Face-to-face questionnaires types were applied in this study for purposive aspects which are explained later in chapter 6. Each questionnaire is a six-page long comprising six sections with total of 77 and 78 questions for new and old shelters respectively.

Hoxley (2008) stated that "piloting is absolutely vital to the success of a questionnaire study". The goal of piloting is to test the questionnaire as a whole under real survey conditions in order to assure the smooth coordination of procedures and to establish correct survey routines (Campanelli, 2008). It also allows the researcher to get an estimate of first contact response rates and to check timings of the length of the questionnaire.

Fieldwork survey started at the beginning of November 2009, after few months of Gaza War and under difficult conditions, while there was a blockade on the Gaza strip. The author of this thesis, like other people, was not allowed to enter Gaza Strip and consequently had to carry all the survey while being in the UK. Therefore, a clear determination for the tasks, the sequence of procedures, and the survey materials was essential in order to counteract these hard circumstances. A team of three architects (two male and one female) who are resident in Jabalia, was chosen for the survey. In addition, the researcher`s two brothers (one is an assistant professor in civil engineering and the other is a graduate in business administration), who both also live in Jabalia, have assisted in the survey procedures.

5.6.1.1 Fieldwork Tasks

Team`s tasks in piloting stage of fieldwork, were defined as follow:

- Finding out the SHC shelters and plotting their locations on the camp`s map
- Updating the site layout of each shelter, which includes updating for surrounding buildings and streets, because the available map for the camp is old
- Determining the height of the surrounding buildings
- Filling out a face-to-face questionnaire for each shelter
- Recording the time spent to carry out each of the above tasks

- Keeping notes related to the questionnaire itself such as; whether any question is not understandable or unclear to respondents.
- Keeping notes related to respondents` interest and attention in participating.
- keeping notes related to any difficulties during fieldwork
- After conducting field tasks, scanning the filled questionnaires and the camp`s map which includes the shelters` locations and the surrounding buildings` heights. Then emailing these copies to the researcher

A copy of each questionnaire and the above tasks were sent to surveyors for reading and noting down, and then discussed with them.

5.6.1.2 Survey Materials

The necessary materials for this stage of fieldwork were prepared, and handed to the survey team. Survey materials consisted of the following:

a. A list of ten old shelters and a list of eight new SHC shelters included the shelters` addresses and households` names
b. Hard copies of Jabalia camp`s map
c. Hard copies of the questionnaires
d. Photo ID name badges for surveyors to be worn during the survey

SHC families` names and addresses are hardly gathered from different departments at the UNRWA offices in Gaza and Jabalia camp. These data were then filtered and organized in tables comprising shelter`s ID number, household`s name, address, status, date, and notes, allowing for well administration of the field survey. However, the available addresses comprised only the house number and the block number. Therefore, the shelters were arranged in the lists in accordance with the block number in order to save the time spent in locating the shelters in the refugee camp during survey.

5.6.1.3 Piloting Results

There was continuous contact between the researcher and survey team during field survey in order to solve any unexpected troubles. After receiving the filled questionnaires, the updated camp`s map, and the surveying notes, the researcher contacted each surveyor and discussed the consequences and the difficulties encountered through the survey. Throughout Piloting stage, eleven questionnaires were filled (five for old shelters and six for new shelters) with an average of forty minutes were spent in answering each questionnaire. The longest time was spent to find out the shelters` locations inside the block with an average of one hour to locate a single shelter.

There was no problem with the questionnaires, while the major obstacles during field survey were the families` names and the shelters` locations; more details about these difficulties are presented later in (section 5.7). According to the findings of the Pilot stage, SHC families list was adjusted and new instructions were identified to be considered through fieldwork.

5.6.2 Fieldwork Stage two- Questionnaires and Site Plan

Survey tasks at this stage included the first four tasks in Piloting stage which were; locating the SHC shelters, updating the site layout, determining the buildings` heights, and filling the questionnaires. Besides, every surveyor was asked to send the researcher a daily report indicating which shelters in the list were successfully surveyed and which shelters were not, with an explanation of the circumstances. Besides, a daily contact between the researcher and the survey team took place through all the period of the survey.

To start fieldwork *stage two*, the survey team was provided with a modified families list and hard copies of the questionnaires. However, prior to commencing this stage of survey and relying on the outcomes of the Pilot stage; new survey instructions were identified to be considered throughout the fieldwork process and discussed with the survey team. Examples of these instructions are below:

- In case of new shelters, surveyor should be sure, by asking the occupants, that the shelters were completely reconstructed by the UNRWA (i.e. not repaired nor partially reconstructed) because the SHC families` lists gathered from the UNRWA offices were proved to be not entirely accurate.
- Respondents should have been occupying the shelters for enough period of time; at least a summer and a winter seasons, to be entitled to answer the questionnaires.

It is worth to mention that this stage of field survey was conducted in autumn and lasted from November to the mid of December 2009. All the survey visits were carried out between 9:30am and 4:00pm in the weekdays which are from Saturday to Thursday in the studied location. There are two reasons to carry out the survey during these hours of the day. The first reason is that the occupants are used to be visited by surveyors and social workers from the UNRWA or any other governmental or non-governmental organizations during the official working hours. If visits are conducted out of these hours, the families may mistrust the surveyors and consequently may refuse to answer the questionnaires. Besides, as mentioned earlier, one of survey team duties was to plot each shelter on the camp`s map which required the surveyors to ask the stores keepers in the area or the local people about the SHC family until reaching the shelter. According to the Palestinian society culture and the political situation in the region, this sort of duty is better to be done during the official working hours in the weekdays to avoid any suspicion from the community. The second reason is that most of SHC households are not working and are almost available at their shelters during the day, and this is related to the fact that the vast majority of SHC families fall under the aged "A", the medical "M", and the widowed "W" categories.

5.6.2.1 Survey Outcomes

At this stage of fieldwork, 155 SHC families were successfully surveyed and their shelters were located along with; the heights of the surrounding buildings and the updating for the sites layouts. These collected data were then sorted out as two AutoCAD drawings; one for the new shelters and the other for the old shelters (see figures 5.3 and 5.4 of these drawings).

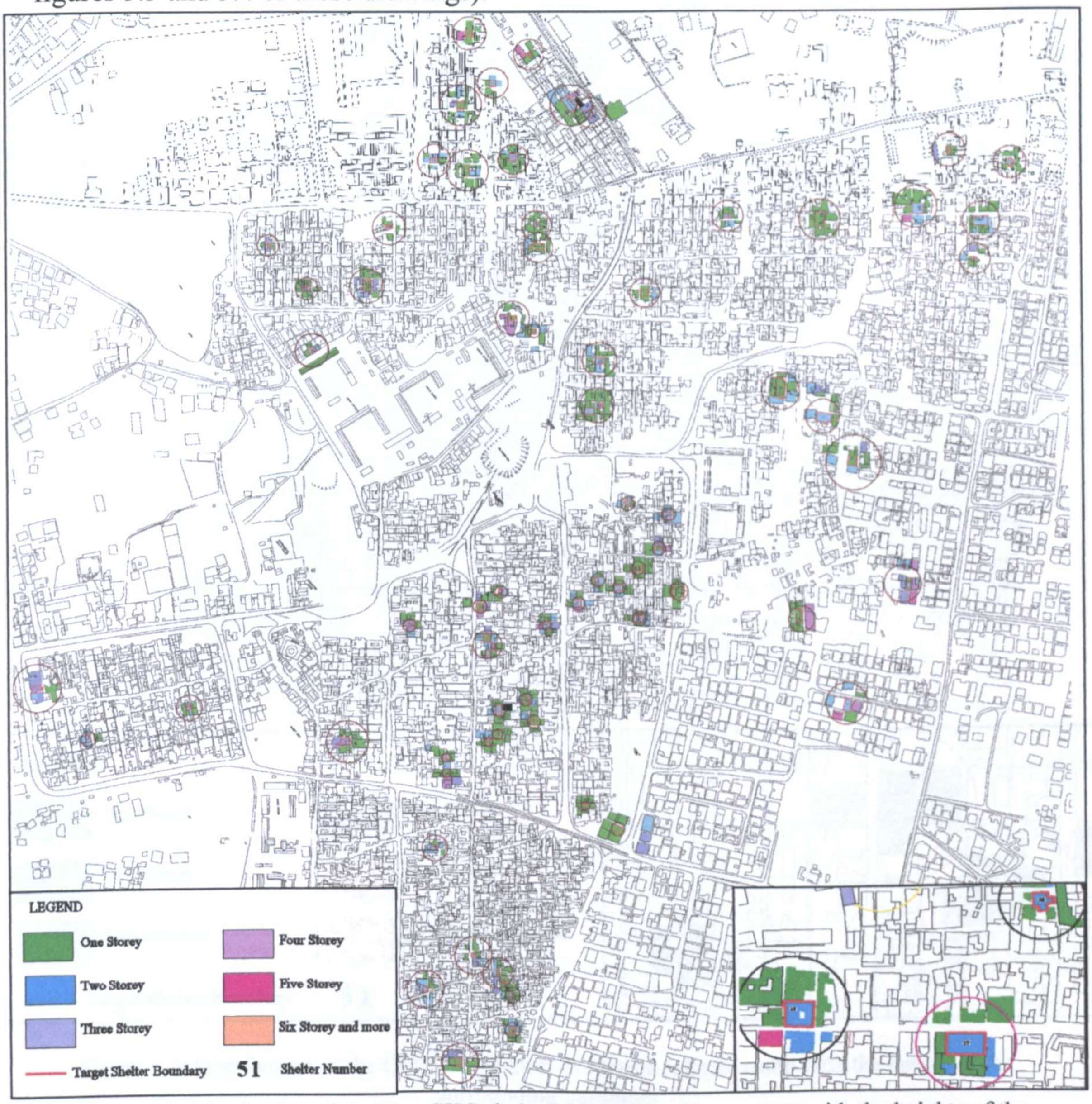


Figure 5.3: Distribution of the New SHC shelters in Jabalia refugee camp with the heights of the surrounding buildings

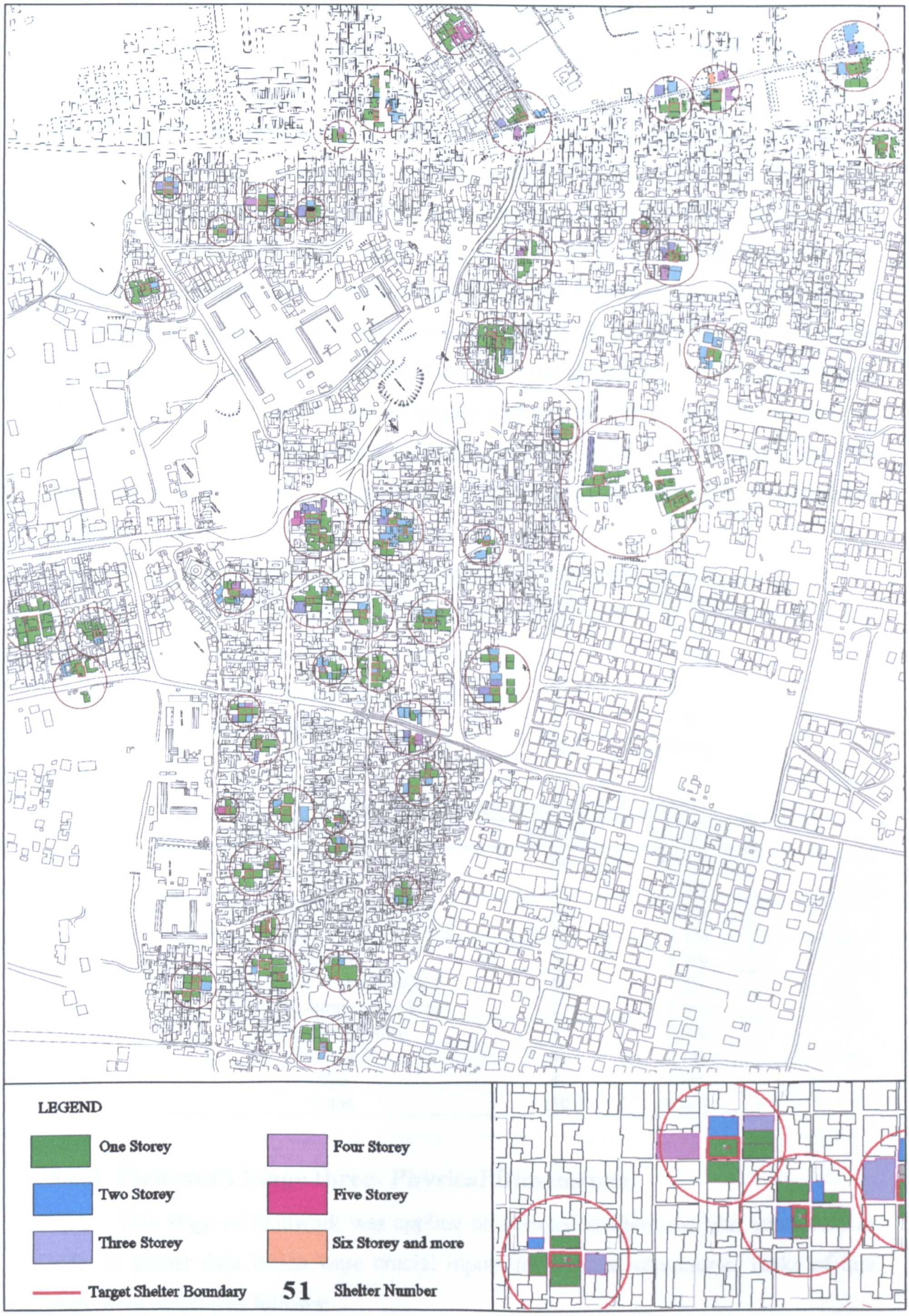


Figure 5.4: Distribution of the Old SHC shelters in Jabalia refugee camp with the height of the surrounding buildings

Out of 204 families surveyed, 155 questionnaires were successfully filled (70 questionnaires for old SHC shelters and 85 questionnaires for new SHC shelters). The average response rate was 74%, where it was higher in the case of the new shelters (90.4%) than in the old shelters (63.6%) as it is indicated in tables (5.7 and 5.8). For new shelters, just one case refused to respond, two shelters were empty, data of one shelter was incorrect, and five SHC families were included in the filled questionnaires. In the case of old shelters, 22 cases were not entitled to fill the questionnaire as 6 shelters were reconstructed by the families themselves, 8 shelters were reconstructed by the UNRWA, and another 8 shelters were demolished by the UNRWA in order to be built (These cases should not be categorized in the old shelter lists which gathered from the UNRWA offices revealing that no regular updating for SHC data in the Agency). In addition, four shelters were failed to be located, five shelters were empty, and two shelters were destroyed during Gaza War. On the other hand, two households refused to respond.

Table 5.7: Results of field survey of the new SHC shelters

New SHC Shelters Survey	Number	Percentage
Filled	**85**	**90.4%**
Empty	2	2.1%
Refuse	1	1.1%
Wrong Data	1	1.1%
Included	5	5.3%
Total	**94**	**100%**

Table 5.8: Results of field survey of the old SHC shelters

Old SHC Shelters Survey	Number	Percentage
Filled	**70**	**63.6%**
Refuse	2	1.8%
Reconstructed by families	6	5.5%
Reconstructed by the UNRWA	8	7.3%
Empty	5	4.5%
Demolished by the UNRWA	8	7.3%
Destroyed during Gaza War	2	1.8%
Occupant disability	1	0.9%
Not found	4	3.6%
Other	4	3.6%
Total	**110**	**100%**

5.6.3 Fieldwork Stage three- Physical Dimensions

This stage of fieldwork was applied on selected shelters and was conducted in order to gather data which were crucial inputs for thermal simulation. Tasks of this stage were defined as follows:

a- Taking the essential physical dimensions for the shelters in order to draw a scaled site plan for each shelter which indicates the streets around the shelter and the surrounding buildings.
b- Taking the essential physical dimensions for the shelters in order to get scaled drawings for the floor plans, the sections and the elevations of each shelter
c- Identifying the materials of the walls, the roofs, and the floors and the type of the windows in each shelter.
d- Finding out any equipment used in each space such as TV, refrigerator, cooker,...etc
e- Recording the times of opening every window and door through 24 hours in both a winter and a summer-day and the percentage of opening
f- Taking interior and exterior photographs

A team of two female architects was chosen for this stage of the fieldwork, one of them was involved in the previous stages of the survey. At this phase of the fieldwork, surveyors need to go into every room in the shelters in order to be able to carry out the tasks presented above. Therefore, females were intentionally selected for this part of the fieldwork as they are more welcomed than males, in view of Palestinian culture, to inter the shelters and the private spaces.

5.6.3.1 Sampling

A purposive sample of 21 shelters (11 new shelters and 10 old shelters) was considered at the fieldwork *stage three*. Various variables which influence buildings` thermal performance were taken into consideration in drawing the sample. Information about these variables was collected in the fieldwork *stage two* and included; the number of floors, the floors` areas, the number of occupants, the number of rooms, and the building materials, in addition to the site layouts with the surrounding buildings` height.

a. Sampling of New Shelters

The first step in drawing the sample of the new shelters was the excluding of all the shelters which had any changes or extensions done by the occupants themselves, because the focus is on evaluating what are reconstructed by the UNRWA. By excluding the shelters with the changes and the extensions, the remains shelters comprise one or two floors. All three-floor shelters are excluded as all SHC shelters which built by the UNRWA are one-floor or two-floor shelters, while the three-floor shelters are resulted from vertical extensions done by the occupants in accordance with their needs and family growth.

Afterwards, ten new shelters were selected in such a manner allowing obtaining diverse shelters in terms of thermal factors mentioned above. Table 5.9 presents the selected ten shelters and the variables which were considered in drawing the sample. As a result, the sample was consisted of four one-floor shelters, four two-floor shelters, and two shelters comprised of two floors in which the first floor area is less than the ground floor area, expressed as (1.5) floor in table (5.9). The total floors areas of the selected shelters ranged from 35 to 130 meter square, while the number of rooms ranged from one to four rooms. In addition, six shelters in the sample had sliding glazing windows while the other four shelters had hinged glazing windows with wooden louvered exterior shutters. Roofing materials in all SHC new shelters are flat concrete slap as indicated earlier; however, corrugated iron existed in five selected shelters where it was almost used to cover staircases. Terrazzo tiles were utilized for flooring in all SHC new shelters; but seven selected shelters had ceramic tiles where generally used in kitchens and bathrooms.

Furthermore, the site layouts of the shelters including the surrounding and the adjacent buildings` heights and orientations, and the streets width, were essential factors in drawing a sample of diverse shelters. Figure 5.5 shows the exterior perspectives for the shelters with their surroundings clarifying the variety of the selected shelters in terms of site layouts.

Table 5.9: Variables of the new shelters` sample

SN	No. of Floors	Area (m^2)			No of rooms			Roof material		Floor materials		Windows	
		GF	FF	Total	GF	FF	Total	Concrete	Corrugated iron	Terrazzo Tiles	Ceramic tiles	Glazing with shutters	Glazing
Sh1	1	86	....	86	4	....	4	Yes	No	Yes	Yes	No	Yes
Sh2	1	88	....	88	2	....	2	Yes	No	Yes	No	Yes	No
Sh3	1	35	....	35	1	....	1	Yes	No	Yes	Yes	Yes	No
Sh4	1	54	....	54	2	....	2	Yes	No	Yes	No	Yes	No
Sh5	1.5	85	30	115	3	1	4	Yes	Yes	Yes	Yes	No	Yes
Sh6	1.5	65	35	100	2	1	3	Yes	Yes	Yes	Yes	No	Yes
Sh7	2	62	62	124	2	2	4	Yes	Yes	Yes	Yes	No	Yes
Sh8	2	55	55	110	2	2	4	Yes	Yes	Yes	Yes	No	Yes
Sh9	2	65	65	130	2	2	4	Yes	Yes	Yes	Yes	No	Yes
Sh10	2	45	45	90	1	2	3	Yes	No	Yes	No	Yes	No

These ten new shelters were later simulated and their thermal performance was discussed in chapter 9. Afterwards, in chapter 10 of this thesis, two shelters of them (one is one-floor and the other is two-floor) were selected according to criteria discussed in this chapter in order to apply fabrics modification on them. However, to get more comprehensive modifications which are appropriate for SHC shelters at the present as well as appropriate for the future (i.e. with any potential vertical extensions), these modifications are better to be examined also on three-floor shelter. As a sequence, a three-floor shelter was added to the sample in order to examine the fabrics modification on it.

Out of the eighty five surveyed new shelters, three of them were three-floor shelters. The second floor in one of them was just a small storage room; so it was excluded from the selection. The ground floor of the second shelter had some changes in its spaces arrangements and an addition of a kitchen and a bathroom, and for this reason it was excluded too. By excluding the two shelters, the remains shelter (Sh21) which consisted of three floors was added to the new shelters` sample. The site layout of this shelter along with the surrounding buildings is also presented in figure 5.5.

b. Sampling of Old Shelters

Similar to the new shelters, the sample of the old shelters was drawn in such a manner allowing obtaining diverse shelters in terms of the same thermal factors applied in drawing the new shelters` sample. In addition, the existing of courtyards and their types were considered in drawing the old shelters` sample (see table 5.10).

As indicated in table (5.10), the sample includes nine one-floor shelters and only one shelter comprising two floors. It is worth to highlight that the vast majority of the surveyed old shelters are one-floor and three out of seventy shelters were two-floor height. Yet, the first floor of these shelters was just one room. The sample of old shelters is more diverse than the sample of new shelters in terms of floor area; where old shelters` areas range from 41 to 306 m^2. Besides, old shelters are more divers in terms of shelter envelop materials. For instance, four types of windows, four roofing materials, and two types of wall materials were included in old shelters sample. It is worth to mention that the majority of roofing was asbestos and corrugated iron; however concrete roofs were mostly used for limited particular spaces. The sample of old shelters also comprised diverse site layouts (see figure 5.6).

Table 5.10: Variables of the old shelters sample

SN	No. of Floors	Area (m^2)		No. of rooms	Walls		Roofs				Floors			Windows				Courtyard type**
		GF	FF		Concrete block	Sand block	Corrugated iron	Asbestos Panels	Rein. Conc slap	Other	Terrazzo tiles	Ceramic tiles	Concrete Slap	Steel	Plastic Louvered	Glazed	Wooden	
Sh11	1	306	....	4	Yes	No	No	Yes	Yes	...	Yes	Yes	Yes	No	Yes	Yes	Yes	2s
Sh12	1	305	...	4	No	Yes	Yes	Yes	No	...	Yes	No	Yes	Yes	Yes	No	Yes	all s
Sh13	1	191	....	6	Yes	No	No	Yes	Yes	...	Yes	Yes	Yes	Yes	Yes	No	Yes	3s
Sh14	1	127	....	2	Yes	Yes	No	Yes	Yes	...	Yes	No	Yes	Yes	No	No	Yes	1s
Sh15	1	44	...	2	Yes	No	Yes	Yes	Yes		Yes	No	No	No	No	No	Yes	3s
Sh16	1	64	....	2	Yes	No	No	Yes	No	...	Yes	No	No	Yes	Yes	No	Yes	....
Sh17	2	70	16	3	Yes	No	Yes	No	Yes	...	Yes	Yes	Yes	No	Yes	No	No	...
Sh18	1	41	...	2	No	Yes	Yes	Yes	No	Fg*	Yes	No	Yes	No	Yes	No	No	....
Sh19	1	136	...	5	Yes	No	Yes	Yes	Yes	...	Yes	No	Yes	No	Yes	No	Yes	...
Sh20	1	105	...	2	Yes	No	Yes	Yes	No	...	Yes	Yes	Yes	No	Yes	No	Yes	...

* Fg: Fibre glass
**Courtyard: 1s: surrounded on one sides, 2s: surrounded on two sides, 3s: surrounded on three sides, all s: surrounded on all sides

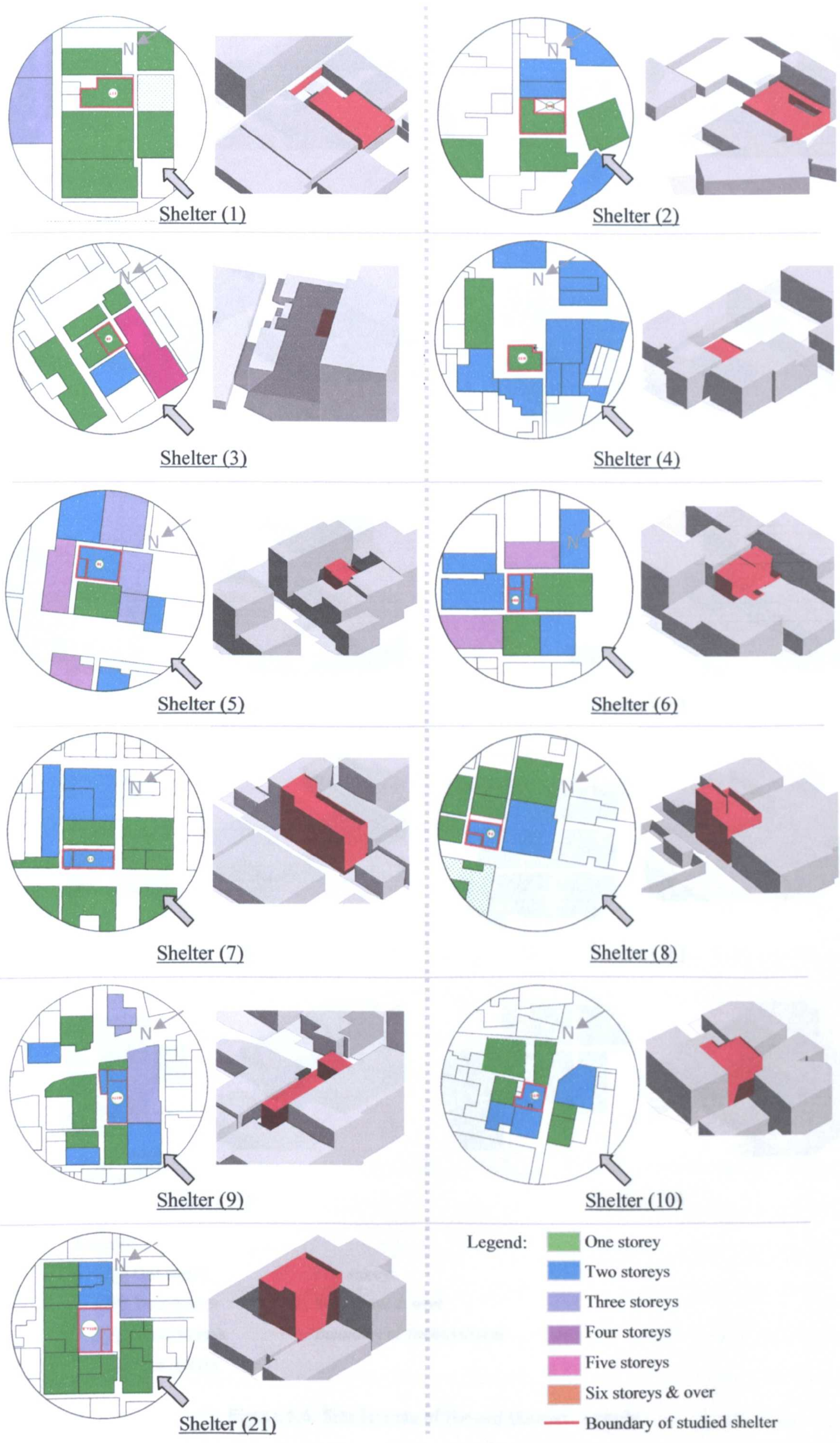


Figure 5.5: Site layouts of the new shelters` sample

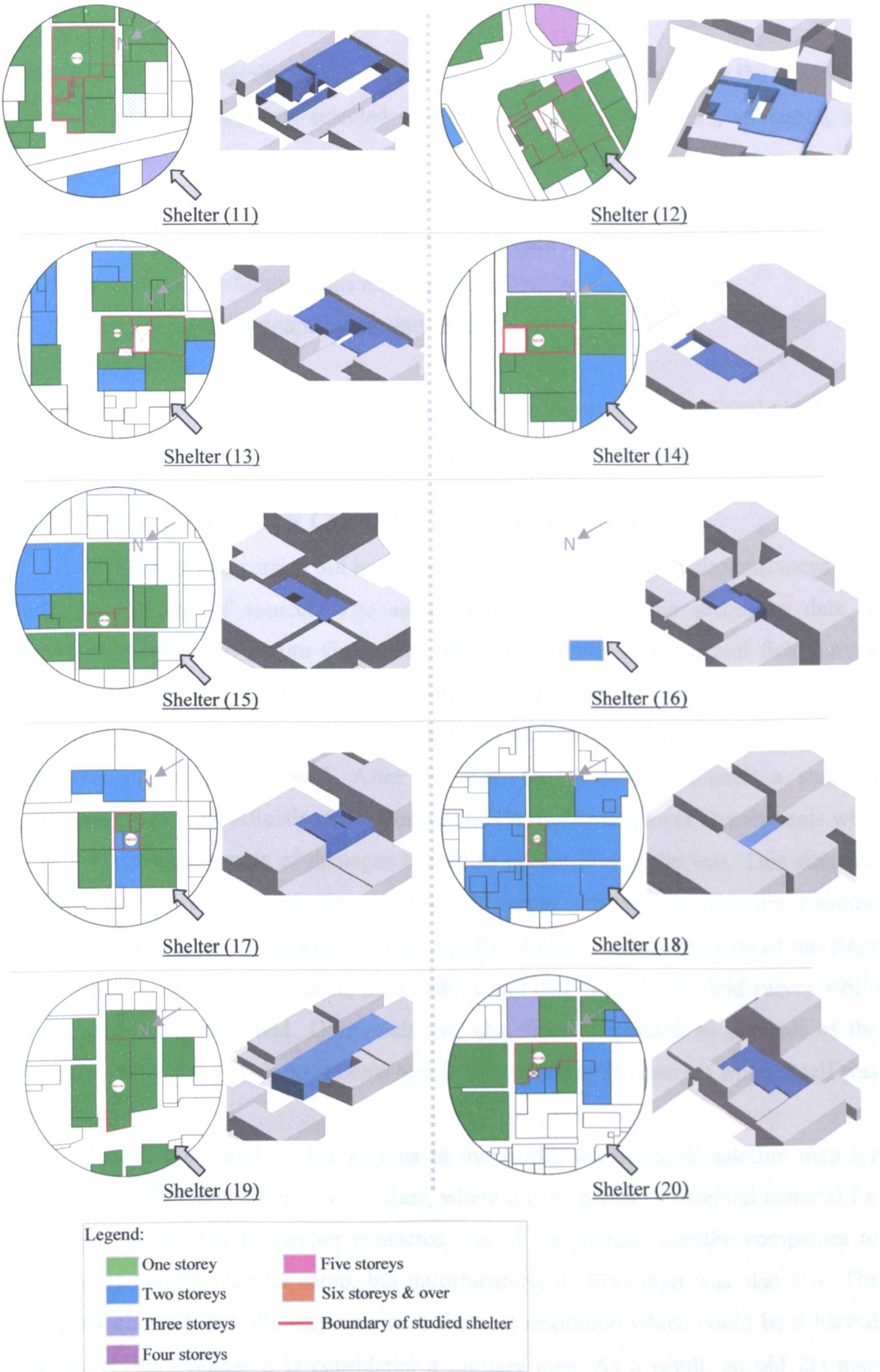


Figure 5.6: Site layouts of the old shelters` sample

5.6.3.2 Survey Materials

Necessary materials for this stage of fieldwork were prepared comprising the following:

a. A list of the twenty one selected shelters with their ID numbers, addresses, and households` names.
b. An updated camp map which includes plotting for the shelters` locations
c. Copies of two survey sheets to be filled out for each shelter; a sheet for windows and doors, and another for materials and appliances.
d. A camera, a measuring-tape, white sheets, and pens

5.6.3.1 Outcomes

The data collected in the fieldwork *stage there* were sorted out in Excel sheets and AutoCAD drawings in order to be used as input data for the thermal simulation.

5.7 DIFFICULTIES IN CONDUCTING FIELDWORK

Fieldwork was carried out in an unstable area under difficult circumstances with a limited breadth of sources. The author started gathering the secondary data of fieldwork two months before Gaza War; while procedures of the actual field survey commenced few months after the war. Electricity and communication networks in Gaza were badly affected; and governmental and nongovernmental organizations such as the UNRWA offices were closed. After the war, the UNRWA declared a state of emergency where all officials at the Design and Camp Development Departments were very busy in assessments of damages caused to homes during the war. This situation affected the flow of data collection and the field survey. Furthermore, the core dilemma is that the researcher was not allowed to visit the studied location because of the siege imposed on Gaza Strip and had to administrate and carry out all the field survey while being away from the field. Gaza mail had also been suspended as a result of the relentless blockade and all documents had to be sent using the internet which itself was influenced too.

In addition, unlike other regions in the world, the available satellite map for Palestine on the Google Earth is not clear, where this map was an essential material for the field survey. The researcher contacted one of commercial satellite companies to purchase a map for Jabalia camp, but unfortunately, its resolution was also low. The company claimed that, the map was with the best resolution which could be achieved for this region because it is considered a military area. As a result, an old 2D map produced in the 1990s had to be used. This required manual updating for the map during the survey as many constructions and changes had occurred during the last twenty years (since the date of production the map until the date of conducting the survey). This task was not easy to be done manually because the camp is overcrowded with narrow alleys.

Another issue encountered in the fieldwork was the difficulty in obtaining the names of the SHC households as the UNRWA did not have database. Names were hardly collected from different departments at the UNRWA offices in Gaza and Jabalia camp, then filtered and sorted out. They were obtained in English language which made it difficult to identify them as Arabic names, especially surnames. Some of these data were not updated and others were not accurate as it was revealed during the actual field survey. For instance, some shelters were listed in the old shelters while they were already reconstructed by the UNRWA, and in other cases the house number and the family`s name were not compatible.

Furthermore, the UNRWA did not have a camp map with plotting of the SHC shelters` locations. The available addresses for these shelters comprised only the house numbers and the block numbers with no post codes or streets` names. According to PCBS (2009b), Jabalia refugee camp is consisted of 5313 buildings distributed in 13 blocks. In actual field, houses numbers were placed on very few buildings which made it very difficult to locate the SHC shelters. Therefore, the only way to approach the studied shelters was by asking the local people in each block about the SHC households using the available names in the list, but it was hard and time-consuming way. In addition, some of these names were for women which made the task harder because the local people almost recognize only the households with men`s names. Besides, some SHC families sold or rented their new shelters, which reconstructed by the UNRWA, and moved to live in other shelters. As a result, in these cases the names did not guide to the targeted shelters.

Finally, shelters` geometries, which were essential input data for thermal simulation, were unavailable for both the old and the new shelters. It was expected that drawings for new shelters could be collected from the UNRWA office in Gaza as these shelters were recently reconstructed by the Agency. Officials at the Camp Development Department in the UNRWA stated that old files were usually gathered in a main store and then disposed of every five years. Consequently, the physical dimensions for the shelters (which selected for the thermal simulation) had to be taken in the field in order to produce the required 2D and 3D drawings.

5.8 SUMMARY

The studied SHC shelters were identified, along with a clarifying of the conditions and the physical aspects of both the old and the new shelters. Studying the two groups of shelters, old and new, was to help assessing the value of the improvement that has already taken place by the UNRWA and to bring greater comprehension of indoor conditions that still needs more enhancements. The Shelters Reconstruction Programme promoted by the UNRWA for the SHC families was also presented including the reconstruction scoring system and the design criteria.

Afterwards, fieldwork methodology was presented and the strategy applied in drawing of a purposive convenience sample was then clarified. Three phases of fieldwork were also discussed including the pilot phase, the questionnaires distribution phase and the physical dimensions phase; along with highlighting for the survey administration. A sample of eleven SHC shelters was surveyed during the pilot stage, while stage two comprised surveying for 204 SHC families with an average response rate of 74 percent. Twenty one shelters were included in the stage three of the fieldwork and the strategy of selecting these shelters for the computer modelling were addressed too. At the end, the difficulties in conducting the fieldwork were summarized.

CHAPTER 6

QUESTIONNAIR DESIGN

6.1 INTRODUCTION

This chapter highlighted questionnaires objectives as an applied research tool and defined the information needed. Questionnaire collection method utilized in this study was clarified, a line with advantages and disadvantages of applying it. The characteristics of questions used; including content, format, wording, and order were discussed. Rating scales and attitude measurements which were employed in questionnaire design were also reviewed, and techniques applied to avoid response errors were then presented.

Questionnaire physical layout was addressed including clarification of questionnaire sections and their sequencing. In addition, the translation process of questionnaire into respondents' spoken language was also examined, followed by reviewing of pretesting phase. At the end, ethical issues considered in questionnaire design were represented, and processing of survey data was reviewed

6.2 QUESTIONNAIRE OBJECTIVES

"A questionnaire is a formalized set of questions for obtaining information from respondents." (Bowers, 2007). Beins (2009) noted that questionnaire is one of the most widely used forms of research and it is a universal method for collecting information. Its purpose is to generate information in a systematic fashion by presenting all participants with questions in a similar form and recording responses in a methodical way. It exemplifies the scientific approach to data gathering. There are various advantages of using questionnaire as research method in collecting data. A standardized questionnaire will ensure comparability of the data, increase speed and accuracy of recording, and facilitate data processing (Bowers, 2007).

A questionnaire is a scientific instrument for measuring and collecting particular kinds of data. And, like all other scientific instruments, a questionnaire must be designed in accordance with particular specifications and tailored to the specific aims. Any questionnaire has three main aims. First, it must translate the information needed into a set of specific questions. Second, a questionnaire should motivate and encourage the respondent to become involved. Third, it should minimize response error (ibid).

6.3 DEFINING THE INFORMATION NEEDED

It is reasonable first to determine the specific types of information to be collected from the questionnaires. The information needed from the SHC families was decided in relation to the aims of this research. So, it was helpful to review components of the research problem, and the research aims and objectives. Then, a blank table was used to catalogue data and to describe how the analysis would be structured once the data had been collected. It was also important to have a clear idea of the target participants as their characteristics had a great influence on questionnaire design. For instance, questions that are appropriate for colleague students may not be appropriate for SHC families.

The questionnaires were ultimately designed to evaluate the indoor environment of SHC shelters with focus on the thermal environment. In addition, the questionnaires were utilized to gather information about the materials of shelters` envelope such as, wall materials, roof materials, floor materials, and windows types. These data about the materials have been used as variables for selecting cases for thermal simulation.

Two questionnaires have been prepared and designed, one for old SHC shelters and another for new SHC shelters, in English version then translated into Arabic, as it is the respondents ` spoken language (appendix B includes a copy for each questionnaire). However, designing a questionnaire is not an easy task, as it requires a good preparing and planning. Figure 6.1 shows questionnaire design steps. In practice, these design steps are interrelated and preparing a questionnaire may involve some looping. For instance, it may be discovered through the "pretesting phase" that respondents misunderstand all the alternatives responses of a question. Subsequently, this requires a loop back to earlier step of the question wording and structure.

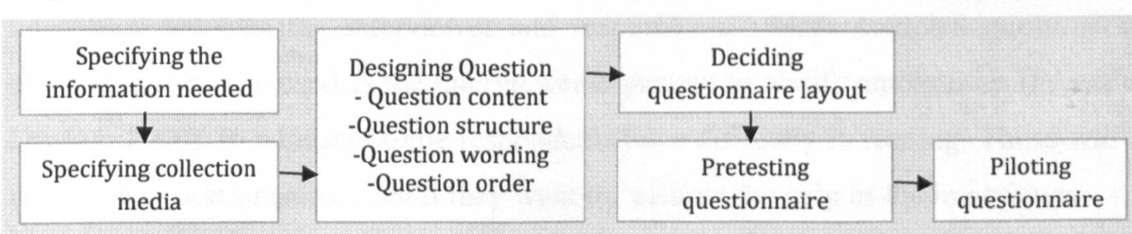


Figure 6.1: Questionnaire design steps, adapted from (Bowers, 2007).

6.4 QUESTIONNAIRE COLLECTION MEDIA

Survey questionnaires may be administered in four major modes: telephone interviews, electronic interviews, mail interviews, and personal interviews (also called face-to-face interviews or interviewer-administered interviews). Personal in-home interviews were utilized in this study for a number of reasons. The main reason is that many diverse questions had to be asked and relatively large amount of data had to be collected which may not encourage the respondents to answer unless by applying personal interviews. Telephone methods were not chosen due to two main reasons. First, the complexity of the questions and the amount of data needed. Second, vast majority of SHC respondents had no land lines. The electronic methods and mail surveys were also ruled out as many SHC families did not have access to mail service, e-mail or the internet.

In this study, respondents were interviewed face to face and interacted with the interviewer, whose task was to contact the respondents, ask questions, and record the responses. Face-to-face method has various advantages which were utilized in this study, in addition to drawbacks which were avoided as explained below.

6.4.1 Advantages of Face-to-Face Questionnaire

a. Flexibility of data collection: Face-to-face method allows the highest flexibility of data collection. Because the respondent and the interviewer meet face to face, the interviewer can administer complex questionnaires, and explain and clarify difficult questions.

b. Quantity of data: Face-to-face interviews allow the researcher to collect large amounts of data. The home environment motivates the respondent to spend more time in the interview. Some personal interviews could last for as long as 75 minutes (Ottaviani, 2007). Besides, less effort is required for the respondent in a personal interview than other modes of survey such as in a telephone or mail interview.

c. Diversity of questions: A wide variety of questions can be asked in a personal interview, because the respondents can see the questionnaire and, there is greater interaction between the interviewer and respondents. More complex questions and explanations can be used as the interviewer is present to clarify ambiguities (Frazer and Lawley, 2000). In addition, some respondents have difficulty in reading. Those will not answer the questionnaire, even if they want to, without the help of the interviewer.

d. Sample control: In-home personal interviews offered the best sample control. It is possible to control who is interviewed, and the degree of participation of other members of the household. However, respondents may be not found at home

e. Control of the data collection environment: Face-to-face interviews offer moderate to good control because the interviewer is present.

*f. **Response rate:*** Face-to-face interviews yield the highest response rate of all survey modes, typically between 60 to 80 percent (Ottaviani, 2007). However, in this mode the interviewer may have to revisit the respondent in the case that he or she is not at home.

6.4.2 Disadvantages of Face-to-Face Questionnaire

a. Control of field survey: Face-to-face interviews are problematic in control of field survey because many interviewers work in many different locations. Therefore, in this study this dilemma was countered by applying a well-designed administration plan, employing a survey team consisting of only three architects, and selecting one location (i.e. one refugee camp).

b. Sensitive information: Face-to-face interviews are relatively not good in obtaining sensitive information such as that related to financial or personal behaviour. However, the collected data in this study are not considered sensitive or threatening.

c. Social Desirability: It is the tendency of the respondents to give answers that are socially acceptable, whether or not they are true. Therefore, the wording of questions was checked against ambiguity that might involve social trends.

d. Potential for interviewer bias: Face-to-face interviews are highly susceptible to interviewer bias. An interviewer can bias the results of a survey by the manner in which he or she asks questions or records answers. In order to avoid occurring of such errors in this study, survey team was provided with clear instructions and guidelines to be taken into consideration through survey. These instructions are presented later in section 6.6

e. Anonymity: It refers to the respondents` perceptions that the interviewer or the researcher will not discern their identities. It is low in personal interviews due to face to face contact with the interviewer. The researcher in this study paid attention to this aspect; and declared, in the cover letter of the questionnaire, that the whole collected information is only for research purpose and will be kept completely confidential. This was typically assured by reporting data without viewing respondents` identities, and only in aggregate summarized form. More details about these ethics are presented later in section 6.10

f. Speed: comparing with telephone and electronic interviews, face-to-face interviews are slow because there is a dead time between interviews while the interviewer travels to the next respondent. In order to save time as much as possible, the lists of SHC shelters provided to survey team were sorted out in a line with the approximate locations of these shelters.

g. Cost: Personal interviews tend to be the most expensive mode of data collection per completed questionnaire, because they require progressively larger field staff and greater supervision and control.

6.5 QUESTION CHARACTERISTICS

The construction of the question is probably the hardest step in designing a questionnaire, because the content, the form, and the wording of a question influence responses (Beins, 2009). Details of question characteristics along with guidelines taken into consideration in asking questions are discussed in this section.

6.5.1 Question Contents

Once the information needed is specified and the type of interviewing method is decided, the next step is to determine individual question content. There are several major concerns that have been pondered in question contents.

**a. Respondents` Ability:** It should not be assumed that respondents can provide accurate or reasonable answers to all questions. Certain factors limit the respondents` ability to provide the desired information. (Bowers, 2007). Question contents were constructed to overcome respondents` inability to answer the question. An option of "I don't know" was provided in all questions that the researcher expected that SHC members may not be familiar or adequately informed about the subject of the question. An example of these questions is presented below.

Using the list below, indicate the reasons that make your shelter hot in summer. (Please indicate just what do you think is applied to you)	
[ ] **I do not know**	[ ] Too much sunshine comes in through windows
[ ] Grate heat gain through roof	[ ] Ventilation through windows is poor
[ ] The area of my shelter is small	[ ] too much sunshine comes in through the courtyard
[ ] Grate heat gain through walls	[ ] roof & walls are exposed to solar radiation most of the time
[ ] Other reasons, please specify..	

Further, respondents may do not have the ability to express or explain their thoughts or feelings clearly in words for certain type of subjects. Therefore, the researcher provided the respondents with all expected alternatives for selecting, along with a free response option to allow for any unmentioned alternative. In the question presented in the above example, various reasons which may make SHC old shelters cold were provided, in addition to an option of "other reasons" to be specified by the respondents.

**b. Respondents` Effort:** Every individual question was designed in a way that reduced the respondents` efforts, because many respondents are unwilling to devote a lot of effort to provide information; even if they are able to answer. For example, it was interested to explore the improvements in indoor environment that SHC families would like to make in their shelters, in order of preference. This information could be obtained in at least two ways as presented below. The respondents could be asked to list all wished improvements and rank them; or a list of all possible enhancements to shelter environment could be provided and asking the respondents to rank the applicable ones.

- Suppose you could make changes to your overall shelter environment. Please list all the changes you would like to make in order of preference, where 1 = the most preferred.

....

- Suppose you could make changes to your overall shelter environment. Using the list below, indicate the changes you would like to make in order of preference, where 1 = the most preferred. (Please indicate just what is applied to you)

[ ] Less noise	[ ] Good natural light	[ ] More speech privacy	[ ] More view out
[ ] More area	[ ] Good ventilation	[ ] More visual privacy	[ ] Comfortable temperatures
[ ] Fresh air	[ ] More security	[ ] Other (please specify)...	

The second option is preferable, because it requires less effort from respondents; so it was used.

c. Memory Questions: If people are asked about behaviours or events that do not stand out in memory, they prone to significant error (Beins, 2009). People may not be lying when they misreport their answers, but they give their best guess (which could be incorrect ones) trying to be helpful. Therefore, questions that exceed the ability of the respondents to remember were avoided. For example, for many SHC families, it would be difficult to answer precisely question, "How many hours does the sunshine enter your shelter in summer?" instead the question used,

How often does the sunshine enter your shelter in summer?
[ ] always [ ] often [ ] seldom [ ] never

Some people are better at remembering than others are. Therefore, asking respondents for too much recall of details may lead some of them to produce low-quality data based on faulty estimates. Further, as the questionnaire measured indoor environment of SHC shelters in both summer and winter, questions related to the same subject and the same period of time were arranged close together. For example, all questions investigating indoor thermal environment in summer were arranged together followed by those investigating thermal conditions in winter. This helped the respondents to generate more accurate responses.

d. **Necessary Questions:** Every question in a questionnaire should contribute to the information needed or serve some specific purpose (Bowers, 2007). Hence, the questionnaires were checked out and any question results have no satisfactory use for data, that question was eliminated. On the other hand, several questions, instead of one, are sometimes needed to obtain the required information in an unambiguous manner. For example, the location of courtyards in SHC old shelters was to be investigated and the question firstly constructed, "Indicate the location of courtyard in your shelter?" However, there was a possibility that some of old SHC shelters did not comprise courtyards. Therefore, another question proceeding the question above was needed which should indicate if the courtyard is existed or not. The two questions were designed as follows:

1- Is there currently a courtyard in your shelter?

[ ] Yes [ ] No

2- If yes; indicate the location of courtyard in your shelter? (The white area indicates the courtyard)

The court is surrounded by rooms on all sides [ ]	The court is surrounded by rooms on three sides [ ]	The court is surrounded by rooms on two sides [ ]	The court is surrounded by rooms on one side [ ]

6.5.2 Question Format

In terms of question and response format, questions were either structured (closed-ended), where the respondents required to select from sets of answers already provided; or unstructured (open-ended), where the respondents answered in their own words. The interviewers were instructed to copy the answer verbatim. In the case of closed questions, the interviewers read the questions and a list of response options from which respondents were asked to choose their answers.

The majority of utilized questions were closed-ended questions where they were used for the collection of quantitative and qualitative data. The three types of structured question which are multiple-choice, dichotomous, and a scale; were applied. On the other hand, open-ended questions were utilized for exploring information by allowing respondents to express any views and to generate answers without limitations regarding length or content. An example of open-ended question used in this study is presented below:

- Please add any additional comments about your shelter environment and about any features, you like or dislike in your shelter.

Each type of question structure has its own advantages and disadvantages (Beins, 2009). The advantage of open-ended questions is that they provide a rich insights and body of information. Further, unstructured questions have a much less biasing influence on response than structured questions (Bowers, 2007). The disadvantage is that they can be harder to categorize and sort and the coding of responses is time consuming. The coding procedures required summarizing responses in a format useful for data analysis and interpretation. Another major disadvantage is that potential for interviewer bias is high. Therefore, survey team was instructed to record the responses word by word.

On the other hand, closed-ended questions are easy to administer and to answer, and the information provided is much easier to score and summarize. Further, with closed-ended questions, it could be sure that the respondent has the chance to answer the questions of critical importance to the research. For example, information about the thermal behaviour of building elements both in summer and winter was needed to be collected. Few people may address that issue in the open-ended question. Therefore, closed-ended question was applied to collect that information from every respondent. However, a major disadvantage of closed-ended questions that they limit response alternatives, and it is difficult to obtain information on alternative not listed (Steenstra, 2000). In order to overcome this drawback, a free response option such as "other" was provided to be specified by the respondents to allow for any unmentioned alternative. Another disadvantage in closed-end questions that respondents are influenced by the overall idea of alternatives provided and may select the similar boxes of different stimulus object. To avoid such effects in the questionnaire, similar scales were not placed close together or they were presented in reverse order. Further, closed-end questions are required considerable effort in constructing and designing (Bowers, 2007).

6.5.3 Question Wording

Question wording is the translation of question contents into words that can be understandable. Bowers (2007) stated that question wording is the most critical and difficult step in designing a questionnaire. Experimental studies show that small changes in question wording sometimes produce very large changes in response distribution (Steenstra, 2000; Gillham, 2008). There are a number of techniques and guidelines, discussed in literature (Oppenheim, 1992; Brace, 2004, Bowers, 2007; Gillham, 2008; Hoxley, 2008) to enhance development of specific target questions. Questions were worded in this study considering those guidelines in mind. Examples of such applied techniques are explained below

- Ordinary simple words were used to match the vocabulary level of the respondents. Further, acronyms and abbreviations were not included. Technical terms were avoided as far as possible, but few had to be used. Therefore, simple and understandable explanations for used terms were provided every time they were mentioned in the questionnaire. The terms which were used included: visual privacy, speech privacy, visual comfort, and cross ventilation. For example "visual privacy" was defined and phrased in respondents` everyday speech as in following question:

> How satisfied are you with the visual privacy in your shelter? (Visual privacy means that no one outside can see you while you are at your shelter)
>
> [ ] Very Satisfied [ ] Satisfied [ ] Moderate [ ] Dissatisfied [ ] Very Dissatisfied

- Questions, and indeed the entire questionnaire, were constructed to be as brief as possible, because long questions that are difficult to understand will result in a poor response rate.

- In deciding on the choice of words, it was considered that respondents understand the word as the researcher intended in the questions. For example, in asking about the number of rooms in a shelter, some respondent may consider rooms to include bedrooms and guest rooms, and others may consider living room in counting the number of rooms. Hence, an explanation was provided for what the word "rooms" meant in the question as following:

> **How many rooms in each floor? (Note: Rooms include bedrooms, guest room and living room)**
>
> **.......In ground floor ....In first floor ....In second floor ....In third floor**

- Questions were also worded so that the respondents did not have to compute or estimates. For example, it was interested to survey the efficiency of SWHS through investigating the number of month in which the system could provide adequate amount of hot water for the family. The question could be: "How many months does solar heating water system provide the family with adequate amount of hot water?" this requires from the respondents to count the months. Instead, a list of the twelve months of the year was provided and the respondents were asked to indicate the months in which the system provides adequate amount of hot water for the family. The researcher then performed the necessary calculations.

- Implicit alternative, which is an alternative that is not explicitly expressed, was avoided as explained in the following two questions.

- Using the features listed below; indicate the features that are better in your new shelter

Temperature	....	Speech privacy	....
Visual privacy	....	Ventilation	....
Natural light	....	Security	....
Noise	....	Air quality	....
Area	....	view out	....

In above question, the alternative of old shelter is implicit, therefore the questions was instead worded as following:

- In terms of the features listed below, indicate which is better; your new shelter, your old shelter, or the same?

	New shelter is better	Old shelter is better	The same
Temperature	....	....	....
Visual privacy	....	....	....
Natural light	....	....	....
Noise	....	....	....
Area	....	....	....
Speech privacy	....	....	....
Ventilation	....	....	....
Security	....	....	....
Air quality	....	....	....
view out	....	....	....

6.5.4 Question Order

Frazer and Lawley (2000) indicated that the order of questions can affect the motivation of respondents to complete the questionnaire. The opening questions can be crucial in getting the confidence and cooperation of respondents. Therefore, simple and easy questions were used at the beginning of the questionnaires. Those questions comprised general information of shelters` physical characteristics such as number of floors, number of rooms, shelter area, and building materials.

Questions were arranged in several sections to deal with different topics such as, thermal environment, visual environment, acoustic environment and other environmental factors. Questions were also sequenced in a logical order in that all of the questions which dealt with a particular topic were asked before starting a new topic. Moreover, comprehensive questions were placed at the end of the questionnaire in the last section. In that way, respondents were required to provide specific information about different aspects before making general evaluations.

6.6 SCALES AND MEASUREMENTS

There are four primary scales of measurement: nominal, ordinal, interval, and ratio. All of these primary scales were used in this study for preparing the questions. The scaling techniques can be classified into comparative and noncomparative. Comparative scales involve the direct comparison of stimulus objects. Comparative scale data must be interpreted in relative terms and have only ordinal or rank order properties. As shown in figure 6.2, comparative scales include *paired comparisons, rank order, constant sum scales,* and *Q-sort and other procedures*. Comparative scales are easily understood and can be applied easily.

In noncomparative scales, each object is scaled independently of the other object in the stimulus set. The resulting data are generally assumed to be interval or ratio scaled. Noncomparative scales include *continuous rating* scale and *itemized rating* scales. In an itemized rating scale, the respondents are provided with a scale that has a number or brief description associated with each category. The categories are ordered in terms of scale position, and the respondents are required to select the specific category that best describes the object being rated (Zalesky, 2007)

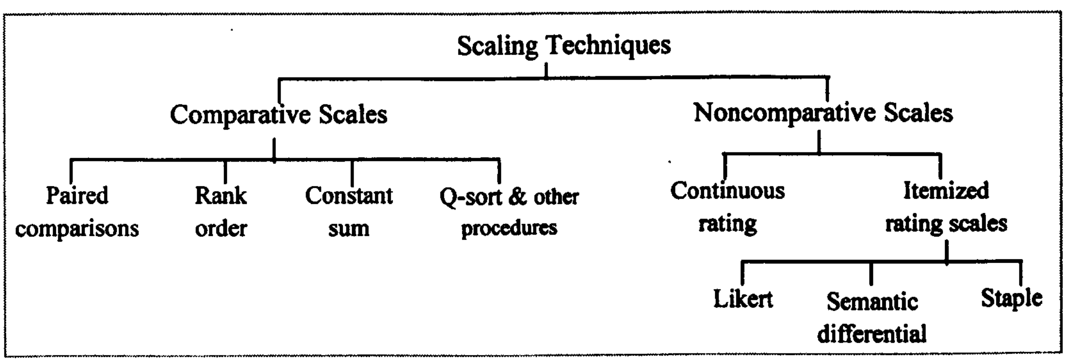


Figure 6.2: a classification of scaling techniques, source (Scoy, 2007).

6.6.1 Comparative Scales

From the variety of available comparative scales, some of them which appropriate this research were applied. Simple scales for application and analysis were used; which can be easily understood by respondents, do not require special skills by them to answer, are easy to instruct, and anticipate respondents` interest.

Comparative scaling techniques used in the questionnaire survey of this research are:

a. Paired comparison scaling: A respondent is presented with two objects at a time and asked to select one object in the pair according to some criterion. For example:

In terms of thermal comfort, in which season (winter or summer) do you think your shelter is better?
[ ] In summer [ ] In winter [ ] The same

Paired comparison data can be analysed in several ways. This scaling is useful when the number of objects is limited, because it requires direct comparison and overt choice. On the other hand, paired comparisons bear little resemblance to the situation that involves selection from multiple alternatives. In the above example, respondents may see that their shelter is better in summer in terms of thermal comfort, but they may not feel that their shelters are comfort in summer.

b. Rank order scaling: It is a comparative scaling technique in which respondents are presented with several objects simultaneously and asked to order or rank them according to some criteria. In this scaling, the most respondents easily understand the instructions for ranking (Scoy, 2007). For example:

Suppose you could make changes to your overall shelter environment. Using the list below, indicate the changes you would make in order of preference, where 1 = the most preferred. (Please indicate just what you would make)			
[ ] Less noise	[ ] Good natural light	[ ] More speech privacy	[ ] Comfortable temperatures
[ ] More area	[ ] Good ventilation	[ ] More visual privacy	[ ] More view out
[ ] Fresh air	[ ] More security	[ ] other (please specify)...	

6.6.2 Noncomparative Itemized Rating Scales

Itemized Rating Scales include Likert, semantic differential, and Stapel. These scales are not needed to be used as originally proposed, but they can take different forms. Examples of itemized rating scales that constructed in this study are listed below:

Importance: not at all – slightly – moderately – largely – very much
Satisfaction: very satisfied – satisfied – neutral – dissatisfied – very dissatisfied
Noise: too much noise – noisy – neutral – calm –very calm
Frequency: always – often – seldom – never
Humidity: Too humid – humid – adequate – dry – too dry

Various practical factors were taken into consideration through the construction of scales in this study; some of them are presented below.

a. Number of scale categories

Zalesky (2007) noted that traditional guidelines suggest that the number of scale categories should be between five and nine categories However, he stated that there is no single optimal number of categories; and he proposed several factors to be taken into account in deciding the number of categories. These include the level of information desired, the capabilities of respondents, the nature of the objects, and the mode of data collection.

In this study the categories numbers used were three, four, five, and seven scale categories. Larger number of categories was employed when the respondents were expected to be knowledgeable about the objects, and when the characteristics of the stimulus objects allow for fine discrimination. On the other hand, fewer categories were used when the objects did not lend themselves to small differences. Two examples from the questionnaire are presented below, one with three categories and the other with five categories.

- How is the air circulation in your shelter in winter? [ ] Still [ ] moderate Circulation [ ] Too Much Circulation
- How do you rate the noise level in your shelter? [ ] Too much noise [ ] Noisy [ ] Neutral [ ] Calm [ ] Very calm

b. Balanced versus unbalanced scales

In general, the scale should be balanced in order to get objective data. Yet, if the distribution of answers is expected to be skewed, either positively or negatively, an unbalanced scale could be appropriate. The majority of scales used in this study were balanced; with some aspects unbalanced scales were used. An example of unbalanced scale is presented below.

- How do you rate the intensity of solar radiation in your shelter in winter? [ ] Excellent [ ] Good [ ] Moderate [ ] Poor [ ] No solar radiation

c. Nature and degree of verbal description

The nature and degree of verbal description associated with scale categories vary considerably and can have an effect on the responses. Scale categories may have verbal, numerical, or even pictorial descriptions. Through constructing the scales, it should be decided whether to label every scale category, some scale categories, or only extreme scale categories. In this study, the researcher labelled all scale categories in order to reduce scale ambiguity, and to make it easier in instructing. The example below presents two options of scale categories where the second option was used in this study.

How satisfied are you with the noise level in your shelter?				
• very satisfied 1	2	3	4	5 very dissatisfied
• [ ] very satisfied	[ ] satisfied	[ ] neutral	[ ] dissatisfied	[ ] very dissatisfied

6.7 RESPONSE ERRORS

Some respondents might give biased answers for different reasons such as social desirability, acquiescence, prestige, or threat. Problems in responses which may take place in this study were avoided in different ways. For example, the researcher avoided social desirability by checking wording questions against ambiguity that might involve social trends. McBurney and White (2007) indicated that, this problem can be avoided also by wording questions so that each alternative appears equally socially desirable. In addition, personal questions directly related to the respondent's image were avoided to prevent biased answers resulting from the respondent`s desire to enhance his image. Further, the cover letter provided with the questionnaire clarified for the respondents that there are no right or wrong answers; and it is only their opinions that are important.

In addition to the above reasons which may lead to response bias, there are still response errors related to the interviewer. Survey should be carried out by applying the same procedure to each respondent, so all respondents must be presented with the same stimuli. Therefore, to avoid interviewer-related errors, survey team was provided with clear instructions and guidelines to be taken into consideration through survey. Examples of these instructions, recommended by Steenstra (2000), are:

- read the questions exactly as worded and as ordered in the questionnaire, without omitting or adding anything
- probe answers in non-leading manner in a neutral way
- record the answer without interviewer`s discretion
- do not provide any positive or negative feedback regarding the specific content of respondent`s answer.
- in the case of questions to be answered by respondent`s own words (open-ended questions), write down the answer word by word.
- if the respondent`s answer is incomplete, reread the question and any clarification or definition provided in the questionnaire in a non-directive way.
- when respondents miss part of the question, reread the entire question.

- If the respondent answers the closed-ended question before the interviewer presents all the options, complete presenting the entire list of options.

6.8 QUESTIONNAIRE LAYOUT

The layout and appearance of a questionnaire can have a significant effect on the results (Bowers, 2007). Further, questionnaire physical structure is important to attract occupant participation and enhance response accuracy. Therefore, the questionnaires were presented in attractive and professional-looking; and reproduced in such a way that they were easy to read and answer. Besides, a brief and persuasive cover letter was provided with the questionnaire which designed to be interesting and motivating.

Gillham (2007) indicated that length of questionnaire is critical; and four to six pages is the usual tolerance maximum. In this study, two questionnaires of six pages long each have been designed; one for old SHC shelters (comprising 78 questions) and another for new SHC shelters (comprising 77 questions). A variety of different types of answer styles were applied in order to get rid of the monotony in answering the questionnaires. In addition, Instructions and directions for individual questions were placed close to the questions to make it easy to administer and answer.

The questionnaire was divided into six parts as following: (1) Background Information, (2) Thermal Environment, (3) Visual Environment, (4) Acoustic Environment, (5) Other Environmental Factors, and (6) General. Each part has a different colour, so that respondents could turn from topic to another with exciting and interesting manner. Further, dividing the questionnaire into parts provided natural transitions and alerted the interviewer and the respondent that, as each part began, a different kind of information was being solicited.

6.9 TRANSLATION OF QUESTIONNAIRES INTO ARABIC

Questionnaires, which to be distributed in actual field survey, must be written with the respondents` spoken language. Therefore, translation of questionnaires into Arabic language began after the source questionnaire has been finalized in wording and design. In deciding to translate a questionnaire, a major premise is that the source (i.e. English version) and the translated (i.e. Arabic version) questionnaires will ask the same questions. It can be expected that small differences in formulation across languages can affect understanding.

English and Arabic languages are essentially different in vocabulary, in structure, and in functions. Semantics and pragmatic meaning of words do not match up neatly across both languages. For instance, one term in English language may cover less or more than what corresponding terms in Arabic language cover. In targeting equivalence or comparability across both versions of questionnaires, i.e. English and Arabic, acknowledge of difference across languages a line with acknowledge of questionnaires` subject area is necessary. In order to get a precise translation, Arabic-Arabic dictionaries were consulted along with English-Arabic dictionaries.

It was important in translating questionnaires to retain semantic content of questions and scale measurement used in closed-ended questions. Answer scales frequently combine negation and quantification, and these differ considerably across languages. A basic problem in trying to match up answer scales is, therefore, that the lexical and structural options available differ across languages. Sometimes, term-for-term equivalence is impossible. For instance, in translating the verbal scale "never-seldom-often-sometime-always" form English to Arabic, the researcher had to transform it to a scale of four categories instead of five categories, to be "never-seldom-often-always", because Arabic language dose not distinguish between "often" and "sometimes".

Another important and challenging scale in translation was the 7-point comfort scale "cold- cool- slightly cool- neutral- slightly warm- warm- hot". The number of categories of this scale, which is seven, had to be maintained. However, there is a single expression in Arabic matches the two words "cold" and "cool". In addition, in Arabic, the term that matches the word "warm" is used in a different way. The term "warm" in Arabic is used in winter as it means "not cold". Therefore, "cool", "slightly cool", "slightly warm" and "warm" had to be removed from the Arabic scale and were replaced with "cold" "slightly cold", "slightly hot" and "hot" respectively. Subsequently, "hot" and "cold" were replaced with "very cold" and "very hot" respectively in order to get comparable scale in the two languages.

6.10 PRETEST THE QUESTIONNAIRE

Pre-testing is an important stage to ensure that potential problems are identified and eliminated (Frazer and Lawley, 2000). The aim of this phase is to certify that each individual question meets all the principles of good questionnaire design and to check the flow of the questionnaire as a whole (Campanelli, 2008). It also allows the researcher to make preliminary observations regarding the time required to fill-out each questionnaire.

For pretesting to be effective, the researcher selected participants who have different specialist knowledge, and who have a good background about Palestinian refugee camps and the studied shelters. Further, some of participants in pretesting phase were also with high degree of knowledge about the topic of questionnaires. Questionnaire samples (for both old and new shelters) with cover letters were distributed among the selected participants. They were asked to check the accuracy and completeness of the questions and the questionnaire as a whole through answering the following:

- Is the wording in each question is clear?
- Are questions easy to understand?
- Are instructions for completing the survey clearly written?
- Are the response choices exhaustive?
- May any question exceed the potential respondents` ability to answer?
- Is the flow of questions and sections convenient?
- Is the physical layout of the questionnaire pleasing?
- Was the cover letter interesting and motivating?
- How long does it take to answer a single questionnaire?
- Do you have any suggestions for improving the questionnaire or the cover letter?

Based on the pretesting phase results, alterations and modifications were made to the questionnaires in line with feedback obtained. Piloting stage, which was the final process of testing the questionnaires, was then applied on a sample of SHC families in Jabalia camp. Details of questionnaire piloting stage were clarified earlier in (section 5.6.1) of the previous chapter.

6.11 ETHICAL ISSUES

It is standard practice to guarantee both the anonymity and confidentiality of responses (Beins, 2009). This means that nobody who is not part of the research will have access information about the respondents or their answers. The researcher in this study paid attention to those two critical considerations. The cover letter of the questionnaires included a declaration that the whole collected information is only for research purpose and will be kept completely confidential. This was typically assured by reporting data only in aggregate summarized form so that nobody can tell who responded in one way or another. Besides, each respondent was assigned a unique identification number in order to be anonymous.

From an ethical standpoint, the cover letter also included the name of the researcher, the broad subject area, and the likely length of the interview. A further ethical constraint is that participants were informed in advance if any video recording or photos would be taken for their shelters. At the end of the survey, the researcher asked the survey team to destroy any information and data related to SHC families' lists and their shelters.

6.12 DATA PROCESSING

Before collecting data, all the variables were categorized and the questions were coded. Processing of survey data started with entering them precisely into the computer, where all data were classified into the three main scale categories: nominal, ordinal, and scale, as a first step in entering them. Data were then revised in order to correct any errors occurred during entering process. By utilizing statistical analysis software package called SPSS (***Statistical Package for the Social Sciences***), data were analysed in accordance to survey objectives. "SPSS is the most used statistical analysis software and is extremely powerful, as well as carrying out the full range of statistical procedures; its chart drawing facility is excellent." (Hoxley, 2008, p127). The results of data analysis have been presented and discussed in the next chapter.

6.13 SUMMARY

Two questionnaires of six pages long each have been prepared and designed, one for old SHC shelters and another for new SHC shelters. They were designed in accordance with particular specifications of question characteristics and scale techniques, and tailored to specific aims. The questionnaires were ultimately designed to evaluate the indoor environment, including thermal environment, visual environment, acoustic environment, and other environmental factors, of SHC shelters with focus on the thermal environment. In addition, they were utilized to gather information about the materials of shelters` envelope.

Face-to-face questionnaire were utilized in this study for a number of reasons. Many diverse questions had been asked and relatively large amount of data had been collected. Processing of survey data started with entering them into statistical analysis software package called SPSS which utilized in data analysis. Next chapter will present data analysis of indoor environment along with discussion of the findings.

CHAPTER 7

SURVEY RESULTS AND ANALYSIS OF INDOOR ENVIRONMENT

7.1 INTRODUCTION

This chapter represents the first phase of the evaluation for the indoor environment of SHC shelters, which was carried out utilizing questionnaires instruments. The gathered data were entered and sorted utilizing SPSS, then analyzed applying various statistical analysis tests. The main tests used were Pearson Chi-square test for independence, a Mann-Whitney U, a Wilcoxon Signed Ranks, Kruskal-Wallis, and Spearman's rho Correlation Coefficient.

Background information about new and old shelters, is firstly summarized. Analysis of the indoor environment including visual, acoustic and thermal environment are presented. Thermal comfort in summer and winter is investigated in more details for both old and new shelters along with exploring for the energy consumption for heating and cooling. Then reasons of thermal discomfort in summer and winter are explored for old and new SHC shelters. Potential correlations between thermal comfort and several factors such as environmental factors, secondary factors, construction materials, shelter height, and integration of courtyards, are explored and discussed. Afterwards, other environmental features comprising; adequacy of space, indoor air quality, security were inspected in SHC shelters a line with highlighting the effect of openings on the indoor environments. At the end, general evaluation for indoor environment of SHC shelters is discussed, followed by clarifying for occupants' comments.

7.2 BACKGROUND INFORMATION

Getting general information about SHC shelters; such as their heights, areas, and construction materials, was useful in drawing a clear background about the studied shelters. This information was used as essential parameters in analysing indoor environment conditions and in drawing sample for thermal simulation. The first section of the questionnaires was utilized to gather these general data which comprise shelters` height, area, number of rooms, and number of occupants and families. Besides, shelters` construction materials were surveyed, along with exploring the integration of courtyards in old shelters and the extensions in new shelters. Results are provided in the following subsections.

7.2.1 Descriptive Analysis

The survey revealed that the number of families who occupied one shelter ranged from one to five families. Majority of shelters (57 and 64 percent of old and new shelters respectively) is occupied with one family, and almost one-third is occupied with two families. The average number of occupants in old shelters (8.71 persons) is slightly higher than that in new shelters (7.47 persons). Besides, the average total built up area of old shelters is about 112 meter square which is higher than that of new shelters (about 81 m^2), with the minimum built up areas are 21 and 20 meter square in old and new shelters respectively. In old shelters, number of rooms ranged from one to eight rooms with two-fifth of shelters comprised two rooms and one-quarter comprised three rooms. In new shelters, number of rooms ranged from one to seven rooms with over one-half of shelters comprised three or four rooms. Table 7.1 provides descriptive analysis for old and new shelters.

Table 7.1: Descriptive features of old and new SHC shelters

Variable	Shelter Type	Mean	Mode	Min.	Max.	Std.Dev.
No. of Families	old	1.59	1	1	5	0.88
	new	1.45	1	1	4	0.72
No. of occupants	old	8.71	8	1	30	4.86
	new	7.47	8	1	19	3.55
Area (m^2)	old	112.42	60	21	430	90.75
	new	81.16	80	20	250	35.24
No. of rooms	old	2.90	2	1	8	1.44
	new	3.38	3	1	7	1.09
Area(m^2)/Person	old	15.38	15	2.15	65	11.57
	new	17.91	20	4.67	80	13.72
No. of floors	old	1.04	1	1	2	0.20
	new	1.71	2	1	3	0.61

In surveying shelters height, it was revealed that vast majority of old shelters (95.7 percent) is one-floor height and the rest (4.3 percent) is two-floors. As indicated in figure 7.1, over one-half of new shelters were two-floor height, and almost 37 percent was one-floor, while a mere 8.2 percent was three-floor height. It is worth mentioning that the UNRWA has been constructing one or two floors for SHC families, however, occupants almost extend vertically in accordance with their needs and family growth.

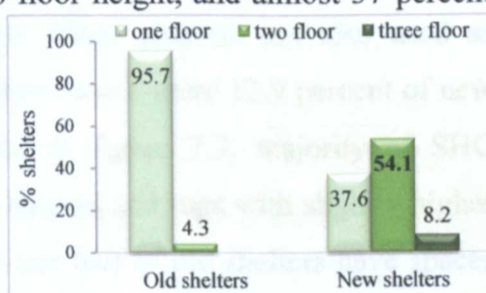


Figure 7.1:No. of floors of old & new shelters

7.2.2 Construction Materials

Figure 7.2 provides the percentage of shelters that include various types of construction materials for; walls, roofs, and floors. It should be mentioned that some shelters comprise more than one type of materials for the same element. For example, old shelters include concrete block walls, sand block walls, or both of them. As indicated in figure 7.2, concrete block walls are found in exactly 70 percent of old shelters while sand block walls are found in about 41.1 percent of old shelters. This means that about 5.5 percent of old shelters include both types of wall materials (concrete and sand block) together in the same shelter. In all new shelters, wall materials are only concrete block.

There are three main types of roof materials used in SHC shelters which are reinforced concrete slap, corrugated iron, and asbestos sheets. As indicated in figure 7.2, all new shelters include flat reinforced hollow concrete slap which is used to cover the main spaces, while nearly 11.4 percent of old shelters include concrete slap which is used to cover some spaces particularly bathrooms. Corrugated iron is used in around one-quarter of new shelters to cover staircases and extension rooms, while it is used to cover main spaces in about two-third of old shelters. Further, vast majority of old shelters (90 percent) includes asbestos sheets as roofing materials, while it is used to cover extension spaces in slightly lower 20 percent of new shelters.

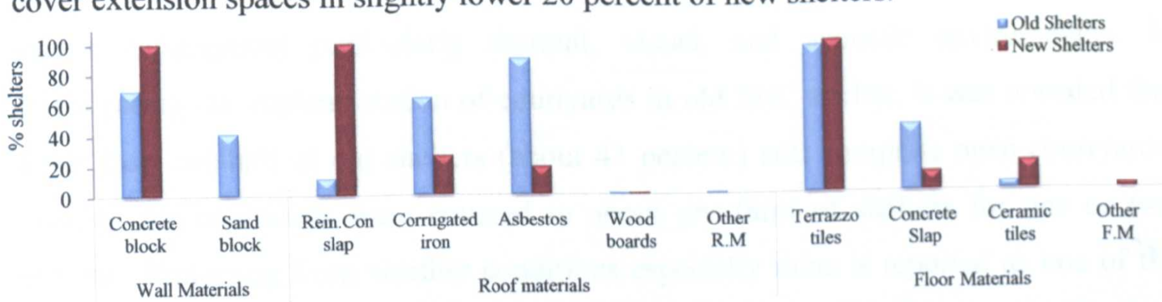


Figure 7.2: Construction materials in old and new SHC shelters

For flooring, terrazzo tiles are used in all new shelters and vast majority of old shelters (97.1 percent), while ceramic tiles are used in only about 18.8 and 5.7 percent of new and old shelters respectively. It is worth noting that ceramic tiles are used in particular spaces such as kitchens and bathrooms. Plain concrete are also used as flooring material in lower than one-half of old shelters; and a mere 12.9 percent of new shelters. In terms of floor covering, as presented in figure 7.3, majority of SHC occupants are using mats and few occupants using carpets and rugs with slightly higher percentage in new shelters. In addition, more than one-half of old shelters have spaces with no floor covering in summer, comparing with about 10 percent of new shelters. In winter, however, there is still around 40 percent of old shelters with no floor covering for some spaces and a mere 3.5 percent in the case of new shelters. It is worth to mention that floor covering used in SHC shelters is almost placed on part of rooms` floor and the rest are remains without covering.

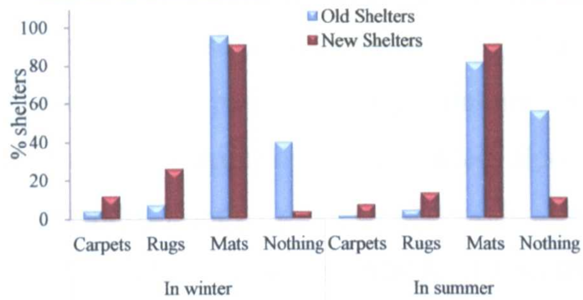


Figure 7.3: Floor cover in summer and winter

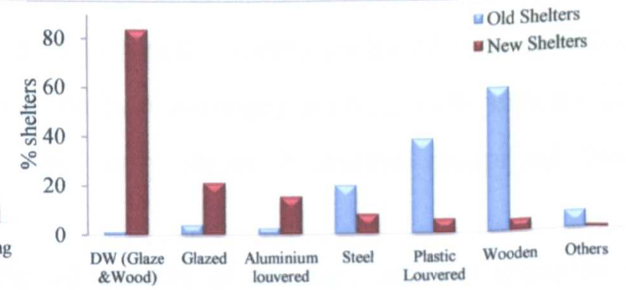


Figure 7.4: Types of windows in old and new shelters

In terms of windows materials, there is an observed difference between old and new shelters, with a variety of types as shown in figure 7.4. Single glazed windows with external wooden shutters are existed in almost 83.5 percent of new shelters, followed by glazed windows (21.2 percent), while the other types range between 4.7 to 15.3 percent. In old shelters, wooden windows are the highest percentage across the other windows types; followed by plastic louvered windows (38.6 percent), steel windows (20 percent), while the other types range only between 1.4 to 7.1 percent

7.2.3 Courtyards in Old SHC Shelters

Courtyard is considered as one of the features that have significant influence on indoor environment particularly thermal, visual, and acoustic environments. In investigating the implementation of courtyards in old SHC shelter, it was revealed that lower than one-half of old shelters (about 43 percent) still comprise open courtyards. Besides, the courtyards were covered in about one-third of shelters for one or two reasons. Protecting from weather conditions especially rains is reported as one of the reasons in 70 percent of the shelters that comprise covered courtyards. Further, achieving visual privacy, expanding the area of indoor spaces, and attaining more safety are reported as one of the reasons in about 20, 13, and 9 percent of the shelters that comprise covered courtyards.

Courtyards` locations inside old shelters were also inspected as they may affect the environmental performance of the shelters. The survey revealed that around one-third of courtyards are surrounded with rooms on one side, one-third are surrounded on two sides, about 17 percent are surrounded on three sides, and the rest are surrounded on all sides.

7.2.4 Extensions in New SHC Shelters

The occupants of new shelters almost apply changes and extensions to their shelters after being constructed by the UNRWA. It was interested to explore these changes and modifications. As revealed by the survey, lower than one-half of the new shelters (about 43.5 percent) had extensions, although the surveyed shelters are the most recent reconstructed ones. Almost 18 percent of new shelters included one extended room and 8 percent of new shelters included two extended rooms, while exactly 20 percent comprised one extended floor, and only about 2 percent comprised two extended floors.

Besides, it was found that nearly 22 percent of the new shelters comprised changes and modifications that applied by the occupants after the reconstruction of their shelters by the UNRWA. Some of those changes were conducted on interior layout such as altering the location of the entrance and the bathroom. Other transformation affected the external form such as erecting pergolas outside, setting up sunshade on the roof, and roofing the external area in the front of the shelter using concrete slap. Some families constructed fences around their shelters, and others expanded rooms' area. In addition, number of modifications comprised multiplying electric lighting and increasing the number of windows. It can be expected that occupants carried out the above mentioned changes consistent with their needs and families growth.

7.3 VISUAL ENVIRONMENT

Visual environment is considered one of the most important features of indoor conditions. As mentioned earlier in chapter 3 of this thesis, good visual environment should facilitate the performance of a visual task, ensure visual comfort and create certain emotional effects as well. The quality of visual environment in SHC shelters were evaluated by inspecting daylight amount, visual comfort, occupants satisfaction, and visual amenity including view out and visual privacy. The findings and results are presented in the following subsections

7.3.1 Amount of Daylight

In order to investigate the amount of daylight inside SHC shelters, occupants were asked to rank the daylight in the various spaces of their shelters, in summer and winter, using a 7-ponit scale ranging from "very dim" to "very bright".

a. Daylight in summer:

In old shelters, overall, the highest daylight level was found in courtyards, followed by halls, rooms, and the lowest was in kitchens. Further, the highest percentage of the category "neutral" was recorded for halls (about 45 percent) and lowest for courtyards (about 16.7 percent), while the percentage of this category in rooms and kitchens was approximately equal. As indicated in figure 7.5, the daylight level in almost three-quarters of courtyards ranged from "slightly bright" to "very bright". On the other hand, the daylight level in over one-half of kitchens and in about 40 percent of rooms ranged from "slightly dim" to "very dim".

In new shelters, the daylight level in rooms is generally slightly higher than that in kitchens and corridors with about one-third of spaces was "neutral". Besides, the daylight level in over one-half of kitchens and corridors, and 44 percent of rooms ranged from "slightly dim" to "very dim" (see figure 7.6).

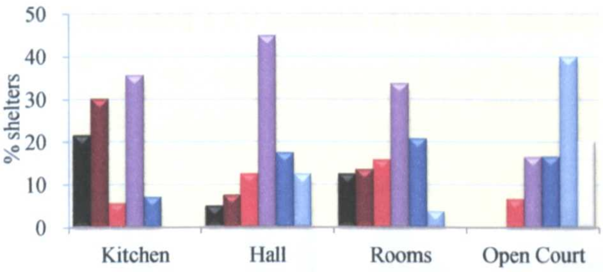


Figure 7.5: amount of daylight in old shelters in summer

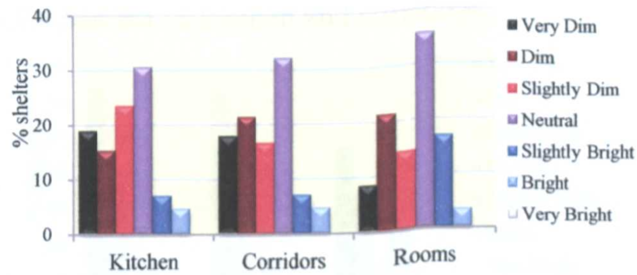


Figure 7.6: amount of daylight in new shelters in summer

As daylight levels are categorical data a comparison between old and new shelters in terms of daylight level was conducted utilizing Pearson Chi-square test for independence. The test revealed a statistically significant association between shelter type and daylight level, $\rho=.016$ (5df), with daylight level tends to be lower in new shelters. Figure 7.7 shows daylight level in both old and new shelters as a total in all spaces.

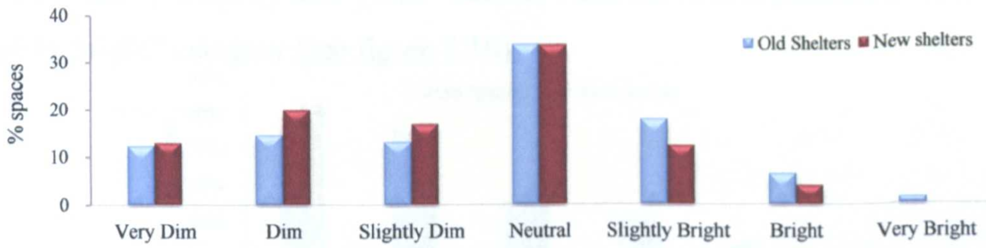


Figure 7.7: amount of daylight in new & old shelters in summer

Nearly 50 percent of new shelters and 40 percent of old shelter got low daylight levels "very dim, dim, and slightly dim", while 16 percent of new shelters and 25 percent of old shelters got high daylight levels "very bright, bright, and slightly bright". However, the percentage of "neutral" level in old and new shelters is similar and represents nearly one-third of shelters.

b. Daylight in winter:

In old shelters, overall, the lowest daylight level was reported for kitchens, followed by rooms, halls, and the highest was in courtyards. As indicated by figure 7.8, over one-half of kitchens, one-third of rooms, 20 percent of halls, and only 6.7 percent of courtyards fell into the daylight category "very dim". Moreover, the low level of light; including slightly dim, dim, and very dim, was recorded for the vast majority of kitchens (95.7 percent), around 90 percent of rooms, three-quarter of halls, and over one-half of courtyards.

In new shelters, kitchens were the lowest in daylight level followed by corridors, and the highest was in rooms. "Very dim" category was the highest daylight level among the other levels reported in all spaces. No daylight level higher than "neutral" was found in new shelters as shown in figure 7.9. Besides, "neutral" category represented 13.9 percent of rooms, and only 5.9 percent of kitchen and corridors.

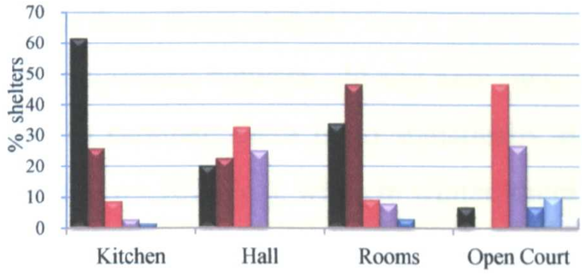


Figure 7.8: amount of daylight in old shelters in winter

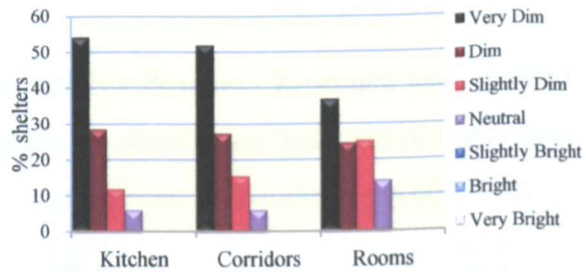


Figure 7.9: amount of daylight in new shelters in winter

For a comparison between old and new shelters, Pearson Chi-square test revealed a statistically significant association between the type of shelters in terms of daylight level ($p<.001$, 4df), with daylight level tends to be lower in new shelters. The highest percentage of total spaces is approximately recorded for "very dim" category , followed by "dim", "slightly dim", then "neutral", and the lowest percentage is recorded for "slightly bright" category (see figure 7.10).

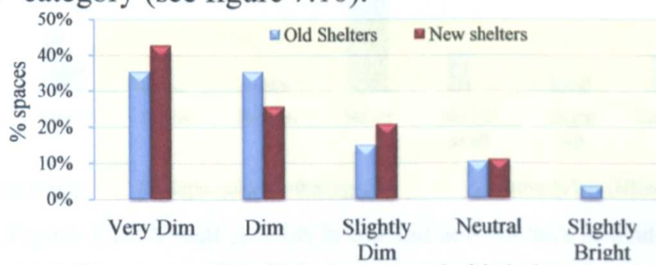


Figure 7.10: amount of daylight in new and old shelters in winter

It can be concluded from the above analysis that the amount of daylight in old and new shelters is generally low particularly in winter, with being lower in new shelters than in old shelters.

7.3.2 Visual Comfort

As indicated in chapter 3 of this thesis, visual comfort could be achieved by a sufficient amount of light for the required visual task, uniform distribution, and the absence of glare. In order to investigate visual comfort in SHC shelters, occupants were asked different questions related to this matter

First of all, occupants were asked to indicate the frequency that the amount of daylight allows them to see clearly. A four-category scale was provided comprising:

always-often-seldom-never. As revealed by the survey, no cases were recorded "never" and "always" categories for summer and for winter respectively. As shown in figure 7.11, for summer, the distributions of both old and new shelters across the three categories are approximately similar, with the highest recorded percentage (about 43 percent) was for "often" category in new shelters. For winter, the highest percentage (around 67 percent of old shelters and 38 percent of new shelters) was reported for "seldom" category where the occupants indicated that the amount of daylight rarely allows them to see clearly.

A comparison between old and new shelters utilizing Pearson Chi-square test revealed that; in summer, there is no statistically significant association between old and new shelters, ρ=.102 (2df), while in winter, there is a significant association, ρ=.002 (2df).

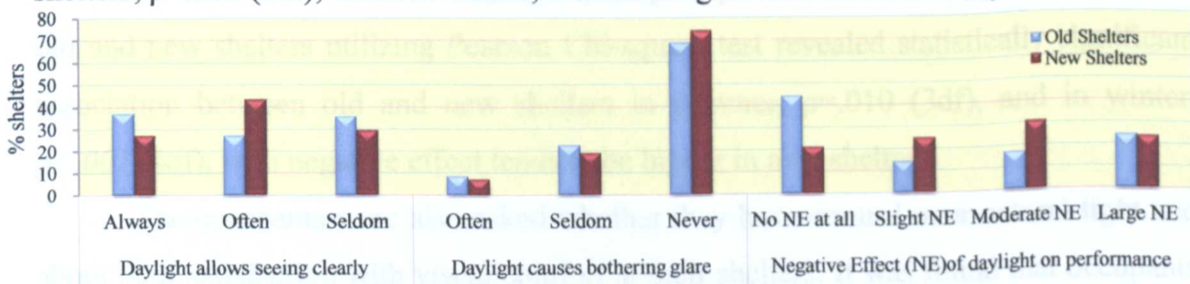


Figure 7.11: Visual comfort in old and new shelters in summer

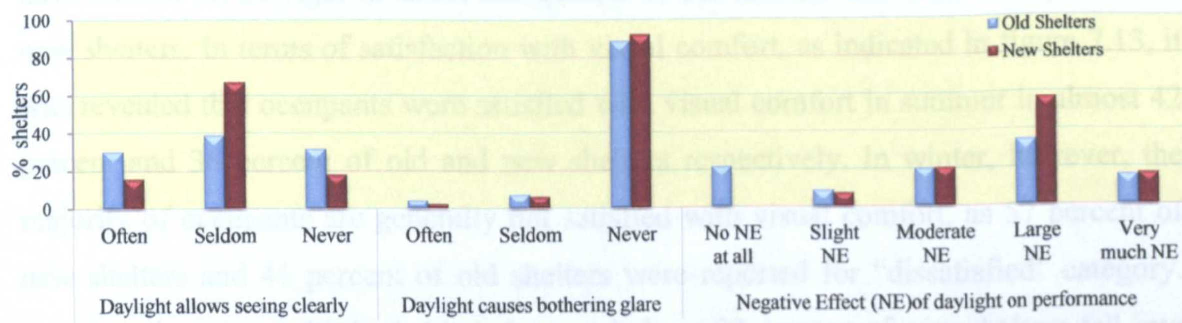


Figure 7.12: Visual comfort in old and new shelters in winter

To examine the visual comfort in SHC shelter, the occupants were also asked to indicate the frequency that daylight causes glare strong enough to bother them. The survey revealed that daylight never cause any glare in vast majority of shelters (91.8 percent of new and 88.6 percent of old shelters) through winter days. In summer, almost three-quarter of new shelters and two-third of old shelters never experienced glare. For a comparison between old and new shelters, Pearson Chi-square test revealed no statistically significant association between the two groups of shelters in terms of glare in both summer (ρ=.748) and winter (ρ=.747).

Moreover, the effect of daylight quality on occupants` performance was examined. As indicated in figure 7.11, the quality of daylight in summer has no negative effect on occupants` performance in 44 percent of old shelters, while it has large negative effect in almost one-quarter of old shelters. The distribution of new shelters, in terms of the negative effect of daylight on occupants `performance, is approximately uniform across four-categories ranging from "no negative effect at all" to "large negative effect", with the highest percentage recorded for "moderate negative effect" (about 30 percent of new shelters). No case in summer, for both old and new shelters, was reported for "very much negative effect".

In winter, as shown in figure 7.12, the quality of daylight has large negative effect on occupants` performance in over one-half of new shelters and almost one-third of old shelters. No case of new shelters in winter was recorded for "no negative effect at all" category, while around 21 percent of old shelters were recorded for that category.

In terms of the effect of daylight quality on performance, a comparison between old and new shelters utilizing Pearson Chi-square test revealed statistically significant association between old and new shelters in summer, ρ=.010 (3df), and in winter, *p<.001* (4df), with negative effect tends to be higher in new shelters.

The occupants were also asked whether they have control over natural light and about their satisfaction with visual comfort at their shelters. It was found that occupants have control on daylight in about one-quarter of old shelters and almost 70 percent of new shelters. In terms of satisfaction with visual comfort, as indicated in figure 7.13, it was revealed that occupants were satisfied with visual comfort in summer in almost 42 percent and 36 percent of old and new shelters respectively. In winter, however, the majority of occupants are generally not satisfied with visual comfort, as 57 percent of new shelters and 41 percent of old shelters were reported for "dissatisfied" category. Besides, almost one-third of old shelters and about 22 percent of new shelters fell into "very dissatisfied" category. A comparison between old and new shelters applying Pearson Chi-square test revealed no statistically significant association between old and new shelters in terms of visual satisfaction in both summer (ρ=.600, 3df), and winter (ρ=.054, 3df).

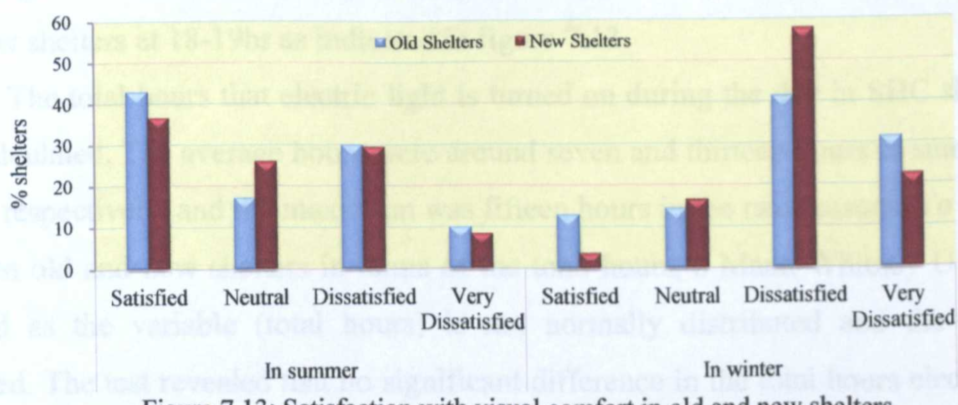


Figure 7.13: Satisfaction with visual comfort in old and new shelters

To sum up, the results indicate that the quality of daylight in SHC shelters is overall not sufficient enough to achieve visual comfort for occupants, particularly in winter. Further, quality of daylight in new shelters is generally worse than that in old shelters. Subsequently, there is no satisfaction with visual comfort in majority of shelters during winter and around 40 percent of shelters during summer.

7.3.3 Using of Electric Light

To evaluate the quality of visual environment in SHC shelters, the use of electric light through summer and winter days is also inspected. Figure 7.14 represents the use of electric light through winter and summer days as a percentage of shelters.

a. In winter: it was revealed that electric lights are turned on through all the daytime (from about 6:00hr to 20:00hr) in majority of shelters (around 81 percent of old and new shelters). The percentage of shelters using electric light starts to increase gradually after 14:00hr until reaching its peak at 16-17hr and 17-18hr in old and new shelters respectively. The percentage of old shelters is slightly higher than the percentage of new shelters in terms of using electric lights.

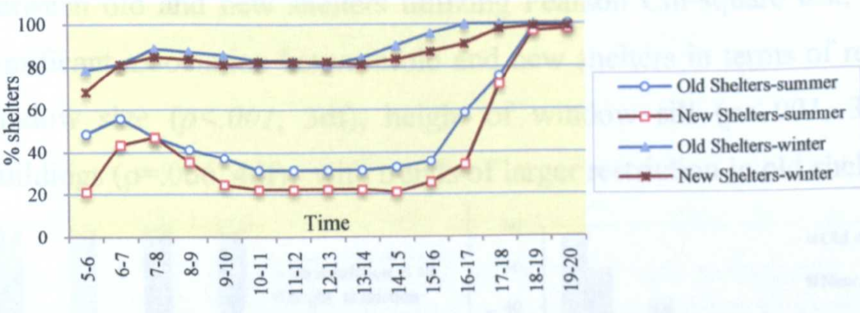


Figure 7.14: Using electric light in SHC shelters

b. In summer: the percentage of shelters turning on electric light through the morning reaches a peak of 55.7 percent at 6-7hr and 47.1 percent at 7-8hr in old and new shelters respectively. After morning peak, there is a steady drop to about 21 percent and 31 percent of new and old shelters respectively. In the afternoon, after 15:00hr, the percentage of shelters increased gradually reaching peaks of 100 and 99 percent of old and new shelters at 18-19hr as indicated in figure 7.13.

The total hours that electric light is turned on during the day in SHC shelters is also calculated. The average hours were around seven and thirteen hours in summer and winter respectively, and the maximum was fifteen hours in the two seasons. To compare between old and new shelters in terms of the total hours, a Mann-Whitney U test was utilized as the variable (total hours) is not normally distributed and the data are unpaired. The test revealed that no significant difference in the total hours electric light turned on in winter days in old SHC shelters (Md=15, n=70) and new SHC shelters (Md=15, n=85), ρ=.475. While it revealed a significant difference in the total hours electric light turned on in summer days in old SHC shelters (Md=5 , n=70) and new SHC shelters (Md=4, n=85), ρ=.049.

7.3.4 View Out

Provision of views and connection to outside have become a predominant aim for creating a good indoor visual environment in addition to provide adequate daylight to interiors. Therefore, outside view was evaluated in SHC shelters, and its importance to the occupants was investigated.

a. View restriction: First of all, elements that may restrict view outside, such as window size, height of window sill, and surrounding buildings, were explored. As shown in figure 7.16, survey revealed that surrounding buildings causes the largest restriction for view, across the other elements, in both old and new shelters. Window size and sill height cause restriction ranging from "slight restriction" to "very much restriction" in vast majority of old shelters, and about 40 percent of new shelters. A comparison between old and new shelters utilizing Pearson Chi-square test, revealed statistically significant association between old and new shelters in terms of restriction caused by window size ($p<.001$, 3df), height of window sill ($p<.001$, 3df), and surrounding buildings (ρ=.006, 4df), with trends of larger restriction in old shelters.

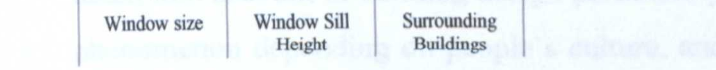


Figure 7.15: View restriction in SHC shelters

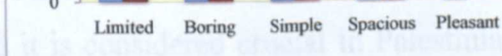


Figure 7.16: Quality of outside view in shelters

b. View description: Quality and types of outside views of SHC shelters were also investigated. "Limited" view and "simple" view were recorded in almost one-half and one-third of SHC shelters respectively, while "spacious" view was reported for only 2.9 percent and 4.7 percent of old and new shelters respectively (see figure 7.15). Besides, "boring" view was recorded for slightly higher two-fifth of old shelters and about 18 percent of new shelters, while "pleasant" view was recorded for a mere 1.4 percent of old shelters.

For a comparison between old and new shelters, Pearson Chi-square test revealed no statistically significant association between the two groups of shelters in terms of "simple" view (ρ=.398), "limited" view (ρ=.290), "spacious" view (ρ=.564), and "pleasant" view (ρ=.265). However, a significant association between the two groups of shelters was revealed in terms of "boring" view (ρ=.002), with higher trend in old shelters.

c. ***View importance:*** Finally, the importance of view for the occupants was inspected revealing that it is important of different degree ranging from "slightly important to "very much" important with no cases recorded for "not at all" category. The highest percentage of shelters fell into "moderately important" category which is about one-half of new shelters and one-third of old shelters. See figure 7.17 for the distribution of shelters according to view importance.

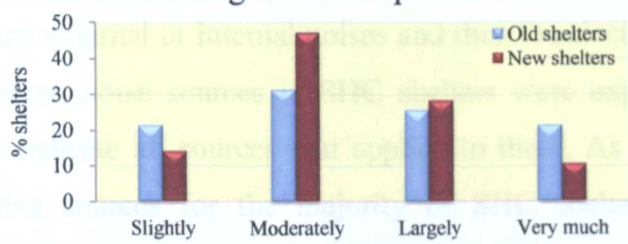


Figure 7.17: Importance of view outside for SHC shelters` occupants

To conclude, the overall findings indicate that view outside SHC shelters are generally simple and limited, and restricted largely by surrounding buildings. Besides, window size and sill height restrict the outside view as well, particularly in old shelters. As an average, view out is moderately important for SHC shelters occupants.

7.3.5 Visual Privacy

Visual privacy is one of the aspects of indoor visual environment that should be taken into account in building design particularly residential buildings. It is a subjective phenomenon depending on people`s culture, and it is considered crucial in Palestinian society. Therefore, occupants' satisfaction with visual privacy was inspected. The survey revealed that the occupants are satisfied with visual privacy in slightly over one-quarter of old shelters and less than one-half of new ones, while they are dissatisfied in around one-quarter of old and new shelters. Besides, as shown in figure 7.18, almost one-quarter of old shelters and a mere 4.7 percent of new shelters fell into "very dissatisfied" category, while no cases fell into "very satisfied" category.

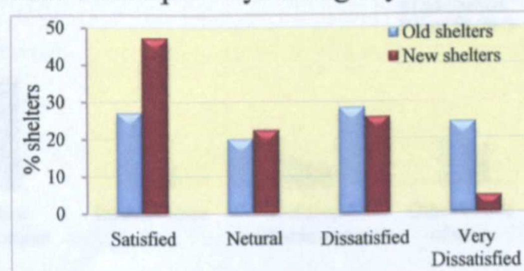


Figure 7.18: occupants' satisfaction with visual privacy

A comparison between old and new shelters utilizing Pearson Chi-square test revealed a statistically significant association between old and new shelters in terms of satisfaction with visual privacy (ρ=.002, 3df), with more satisfaction in new shelters than in old shelters.

7.4 ACOUSTIC ENVIRONMENT

The quality of the indoor environment depends also on several aspects of sound. Noise levels in SHC shelters were investigated and occupants' satisfaction with these levels was explored as well. Further, noise sources were surveyed. Findings are discussed below.

7.4.1 Noise Source

The first step in controlling noise in buildings is to determine noise sources whether they are external or internal noises and then to select the appropriate means for control. Therefore, noise sources in SHC shelters were explored, where respondents were asked to indicate all sources that applied to them. As shown in figure 7.19, the highest recorded sources for the majority of SHC shelters (ranging from 83-100 percent), were "children playing in neighbouring areas", "people passing in the street", and "people talking in neighbouring areas" . Noise generated from "outdoor traffic" was reported to over one-half of SHC shelters, while "outdoor mechanical noise" was reported for only 14.3 percent and 10.6 percent of old and new shelters respectively. Other external noise sources, which were reported for over one-fifth of SHC shelters, included "hawkers", "neighbours` electricity generators", "schools", "kindergartens", and "the market". On the other hand, internal noise was found in one-fifth of old shelters and a mere 11 percent of new shelters.

For a comparison between old and new shelters, Pearson Chi-square test revealed no statistically significant association between the two groups of shelters in terms of noise sources, with ρ ranges between 0.1 and 0.48 (1df).

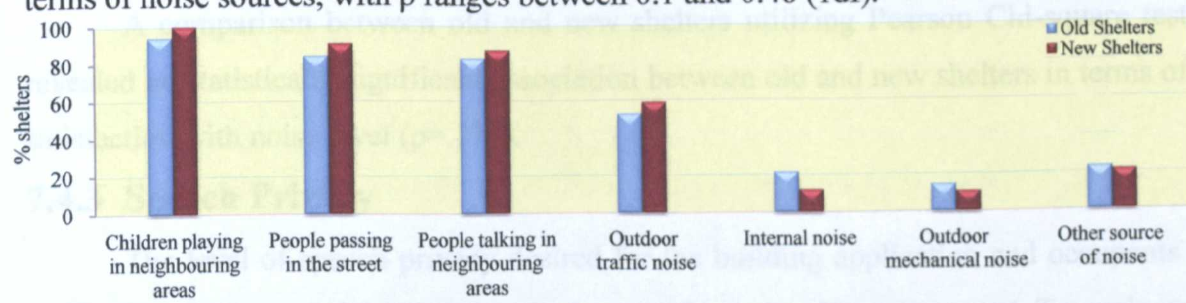


Figure 7.19: Noise sources in old and new shelters

7.4.2 Noise Level and Occupants Satisfaction

Noise level in SHC shelters was evaluated by asking respondents to rate the noise level at their shelters using a five-point scale "too much noise-noisy-neutral-calm-very calm". As indicated in figure 7.20, over one-half of respondents rated their shelters to be "neutral", while less than 40 percent of old shelters and one-quarter of new shelters were recorded to be "noisy". Low percentages (4.3 to 11.8) were reported for "too much noise" and "calm" categories, and no cases were reported for "very calm" category. For comparison between old and new shelters, no statistically significant association between the two groups was indicated by Pearson Chi-square test, ρ=.149, (3df).

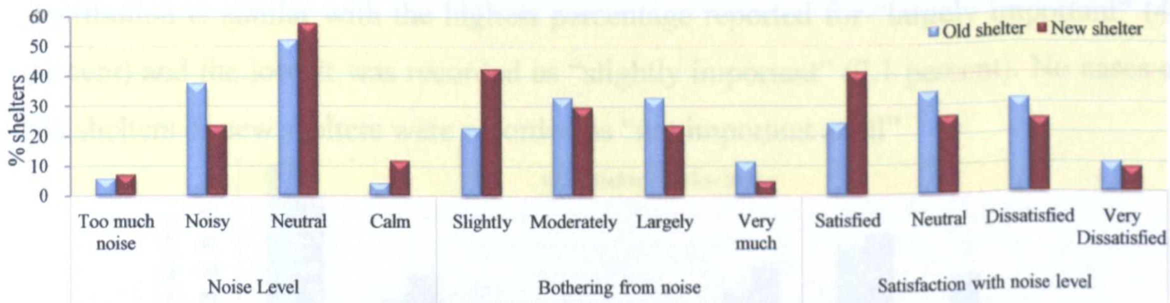


Figure 7.20: Noise level and occupants satisfaction in old and new shelters

To evaluate occupants' satisfaction with noise level, they firstly were asked whether distraction from noise bother them, then were asked to indicate their satisfaction. The distributions of shelters among scale`s options in the two questions were almost compatible, as shown in figure 7.20. The survey revealed, in new shelters, almost 40 percent of respondents are satisfied with noise level, while about one-quarter of them are dissatisfied and a mere 8.2 percent of respondents are very dissatisfied. In old shelters, almost one-quarter of respondents are satisfied with noise level, while about one-third of them are dissatisfied and only 10 percent of respondents are very dissatisfied. The rest of respondents indicated their neutral, which accounted for one-quarter of new shelters and one-third of old shelters.

A comparison between old and new shelters utilizing Pearson Chi-square test revealed no statistically significant association between old and new shelters in terms of satisfaction with noise level (ρ=.177).

7.4.3 Speech Privacy

The level of speech privacy desired for the building application and occupants` preferences is an essential aspect in creating comfort acoustic environment. To evaluate the level of speech privacy in SHC shelters, occupants were asked whether they overhear their neighbours` private conservation. In addition, the importance of speech privacy for respondents was measured. The results are presented in figure 7.21. It is concluded that the level of speech privacy is generally not sufficient as around 60 percent of respondents "always" overhear their neighbours` private conservation, almost one-quarter were reported for "often overhear", and no cases were reported for "never overhear".

In terms of the importance of speech privacy to the occupants, the highest percentage in new shelters was recorded as "largely important" (43.5 percent), followed by "moderately important" (31.8 percent), then "slightly important" (12.9 percent), and the lowest was recorded as "very much important" (11.8 percent). In old shelters the distribution is similar with the highest percentage reported for "largely important" (40 percent) and the lowest was recorded as "slightly important" (7.1 percent). No cases of old shelters or new shelters were recorded as "not important at all"

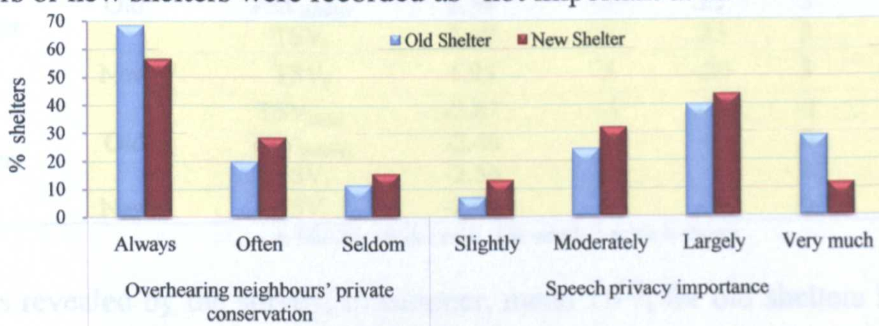


Figure 7.21: Speech privacy in old and new shelters

For a comparison between old and new shelters, Pearson Chi-square test revealed no statistically significant association between the two groups of shelters in terms of speech privacy level (ρ=.302, 2df), or importance (ρ=.052, 3df).

To sum up, there are several external noise sources demonstrated by the majority of occupants of SHC shelters. In terms of noise level, the highest percentage of shelters was rated as "neutral" (52.2 and 57.6 percent), followed by "noisy" (37.7 and 23.5 percent) of old and new shelters respectively. Further, speech privacy which proved to be important for the occupants was insufficient for people desires.

7.5 THERMAL ENVIRONMENT

Thermal environment, the main focus of this study, plays the major role among the other indoor conditions in human comfort and has the greatest effect on energy consumption. Thermal comfort in SHC shelters was investigated, and reasons of discomfort in summer and winter were explored as well. Energy consumption for heating and cooling purposes was also inspected. The findings are presented and discussed in the following subsections.

7.5.1 Thermal Sensation Vote (TSV) in Summer and Winter

Occupants of SHC shelters were asked to rate their thermal comfort in every space of their shelters; including rooms, halls, kitchens and courtyards, utilizing a seven-point thermal sensation scale ranging from cold (−3) to hot (+3). Thermal sensation vote for new shelters is then calculated for the whole shelter (TSV_t) by computed the average thermal sensation votes for all spaces, while for old shelters it is calculated for the indoor spaces (TSV_{indoor}) and for the whole shelter including courtyards (TSV_t). The results for old and new shelters are presented in table 7.2.

Table 7.2: Thermal Sensation Vote TSV in old and new shelters in summer and winter

Season	Shelter type	TSV	Mean	Mode	Min.	Max.	Std.Dev.
Summer	Old	TSV_{court}	1.41	.00[a]	0	3	1.15
		$TSV_{indoors}$	2.59	3	.25	3	0.66
		TSV_t	2.48	3	.25	3	0.66
	New	TSV_t	1.95	3	-.25	3	1.05
Winter	Old	TSV_{court}	-2.87	-3	-3	-1	0.43
		$TSV_{indoors}$	-2.46	-3	-3	0	0.77
		TSV_t	-2.50	-3	-3	-.17	0.72
	New	TSV_t	-2.07	-3	-3	0	1.03

a. Multiple modes exist. The smallest value is shown

As revealed by the survey, in summer, mean TSV_t for old shelters is over (+2), though for courtyards is less than (+2), (TSV_{court}= +1.41), which is lower than that for indoor spaces ($TSV_{indoors}$= +2.59). In new shelters, mean TSV_t in summer is slightly lower (+2). On the other hand, in winter, mean TSV_t for both old and new shelters is lower than (-2), with the highest reported for new shelters (TSV_t= -2.07), followed by indoor spaces of old shelters ($TSV_{indoors}$= -2.46), and the lowest reported for courtyards (TSV_{court}= -2.87).

For a comparison between the two groups of shelters, preliminary analyses were performed first to examine the normality of TSV in summer and winter for the both groups of old and new shelters. The normality test revealed that TSVs are not normally distributed (see figure 7.22); therefore, non-parametric test Mann-Whitney U is applied to compare TSV in old shelter with TSV in new shelters

In summer, a Mann-Whitney U test revealed a statistically significant difference in TSV for old SHC shelters (n=70) and TSV for new SHC shelters (n=85), ρ=.004, with a small effect size (r=.23). The median of TSV for old shelters (Md=2.75) is higher than the median of TSV for new SHC shelters (Md=2.2) as indicated in figure 7.23.

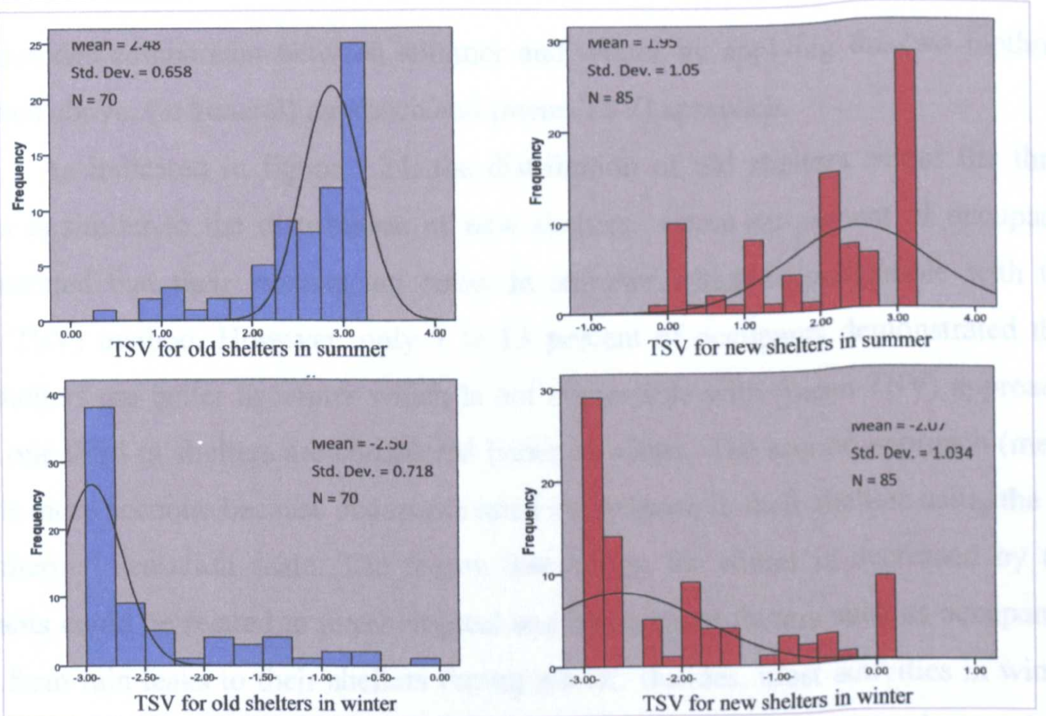


Figure 7.22: TSV distribution for old and new shelters, in summer and winter

In winter, a Mann-Whitney U test revealed also a significant difference in TSV for old SHC shelters and TSV for new SHC shelters, ρ=.010, with a small effect size (r=.21). The median of TSV for old shelters (Md=-2.87) is lower than the median of TSV for new SHC shelters (Md=-2.6).

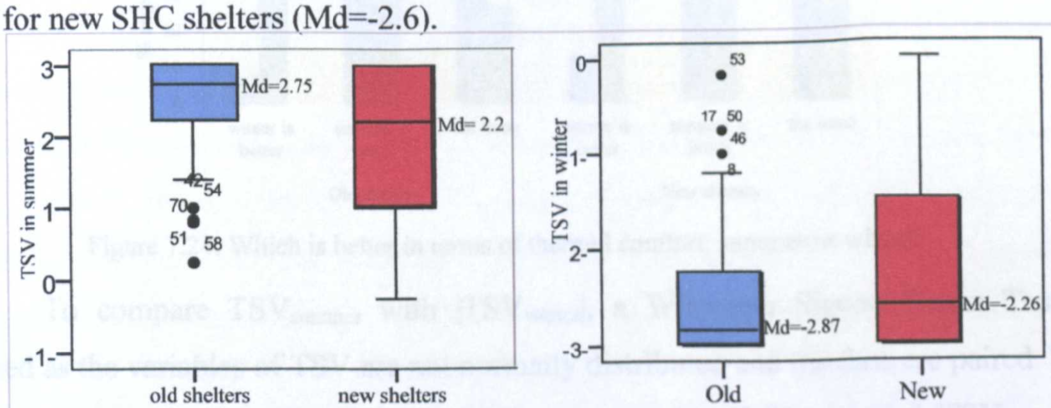


Figure 7.23: Boxplots of TSV distribution for old and new shelters, in summer and winter

For a comparison between summer and winter, occupants were asked to indicate in which season they think that their shelters are better in terms of thermal comfort, by providing them three option for selection (in winter– in summer– the same). Another approach for the comparison is also applied by inspecting TSV_t which calculated earlier as the average for all spaces, for summer and that for winter. In this approach, the absolute value of TSV in winter $|TSV_{winter}|$ is used, then winter is considered better when ($TSV_{summer} > |TSV_{winter}|$), summer is considered better when ($|TSV_{winter}| > TSV_{summer}$), and they are considered the same when ($TSV_{summer} = |TSV_{winter}|$). Figure

7.24 provides comparison between summer and winter by applying the two methods explained above; (in general) approach and (mean TSV) approach.

As indicated in figure 7.24, the distribution of old shelters across the three options is similar to the distribution of new shelters. About 40 percent of occupants demonstrated that their shelters are better in summer which is compatible with the (mean TSV) method. However, only 7 to 13 percent of occupants demonstrated that their shelters are better in winter which is not compatible with (mean TSV) approach, where one-third of shelters are considered better in winter. The second approach (mean TSV) is more accurate because occupants rated every space in their shelters using the 7–point thermal sensation scale. The reason that voting for winter is decreased by the occupants could be related to psychological and behavioural factors such as occupants` suffer from rain leaks to their shelters during winter. Besides, most activities in winter have to be done indoors, unlike summer where many activities are done outdoors, where the thermal environment is more comfortable than indoor condition.

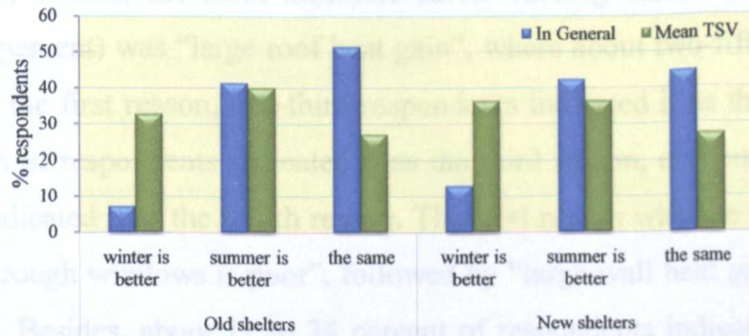


Figure 7.24: Which is better in terms of thermal comfort: summer or winter?

To compare TSV_{summer} with $|TSV_{winter}|$, a Wilcoxon Signed Ranks Test is utilized as the variables of TSV are not normally distributed and the data are paired. The test revealed no statistically significant difference between TSV_{summer} and $|TSV_{winter}|$ in both old SHC shelters (ρ=.574) and new SHC shelters (ρ=.44) with very small effect size (r=.05 in old shelter and r=.06 in new shelters). In old shelters, the median of TSV_{summer}, Md=2.75 is close to median of $|TSV_{winter}|$, Md=2.87. In new shelters, the median of TSV_{summer}, Md=2.2, is also similar to median of $|TSV_{winter}|$, Md=2.26.

To sum up, indoor thermal environment during summer and winter is not comfortable in both old and new shelters; with trend to be worse in old shelters. Further, in inspecting which season is worse in terms of thermal comfort, summer or winter, it was revealed no significant difference between them.

7.5.2 Reasons of Discomfort in Summer

Factors that cause thermal discomfort in SHC shelters were examined by asking occupants to indicate the reasons that make their shelters hot and to mark these reasons in the order of their influences. Figures 7.25 and 7.26 represent reasons of discomfort during summer in old and new shelters respectively.

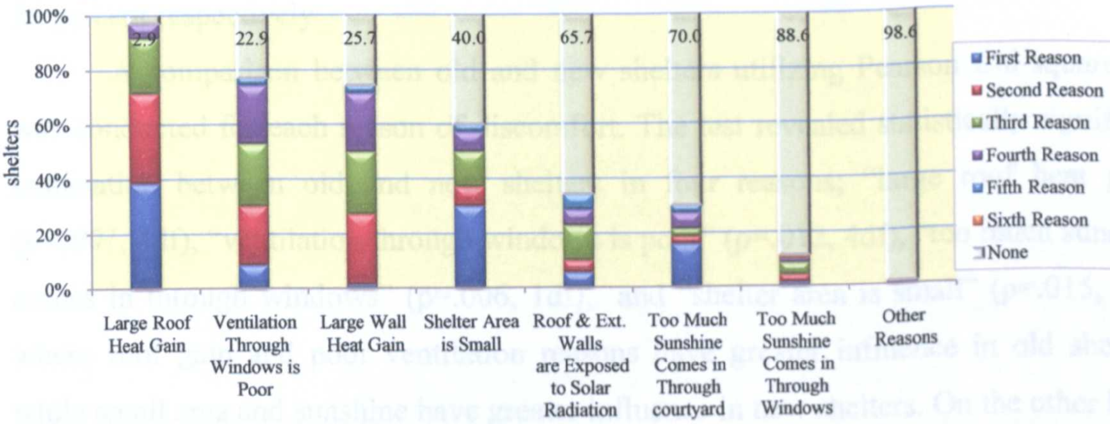


Figure 7.25: Reasons of discomfort in old shelters in summer

In old shelters, overall, the most influence factor causing discomfort in majority of shelters (97.1 percent) was "large roof heat gain", where about two-fifth of respondents indicated it as the first reason, one-third respondents indicated it as the second reason, about one-fifth of respondents indicated it as the third reason, and only 5.7 percent of respondents indicated it as the fourth reason. The next reason with the most influence is "ventilation through windows is poor", followed by "large wall heat gain", and "shelter area is small". Besides, about 11 to 34 percent of respondents indicated other reasons including "roofs and external walls are exposed to solar radiation", "too much sunshine comes in through windows", and "too much sunshine comes in through courtyards".

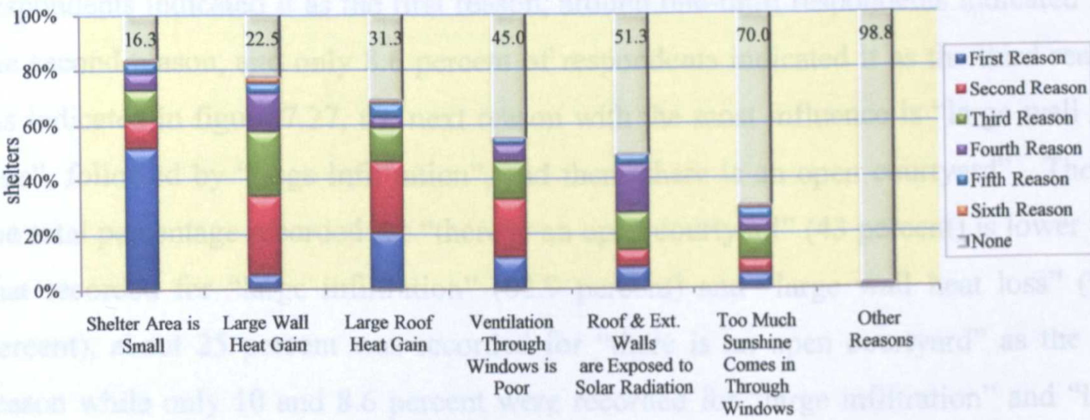


Figure 7.26: Reasons of discomfort in new shelters in summer

In new shelters, overall, the most influence factor causing discomfort in majority of shelters (83.7 percent) was "shelter area is small", followed by "large wall heat gain" (78 percent), "large roof heat gain" (69 percent), and "ventilation through windows is poor" which accounted for 55 percent of shelters. Though the total percentage recorded for wall heat gain is higher than that recorded for roof, only 5 percent was recorded for walls as the first reason while 20 percent was recorded for roof as the first reason. The remaining reasons, which are "roofs and external walls are exposed to solar radiation" and "too much sunshine comes in through windows", were reported for 48 percent and 30 percent respectively

A comparison between old and new shelters utilizing Pearson Chi-square test was conducted for each reason of discomfort. The test revealed statistically significant association between old and new shelters in four reasons; "large roof heat gain" ($p<.001$, 4df), "ventilation through windows is poor" (ρ=.012, 4df), "too much sunshine comes in through windows" (ρ=.006, 1df), and "shelter area is small" (ρ=.015, 4df), where roof gain and poor ventilation reasons have greater influence in old shelters, while small area and sunshine have greater influence in new shelters. On the other hand, no statistically significant association between old and new shelters was revealed in terms of the rest reasons; "roofs and external walls are exposed to solar radiation" and "too much sunshine comes in through windows".

7.5.3 Reasons of Discomfort in Winter

Reasons of thermal discomfort in winter were explored by asking occupants to indicate the reasons that make their shelters cold in winter and to mark these reasons in order of their influences.

In old shelters, overall, the most influence reason of thermal discomfort in majority of shelters (92.9 percent) was "large roof heat loss", where over one-half of respondents indicated it as the first reason, around one-third respondents indicated it as the second reason, and only 8.6 percent of respondents indicated it as the third reason. As indicated in figure 7.27, the next reason with the most influence is "large wall heat loss", followed by "large infiltration", and then "there is an open courtyard". Though the total percentage recorded for "there is an open courtyard" (43 percent) is lower than that recorded for "large infiltration" (62.9 percent) and "large wall heat loss" (91.4 percent), about 25 percent was recorded for "there is an open courtyard" as the first reason while only 10 and 8.6 percent were recorded for "large infiltration" and "large wall heat loss" respectively as the first reason. Furthermore, a total of 35 percent of respondents indicated "the shelter is shaded by surrounding buildings" as one of the reasons of discomfort, and a total of 30 percent is recorded for "very little sunshine comes in through windows".

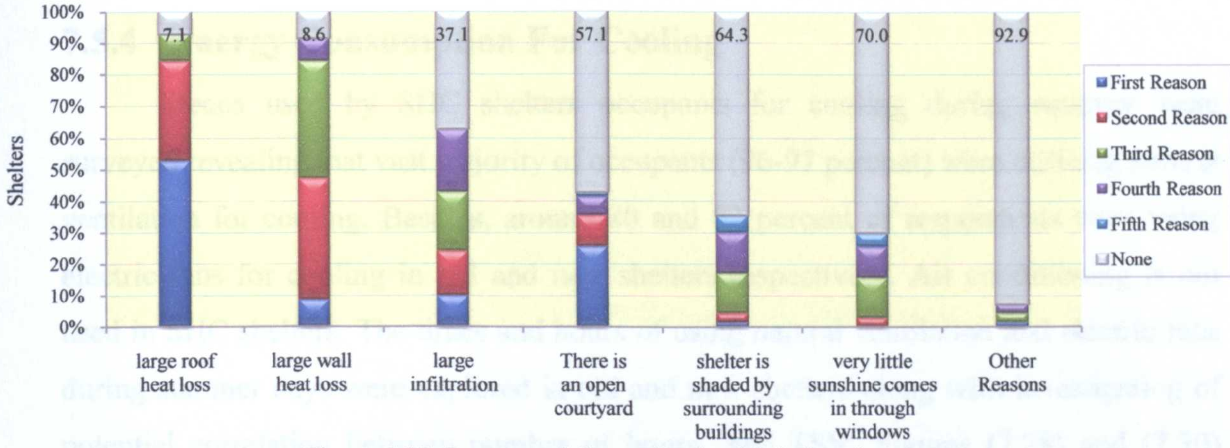


Figure 7.27: Reasons of discomfort in old shelters in winter

In new shelters, overall, the most influence factor causing discomfort in majority of shelters (83.7 percent) was "large wall heat loss", followed by "the shelter is shaded by surrounding buildings" (72.5 percent), "very little sunshine comes in through windows" (71.2 percent), and "large roof heat loss" which accounted for 62.5 percent of shelters. Though "large roof heat loss" appeared in the fourth place as total percentage, it got the highest recorded percentage as the first reason (27.5 percent). As shown in figure 7.28, the last reason "large infiltration" was reported for only 13.7 percent of new shelters.

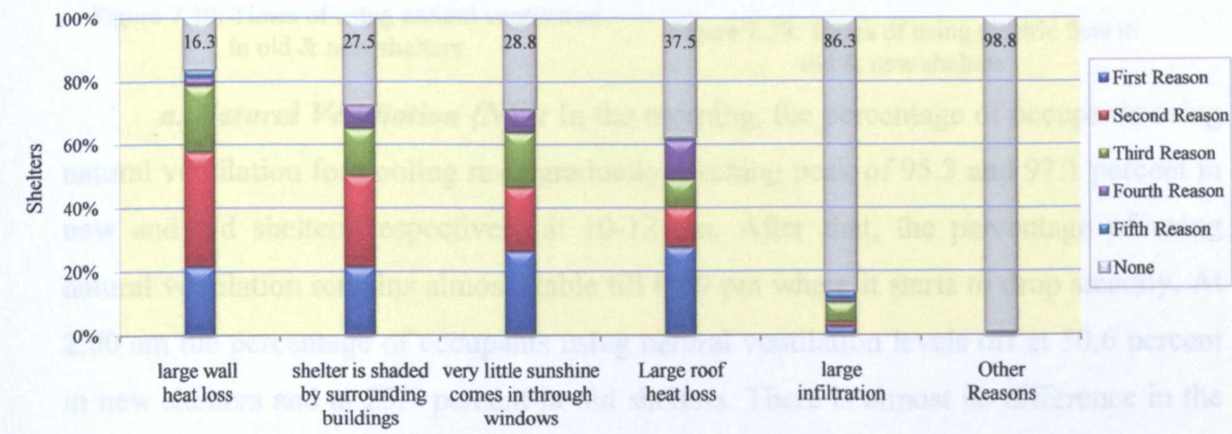


Figure 7.28: Reasons of discomfort in new shelters in winter

A comparison between old and new shelters utilizing Pearson Chi-square test revealed statistically significant association between old and new shelters in all factors; "large roof heat loss" ($p<.001$, 4df), "large infiltration" ($p<.001$, 1df), "very little sunshine comes in through windows" ($p<.001$, 4df), "the shelter is shaded by surrounding buildings" ($p<.001$, 4df), and "large wall heat loss" ($p=.027$, 3df), where roof loss and infiltration reasons have greater influence in old shelters, while the rest factors have greater influence in new shelters.

7.5.4 Energy Consumption For Cooling

Means used by SHC shelters occupants for cooling during summer were surveyed revealing that vast majority of occupants (96-97 percent) were utilizing natural ventilation for cooling. Besides, around 80 and 82 percent of respondents were using electric fans for cooling in old and new shelters respectively. Air conditioning is not used in SHC shelters. The times and hours of using natural ventilation and electric fans during summer days were explored in old and new shelters along with investigating of potential correlation between number of hours and TSV. Figures (7.29) and (7.30) show times of using fans and natural ventilation respectively through 24 hours.

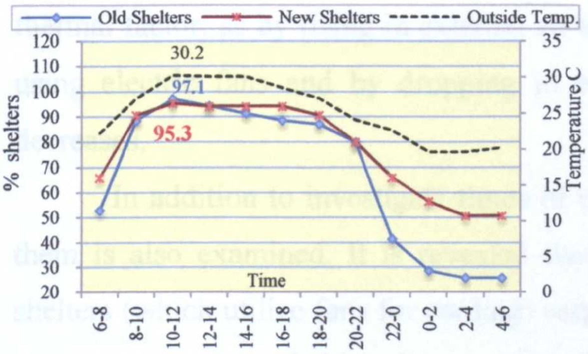


Figure 7.30: Times of using natural ventilation in old & new shelters

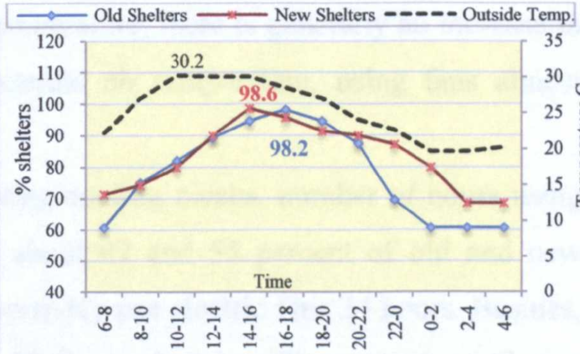


Figure 7.29: Times of using electric fans in old & new shelters

a. Natural Ventilation (NV): In the morning, the percentage of occupants using natural ventilation for cooling rises gradually reaching peak of 95.3 and 97.1 percent in new and old shelters respectively at 10-12 am. After that, the percentage of using natural ventilation remains almost stable till 8:00 pm where it starts to drop steadily. At 2:00 am the percentage of occupants using natural ventilation levels off at 50.6 percent in new shelters and at 25.7 percent in old shelters. There is almost no difference in the percentage of using NV between old and new shelter during the day, while in the evening and during the night using NV in new shelters tends to be higher with a maximum difference of 25 percent.

As shown in figure 7.29, the trend of external temperature is similar to the trend of percentage of using NV, where external temperature and using NV reach peak in the morning and both drop during the night. Subsequently, it could be concluded that using natural ventilation in SHC shelters is more affected with other factors than it is affected with thermal factor. Most of the occupants close windows during the night (where external temperature falls down and windows should be opened to allow for night ventilation) seeking for more security, or more visual privacy, or to avoid hazards (more details about reasons to close windows is provided later in section 7.7.4).

b. Electric Fans: Overall, percentage of using electric fans for cooling is higher than that of NV with minimum of 60.07 percent and 68.6 percent in old and new shelters respectively. In the morning, the percentage of occupants using electric fans rises gradually reaching peaks of 98.6 percent at 14-16hr in new shelters and 98.2 percent at 16-18hr in old shelters. Afterwards, in new shelters, using electric fans decreases steadily till 2:00 am where it levels off at 68.6 percent. In old shelters, using fans drops sharply from 87.5 percent at 22:00hr to 60.7 percent at midnight.

Unlike using NV, times of using electric fans are somewhat more affected by thermal factor; as by rising in external air temperature, there is generally an increase in using electric fans and by dropping in external air temperature, using fans almost decreases.

In addition to investigate times of using cooling means, number of hours using them is also examined. It is revealed that about 47 and 55 percent of old and new shelters (which utilize fans for cooling) respectively use electric fans 24 hours. Besides, almost one-quarter of old shelters and one-half of new shelters utilize natural ventilation 24 hours. Table 7.3 provides statistical description for the number of hours using cooling means.

Table 7.3: Descriptive statistics for number of hours using cooling means

Cooling means	Shelter Type	Mean	Mode	Median	Min.	Max.	Std.Dev.
Electric fans	old	18.68	24	24	2	24	6.97
	new	19.91	24	24	4	24	6.57
Natural ventilation	old	16.03	14	16	0	24	6.06
	new	18.56	24	24	0	24	6.55

For a comparison between old and new shelters, preliminary analyses were firstly performed to examine the normality of number of hours of using fans and NV for the both groups of old and new shelters. The normality test revealed that number of hours variables are not normally distributed; therefore, non-parametric test Mann-Whitney U is applied. The test revealed no statistically significant difference in number of hours using electric fans as cooling means in old SHC shelters with that in new SHC shelters (ρ=.339), with a very small effect size (r=.09). However, a Mann-Whitney U test revealed a significant difference in number of hours using Natural Ventilation NV as cooling means in old SHC shelters (n=70) and that in new SHC shelters (n=85), ρ=.005, with a small effect size (r=.22). The median of total hours using NV in old shelters (Md=16) is lower than the median of total hours using NV in new SHC shelters

(Md=24). Figure 7.31 shows the distribution for number of hours using NV in old and new shelters.

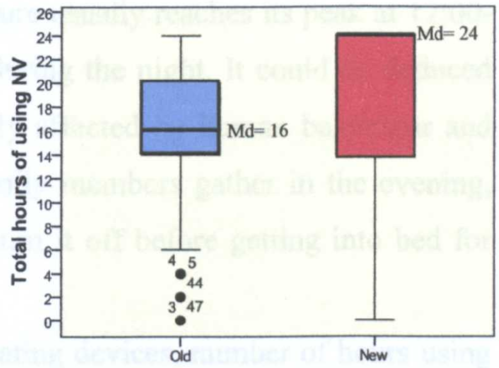


Figure 7.31: the distribution for number of hours using NV in old and new shelters.

Furthermore, potential correlations between TSV in summer and the number of hours of using fans and NV were explored using Spearman's rho Correlation Coefficient. It was revealed that there are non-significant weak positive correlations between TSV and number of hours of using Fans, r= .07, n=126, ρ=.433 and between TSV and number of hours of using NV, r= .04, n=155, ρ=.596.

7.5.5 Energy Consumption For Heating

Survey revealed that various means for heating during winter are used in SHC shelters including; electric fires, firewood, charcoal and kerosene fires. No air conditioning or gas fires are used. It is worth to mention that over one-half of SHC shelters` occupants (56.1 percent) do not use any heating means in winter which could be related to their financial conditions. The percentage of using heating means is provided in figure 7.32. Electric fires are the most used (about one-third of shelters), followed by firewood, charcoal, and the least used is kerosene fires. The times and hours of using heating means during winter days were explored in old and new shelters along with investigating of potential correlation between number of hours and TSV. Figure 7.33 shows times of using heating means in old and new shelters.

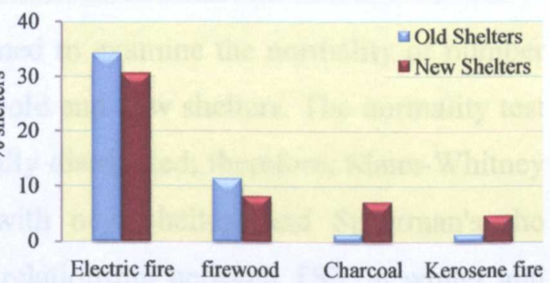


Figure 7.32: Heating means in old and new shelters

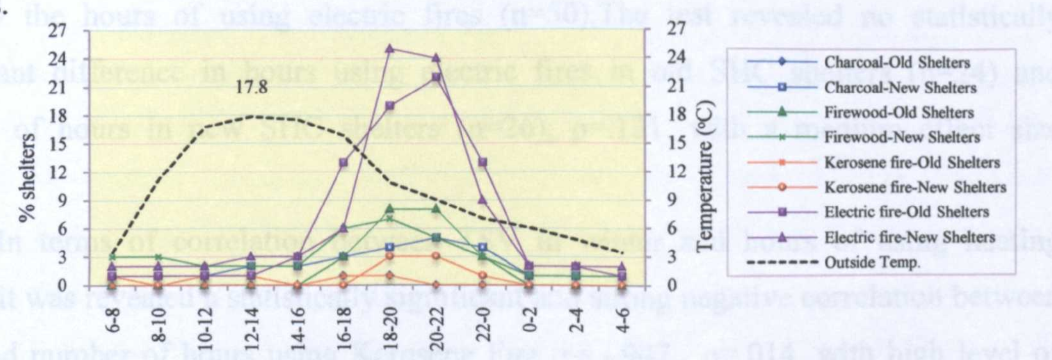


Figure 7.33: Times of using heating means in old & new shelters

As revealed by the survey, most of occupants use heating means in the evening where the percentage rises at 16:00hr reaching the peak between 18:00hr and 22:00hr then fall at the mid of the night. External temperature usually reaches its peak at 12:00-14:00hr then starts to fall down to its minimum during the night. It could be deduced that times of using heating means are significantly affected by human behaviour and activities along with thermal factor. When all family members gather in the evening, they cluster around the heating device, and they turn it off before getting into bed for safety issue.

In addition to investigate times of using heating devices, number of hours using them is also examined and statistical description is provided in table 7.4. It is obvious that the median hours range between 4-8 hours, while the minimum is two hours a day and the maximum is 24 hours a day.

Table 7.4: Descriptive statistics for number of hours using heating means

Heating Means	Shelter Type	N	Mean	Mode	Median	Min.	Max.	Std.Dev.
Kerosene fire	old	1	4	4	4	4	4	
	new	4	5	2[a]	5	2	8	2.58
Charcoal	old	1	4	4	4	4	4	
	new	6	8.7	6	6	4	24	7.55
Firewood	old	8	5.5	6	6	4	6	0.93
	new	7	10.3	4[a]	8	4	24	6.97
Electric fire	old	24	6.6	6	6	2	24	4.11
	new	26	6.3	4	4	2	24	5.14

a.Multiple modes exist. The smallest value is shown

Preliminary analyses were also performed to examine the normality of number of hours of using each heating device for both old and new shelters. The normality test revealed that the hours variables are not normally distributed; therefore, Mann-Whitney U test is applied to compare old shelter with new shelters and Spearman's rho Correlation Coefficient is utilized to find the relationship between TSV in winter and hours of using heating means. Since the numbers of users for Kerosene fire, Charcoal, and Firewood are small, the comparison between old and new shelters was performed on only the hours of using electric fires ($n=50$).The test revealed no statistically significant difference in hours using electric fires in old SHC shelters ($n=24$) and number of hours in new SHC shelters ($n=26$), $\rho=.121$, with a medium effect size ($r=.22$).

In terms of correlation between TSV in winter and hours of using heating means, it was revealed a statistically significant and strong negative correlation between TSV and number of hours using Kerosene Fire, $r= -.947$, $\rho=.014$, with high level of TSV associated with lower number of hours using Kerosene Fire. However, statistically non-significant correlations were found between TSV in winter and the rest heating means. Table 7.5 provides Spearman's rho Correlation Coefficient between TSV in winter and heating devices.

Table 7.5 : Spearman's rho correlation coefficient between TSV in winter and hours using heating means

		hours using Firewood	hours using Kerosene Fire	hours using Electric fire	hours using Charcoal
TSV in winter	Correlation Coefficient	-.403	**-.947-***	.096	.124w
	Sig. (2-tailed)	.136	**.014**	.506	.791
	N	15	5	50	7

7.6 FACTORS OF THERMAL COMFORT

Various factors that could influence thermal comfort in SHC shelters were inspected including; environmental and secondary factors along with examining the effect of floor level and envelope materials. Potential correlations between TSV and these factors were explored as well. The results and findings are discussed below.

7.6.1 Environmental Factors

Air humidity, air circulation, and indoor solar radiation in SHC shelters were investigated. Figure 7.35 provides the air humidity condition in old and new shelters during summer and winter. It is observed that majority of occupants (85.7 percent) in old shelters demonstrated that the air is too humid inside their shelters during winter, while around two-fifth and 38.8 percent of new shelters were recorded to be "too humid" and "humid" respectively.

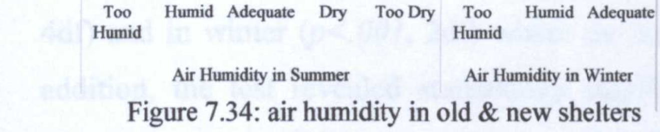


Figure 7.34: air humidity in old & new shelters

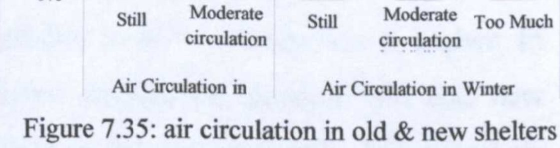


Figure 7.35: air circulation in old & new shelters

In terms of air circulation in summer, as indicated in figure 7.34, around two-third of old shelters` occupants and less than one-half of new shelters` occupants reported that the air is "still" inside their shelters, while the rest of occupants demonstrated that the indoor air circulation is moderate. In winter, "too much" air circulation was recorded for majority of old shelters and one-fifth of new shelters, while "moderate circulation" was recorded for one-fifth of old shelters and two-fifth of new shelters. The survey also revealed that almost two-third of occupants in old shelters did not have control on air circulation inside their shelters.

Indoor solar radiation was also examined in SHC shelters through surveying its access frequency to shelters a line with rating for its intensity during summer and winter. The survey revealed that, as shown in figure 7.36, solar radiation never access to almost one-half of shelters during winter and it seldom access to about 43.5 percent of new shelters and one-third of old shelters. Subsequently, almost 44 percent of new shelters` occupants and 38 percent of new shelters` occupants demonstrated that the intensity of solar radiation in their shelter is poor. In summer, as indicated in figure 7.37, solar radiation always accesses to almost one-quarter of old shelters and only 7.1 percent of new shelters while it often accesses to about two-fifth of new shelters and 23 percent of old shelters. Accordingly, almost 17 percent of new shelters` occupants and a mere 3.5 percent of new shelters` occupants demonstrated that the intensity of solar radiation inside their shelter is too much during summer. The survey also revealed that almost three-quarter of occupants in old shelters did not have control on solar radiation inside their shelters.

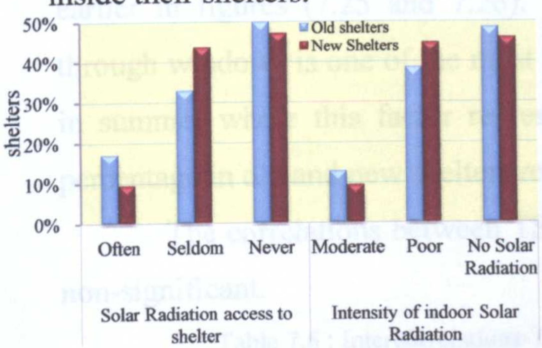


Figure 7.36: Indoor solar radiation of old & new shelters in winter

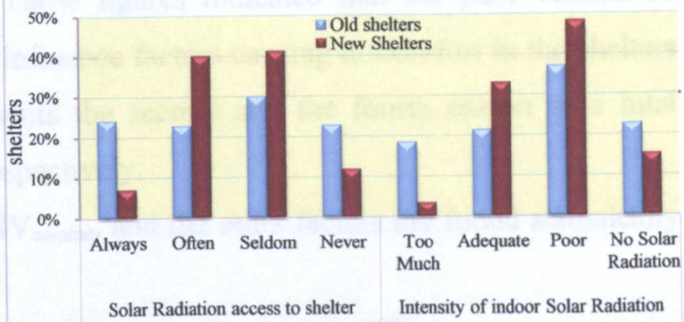


Figure 7.37: Indoor solar radiation of old & new shelters in summer

Comparisons between old and new shelters in terms of environmental factors were carried out utilizing Pearson Chi-square test. It was revealed statistically significant association between old and new shelters in air humidity in summer (ρ=.02, 4df) and in winter (*p<.001*, 2df) where air humidity level in old shelters is higher. In addition, the test revealed statistically significant association between old and new shelters in air circulation in summer (ρ=.045, 1df) and in winter (*p<.001*, 2df) where air circulation in new shelters is lower. On the other hand, no statistically significant association between old and new shelters was found in solar radiation access in winter (ρ=.226, 2df) and indoor solar radiation intensity in winter (ρ=.664, 2df). However, in summer, statistically significant association between old and new shelters was revealed in solar radiation access (ρ=.002, 3df) and indoor solar radiation intensity (ρ=.006, 3df) where access and intensity of solar radiation are higher in old shelters.

7.6.2 Correlation Between TSV and Environmental Factors

As TSV variables are not normally distributed, the relationships between TSV and the environmental factors; including air humidity, air circulation, availability, intensity and control of solar radiation, were explored for summer and winter using Spearman's rho Correlation Coefficient. In addition, the relations between these several factors were examined. The results are presented in the correlation matrixes in tables (7.6) and (7.7).

In summer: As indicated in table 7.6, the correlation analysis revealed a statistically significant moderate negative correlation between TSV_{summer} and air circulation (r= -.401, $p<.001$), with low level of air circulation associated with higher level of TSV. This means that, in summer, shelters with poor ventilation are hotter than shelters with good ventilation. It is worth to highlight that this correlation result coincides with the reasons of discomfort in summer which were surveyed and presented earlier in figures (7.25 and 7.26). These figures indicated that the poor ventilation through windows is one of the most influence factors causing discomfort in the shelters in summer where this factor represents the second and the fourth reason as a total percentage in old and new shelters respectively.

The correlations between TSV_{summer} and the other factors are found statistically non-significant.

Table 7.6 : Intercorrelations-TSV in summer and Environmental Factors

		Spearman's rho	TSV in summer	Air Humidity	Air Circulation	Solar Radiation Avail.	Solar Radiation Inte.	Solar Radiation Con.
	TSV in summer	Correlation Coeff.	1.00					
		Sig. (2-tailed)	.					
		N	155					
	Air Humidity	Correlation Coeff.	-.006	1.00				
		Sig. (2-tailed)	.946	.				
		N	155	155				
	Air Circulation	Correlation Coeff.	-.401**	.002	1.00			
		Sig. (2-tailed)	.000	.984	.			
		N	155	155	155			
Solar Radiation	Availability	Correlation Coeff.	-.149	.032	.288**	1.00		
		Sig. (2-tailed)	.064	.693	.000	.		
		N	155	155	155	155		
	Intensity	Correlation Coeff.	-.117	-.019	.263**	.888**	1.00	
		Sig. (2-tailed)	.147	.810	.001	.000	.	
		N	155	155	155	155	155	
	Control	Correlation Coeff.	.043	-.237*	.380**	.281*	.257*	1.00
		Sig. (2-tailed)	.723	.048	.001	.018	.032	.
		N	70	70	70	70	70	70

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

In addition, the test showed the sort of relations between environmental factors each other. The highest and the strongest correlation was found between intensity of solar radiation and availability of solar radiation (r = 0.888, $p<.001$), which is an expected result as more available sunshine associated with more intensity of solar radiation. The rest of correlations between environmental factors ranged between weak and moderate correlations. Among the statistically significant correlations, a weak positive relation was revealed between air circulation and availability and intensity of solar radiation (r=.288, and r=.263 respectively).

Table 7.7: Intercorrelations-TSV in winter and Environmental Factors

		Spearman's rho	TSV in Winter	Air Humidity	Air Circulation	Control Air Circul.	Solar Rad. Avia.	Solar Rad. Inte.
TSV in winter		Correla. Coeff.	1					
		Sig. (2-tailed)	.					
		N	155					
Air Humidity		Correla Coeff.	**-.374****	1				
		Sig. (2-tailed)	**.000**	.				
		N	**155**	155				
Air Circulation		Correla. Coeff.	-.152	**.340****	1			
		Sig. (2-tailed)	.058	**.000**	.			
		N	155	**155**	155			
Control Air Circulation		Correla. Coeff.	.107	-.155	-.117	1		
		Sig. (2-tailed)	.377	.200	.334	.		
		N	70	70	70	70		
Solar Radiation	Availability	Correla. Coeff.	.098	-.126	**.274****	-.008	1	
		Sig. (2-tailed)	.226	.119	**.001**	.946	.	
		N	155	155	**155**	70	155	
	Intensity	Correla. Coeff.	.145	**-.189***	**.243****	.022	**.917****	1
		Sig. (2-tailed)	.071	**.019**	**.002**	.854	**.000**	.
		N	155	**155**	**155**	70	**155**	155

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

In winter: The analysis showed that TSV_{winter} correlated moderately with air humidity (r= -.374, p<.001), with high level of air humidity associated with lower level of TSV. The other revealed correlations are non-significant weak positive and negative as indicated in table (7.7). Besides, the correlations between environmental factors each other ranged between weak and strong correlations. Like summer, the strongest significant correlation was found between intensity of solar radiation and availability of solar radiation (r = .917, $p<.001$). In addition, air circulation correlated moderately with air humidity (r = 0.340, $p<.001$), while the rest significant correlations between environmental factors were weak.

7.6.3 Secondary Factors of Thermal Comfort

As TSV variables are not normally distributed, the relationships between TSV and the secondary factors; including gender, age, and occupancy period were explored for summer and winter using Spearman's rho Correlation Coefficient. As indicated in table 7.8, all correlations revealed by the analysis were weak, positive and negative, with only one significant correlation between TSV_{winter} and occupancy period ($r = -.164$, $p=.041$), while other correlations were non-significant.

Table 7.8: Intercorrelations-TSV and secondary factors

	Spearman's rho	TSV in summer	Gender	Age	Occupancy period
TSV in summer	Correlation Coefficient	1.00	-.038	-.031	.055
	Sig. (2-tailed)	.	.641	.702	.493
	N	155	155	155	155
TSV in winter	Correlation Coefficient	-.379**	.062	-.077	**-.164***
	Sig. (2-tailed)	.000	.441	.340	**.041**
	N	155	155	155	**155**

7.6.4 The Effect of Materials on Thermal Comfort

The effect of envelop materials (comprising walls, roofs, and windows) on thermal comfort was examined by applying statistical analysis tests such as Kruskal-Wallis test and Mann-Whitney test. In SHC shelters, several materials could be found in a single shelter. To examine the effect of single material of one building component on TSV, shelters with one type of material is considered in the analysis and shelters with several materials are excluded. For instance shelters with concrete roofs were compared with shelters with asbestoses sheets roofs, while shelters including concrete and asbestoses sheets roofs together were excluded. Thus the number of cases considered in these tests decreased. The effect of the various floor materials on TSV could not be conducted because the number of shelters comprising a single type of floor materials is small, excluding only one type of floor material (terrazzo tiles).

a. Wall Materials: To examine the influence of wall materials, TSV for shelters comprising only concrete block walls was compared with TSV for shelters comprising only sand block walls, while shelters comprising concrete and sand block together were not considered. As the variables of TSV are not normally distributed and the data are unpaired, Mann-Whitney test was utilised which revealed a significant difference in TSV for shelters with sand block ($n=21$) and TSV for shelters with concrete block ($n=126$) in summer and winter, with a small effect size ($\rho=.041$, $r=.16$ for summer and $\rho=.015$, $r=.2$ for winter). In summer, the median of TSV for shelters with concrete block ($Md=2.31$) is lower than the median of TSV for shelters with sand block ($Md=2.31$), while, in winter, the median of TSV for shelters with concrete block ($Md=-2.67$) is higher than the median of TSV for shelters with sand block ($Md=-3$). This means that shelters consisting of sand block walls are hotter in summer and colder in winter than shelters consisting of concrete block walls. Figures (7.38 and 7.39) show the distribution of TSV, in summer and winter, for shelters according to wall materials.

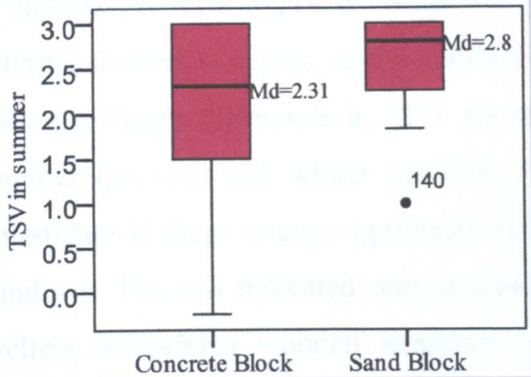


Figure 7.38: distribution of TSV in summer according to wall materials

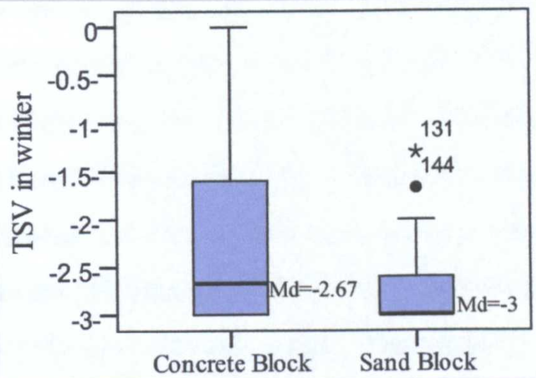


Figure 7.39: distribution of TSV in winter according to wall materials

b. Roof Materials: Kruskal-Wallis Test was utilized to investigate the effect of roof materials on thermal comfort by comparing TSV of three groups of shelters comprising; shelters roofed with only concrete slap, shelters roofed with only asbestos sheets, and shelters roofed with only corrugated iron. This test was applied as the variables of TSV are not normally distributed and the data are for more than two groups. The test showed a statistically non-significant difference in TSV across the three groups (ρ=.231 for summer, ρ=.140 for winter). Mann-Whitney Test was then performed between pairs of groups to investigate if there is any significant difference in TSV between every two types of roof materials. The test also indicated no statistically significant difference. Figures (7.40 and 7.41) show the distribution of TSV according to roof materials for winter and summer respectively. What is interesting to note in the figures (although it is statistically not significant) that the highest recorded TSV in summer was overall for corrugated iron shelters followed by asbestoses sheets shelters and the lowest TSV recorded for concrete slap shelters. In winter, TSV in concrete slap shelters is generally higher than that of asbestoses sheets and corrugated iron shelters.

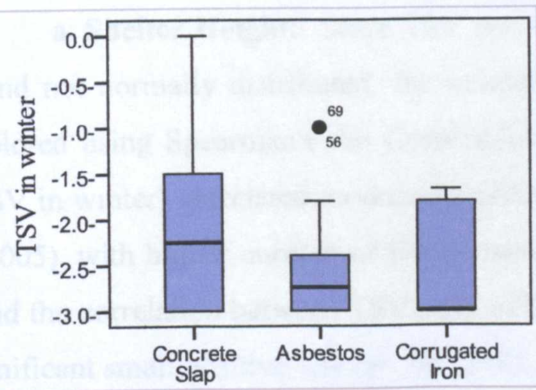


Figure 7.40: distribution of TSV in winter according to roof materials

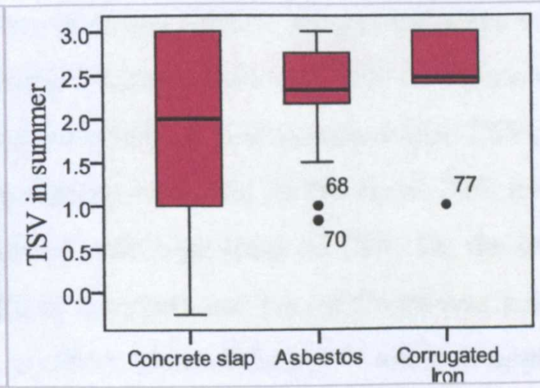


Figure 7.41: distribution of TSV in summer according to roof materials

c. Windows Types: Kruskal-Wallis Test was also performed to investigate if there is significant difference in TSV for shelters with different windows types. The test is applied on three types of windows; wooden, plastic louvered, and glazing with external shutters windows, as the numbers of the rest types are small. The test showed a non- significant difference in TSV for shelters with the three types of windows for summer (ρ=.165) and winter (ρ=.094). Mann-Whitney Test was then performed to investigate if there is any significant difference in TSV between every two types of windows. The test indicated only a significant difference in TSV for winter between shelters comprising wooden windows (n=29) and shelters comprising glazing with external shutters windows (n=45), ρ=.031, with a small effect size (r=.25). The median of TSV for shelters with wooden windows (Md=-3) is lower than the median of TSV for shelters comprising glazing with external shutters windows (Md=-2.75) (see figure 7.42). This means that shelters comprising wooden windows are colder in winter than shelters comprising glazing with external shutters windows.

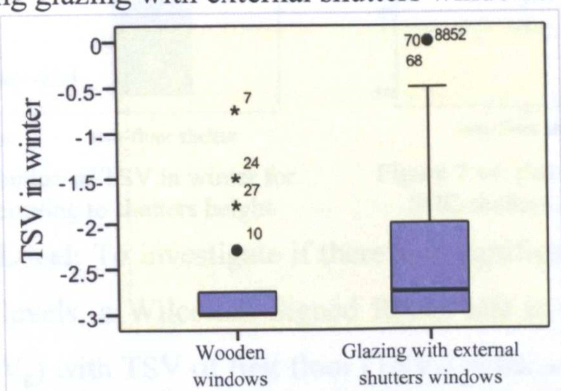


Figure 7.42: distribution of TSV in winter for SHC shelters according to windows types

7.6.5 The Effect of Shelter Height and Floor Level on Thermal Comfort

The following investigations were performed on new shelters while old shelters were excluded because old shelters are almost of the same height and vast majority of them (95.7 percent) are one-floor.

a. Shelter Height: Since TSV and No. of floors (shelter height) variables were found not normally distributed, the relationship between TSV and No. of floors was explored using Spearman's rho Correlation Coefficient. It was revealed that TSV_{winter} (TSV in winter) correlated moderately and positively with No. of floors (r=.299, n=85, ρ=.005), with higher number of floors associated with high level of TSV. On the other hand the correlation between TSV_{summer} (TSV in summer) and No. of floors was a non-significant small positive one (r= .02, n=85, ρ=.858). Mann-Whitney U test was applied also to compare TSV in one-floor shelters with that of two-floor shelters, where three-floor shelters were excluded in this test because they are few (8.2 percent of new shelters). The test revealed a statistically significant difference in TSV_{winter} in one-floor shelters (n=32) and that in two-floor shelters (n=46), ρ=.006, with a medium effect size (r=.309). The median of TSV_{winter} in one-floor shelters (Md= -2.75) is lower than the median of TSV_{winter} in two-floor shelters (Md= -2). This means that one-floor shelters are colder in winter than two-floor shelters. The difference between TSV_{summer} in one-floor shelters and that of two-floor shelters was found not statistically significant (ρ=.662), with a very small effect size (r=.049). Figures (7.43 and 7.44) show the distribution of TSV_{summer} and TSV_{winter} according to shelter height.

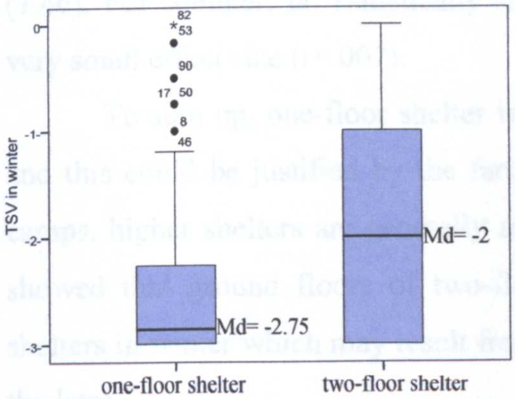


Figure 7.43: distribution of TSV in winter for SHC shelters according to shelters height

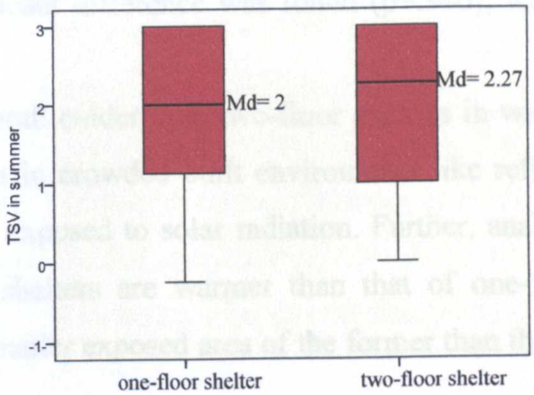


Figure 7.44: distribution of TSV in summer for SHC shelters according to shelters height

b. Floor Level: To investigate if there is a significant difference in TSV for the different floor`s levels, a Wilcoxon Signed Ranks test is utilized to compare TSV of ground floor (TSV_g) with TSV of first floor (TSV_f) in the same shelter for both summer and winter. This test is applied because the variables of TSV are not normally distributed and the data are paired. The two-floor shelters which were completely reconstructed by the UNRWA were considered in the test, while two-floor shelters in which the first floors were constructed by the occupants were excluded. The test revealed statistically non-significant difference between TSV_g and TSV_f in summer (ρ=.206) and in winter (ρ=.635). Although the difference is statistically not significant, it was observed that TSV_g (Md= 2.16) in summer is overall lower than TSV_f (Md= 2.5). Figure (7.45) provides the distribution of TSV_g and TSV_f in summer.

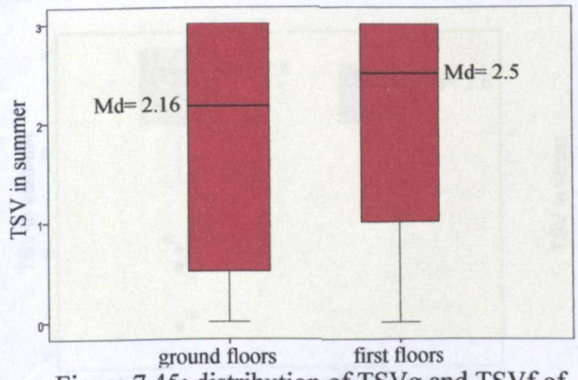


Figure 7.45: distribution of TSVg and TSVf of two-floor SHC shelters in summer

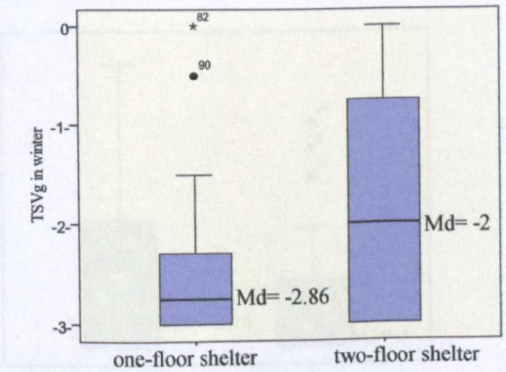


Figure 7.46: distribution of TSVg for one-floor and two-floor shelters in winter

Comparison between TSV_g in one-floor shelters with TSV_g in two-floor shelters was also carried out using Mann-Whitney U test. This test was used because the variables of TSV are not normally distributed and the data are unpaired. The test revealed a statistically significant difference between them in winter (ρ=.023), with a medium effect size (r=.26). The median of TSV_g in one-floor shelters (Md= -2.86) is lower than the median of TSV_g in two-floor shelters (Md= -2), as presented in figure (7.46). For summer, no statistically significant difference was found (ρ=.946), with a very small effect size (r=.007).

To sum up, one-floor shelter is overall colder than two-floor shelters in winter, and this could be justified by the fact that in crowded built environment like refugee camps, higher shelters are generally more exposed to solar radiation. Further, analysis showed that ground floors of two-floor shelters are warmer than that of one-floor shelters in winter which may result from smaller exposed area of the former than that of the later.

7.6.6 The Effect of Courtyards on Thermal Comfort

Courtyard has great effect on indoor environment and its usefulness depends on how it is integrated and treated. As clarified earlier, about 43 percent of old SHC shelters comprised courtyards. The effect of courtyards on thermal comfort in old SHC shelters was investigated by carrying out a comparison between TSV of shelters comprising courtyards and that of shelters without courtyards utilizing Mann-Whitney U test. It was found non-statistically significant difference in TSV of courtyard-shelters (n=30) and that of shelters without courtyard (n=40), in both summer (ρ=.243) and winter (ρ=.275) with small effect size (r=.14, and r=.13 respectively). As indicated in figures (7.47 and 7.48) , there is an observed slight difference, though not statistically significant, between TSV of courtyard-shelters and that of shelters without courtyard, where TSV is overall lower in courtyard-shelters in both summer and winter.

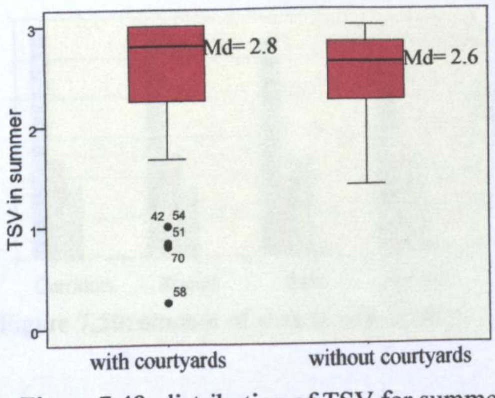


Figure 7.48: distribution of TSV for summer in shelters with and without courtyards

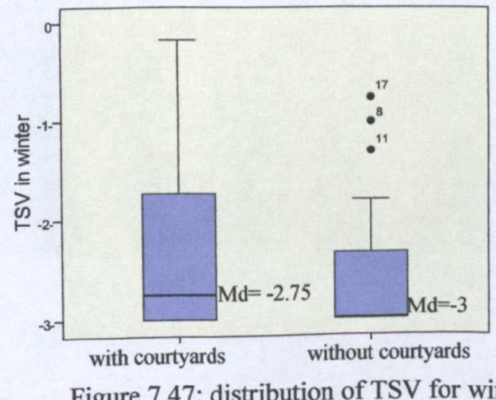


Figure 7.47: distribution of TSV for winter in shelters with and without courtyards

Further, the influence of various types of courtyards; Gp1 (surrounded on one side), Gp2 (surrounded on two sides), Gp3 (surrounded on three sides), and Gp4 (surrounded on all sides), was investigated utilizing Kruskal-Wallis test by comparing TSV across shelters comprising the different four courtyard types. This test was applied as the variables of TSV are not normally distributed and the data are for more than two groups. No statistically significant difference in TSV across the four group shelters (Gp1: n=10, Gp2: n=10, Gp3: n=5, Gp4: n=5) was found, with ρ=.917 and ρ=.275 for summer and winter respectively. Afterwards, comparison for TSV between every two types of courtyard-shelters was performed using a Mann-Whitney U Test revealing statistically significant difference in TSV between Gp1(surrounded on one side) and Gp4 (surrounded on all sides) in winter (ρ=.038), with a small effect size (r =.11). The median of TSV in shelters with courtyards surrounded on all sides (Md= -2.75) is higher than the median of TSV in shelters with courtyards surrounded on one side (Md= -3).

7.7 OTHER INDOOR ENVIRONMENTAL ASPECTS

In addition to investigate thermal, visual, and acoustic environments in SHC shelters, other indoor environmental features were examined as well including; adequacy of space, indoor air quality, security, and windows with their using. Besides, solar water heating system, as a clean and energy saving system implemented in refugee shelters, was also examined in the survey.

7.7.1 Adequacy of Space

Adequacy of space is one of the requested aspects of the evaluation of indoor environment, in particular low cost residential buildings. Occupants of SHC shelters were asked to rate the amount of space in their shelters, a line with their satisfaction with its sufficiency. Figures (7.49 and 7.50) provide rating for the amount of area in old and new shelters respectively.

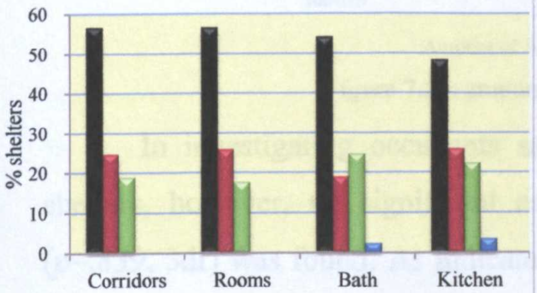


Figure 7.50: amount of area in new shelters

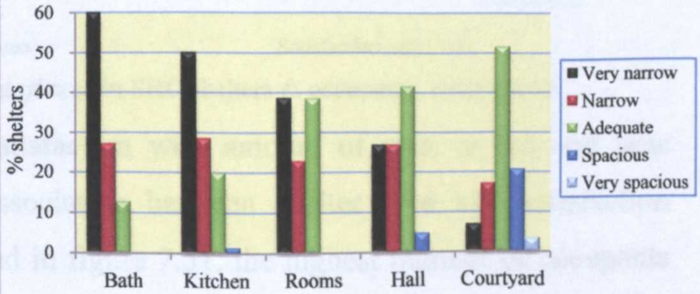


Figure 7.49: amount of area in old shelters

The survey revealed that almost over one-half of occupants of new shelters rated rooms, bath, and corridors at their shelters "very narrow", and about 48.2 percent recorded kitchen under this category as well. In addition, around one-quarter of new shelters` occupants demonstrated that rooms, kitchen, and corridors are narrow. The percentage recorded for "adequate" in new shelters ranged between 17.6 percent (for rooms) and 22.4 percent (for kitchen). In old shelters, however, "adequate" category was reported for about one-half of courtyards, followed by hall (41 percent), rooms (38.6 percent), kitchen (20 percent), and the lowest recorded for bath (12.9 percent). On contrast, the highest percentage reported for "very narrow" category in old shelters was for bath (60 percent), followed by kitchen (50 percent), rooms (38.6 percent), hall (26.8 percent), and the lowest recorded for courtyard (6.9 percent). Moreover, overall one-quarter of old shelters` occupants demonstrated that all indoor spaces are "narrow", while one-fifth stated that courtyard is "spacious".

A comparison between old and new shelters in terms of adequacy of space was conducted utilizing Pearson Chi-square test for independence. The test revealed a statistically significant association between shelter type (old and new) and adequacy of space ($p<.001$, 3df), with amount of area being less sufficient in new shelters. Figure 7.51 shows adequacy of space in both old and new shelters as a total in all spaces. In approximately, 60 and 40 percent were rated as "very narrow", while 19 and 32 percent were rated as "adequate" for new and old shelters respectively. A "spacious" category was recorded for a mere of 2.5 percent of old shelters and only 0.5 percent of new shelters.

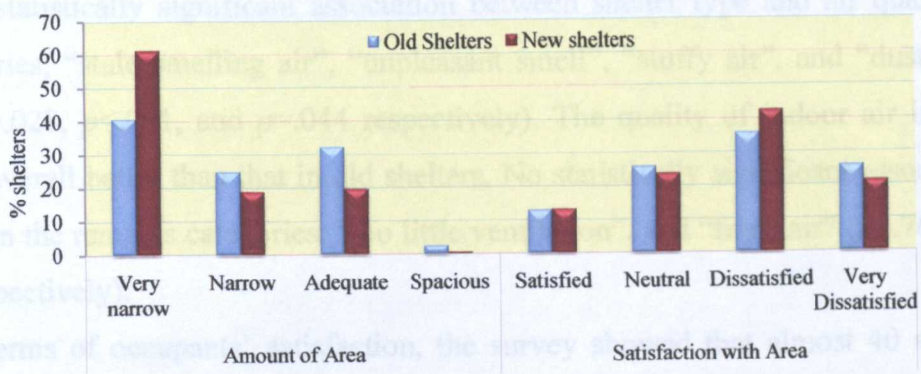


Figure 7.51: amount of area in SHC shelters & occupants` satisfaction

In investigating occupants satisfaction with amount of area in old and new shelters, however, no significant association between shelter type and satisfaction ($p=.839$, 3df) was found. As indicated in figure 7.51, the highest number of occupants were dissatisfied with amount of area (42 and 36 percent of new and old shelters respectively), and the lowest were satisfied (12.9 percent of old and new shelters).

Besides, almost one-quarter and one-fifth of occupants of old and new shelters respectively were very dissatisfied with adequacy of space.

7.7.2 Indoor Air Quality

Indoor air quality is considered an important parameter influencing performance and efficiency of indoor environment. Air quality in SHC shelters was investigated in the survey along with occupants' satisfaction. As indicated in figure 7.52, almost one third of old shelters` occupants described the air inside their shelters as dusty, stuffy, and stale smelling, about 35 percent of them stated unpleasant smell, two-fifth of occupants demonstrated too little ventilation, while about 38 percent of occupants emphasized fresh air. On the other hand, in new shelters, the highest percentage was reported for "fresh air" (41 percent), followed by "too little ventilation" (37 percent), and "unpleasant smell" (20 percent). A mere of 7.1 percent of new shelters was recorded for "stuffy air" and "stale smelling air".

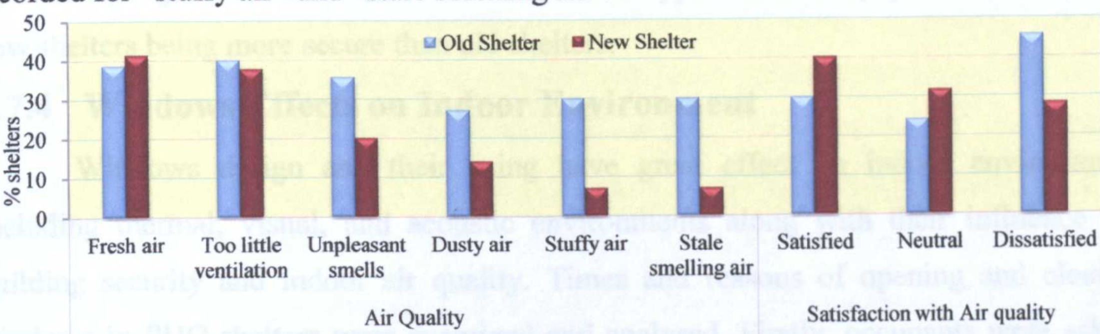


Figure 7.52: Air quality in old and new shelters and occupants` satisfaction

A comparison between old and new shelters utilizing Pearson Chi-square test revealed a statistically significant association between shelter type and air quality in four categories; "stale smelling air", "unpleasant smell", "stuffy air", and "dusty air" (p<.001, p=.028, p<.001, and p=.044 respectively). The quality of indoor air in new shelters is overall better than that in old shelters. No statistically significant association was found in the remains categories; "too little ventilation", and "fresh air" (p=.765 and p=.742, respectively).

In terms of occupants' satisfaction, the survey showed that almost 40 and 30 percent of occupants were satisfied with indoor air quality, while 28 and 45 percent of them were dissatisfied, in new and old shelters respectively. No statistically significant association between shelter type and satisfaction (p=.079, 2df) was found. However, as provided in figure 7.52, it was observed that occupants of new shelters were generally more satisfied with air quality than those of old shelters.

7.7.3 Security

Security, as an essential factor of indoor environment quality, was inspected in SHC shelters by asking the occupants to rate the security level in their shelters. The survey revealed, as indicated in figure 7.53, the majority of new shelters` occupants (67 percent) stated that security level of their shelters is high, and around 22 percent of them clarified that their shelters are moderately secure, while security level was found low in only about 10 percent of new shelters. In old shelters, security was found high in about 41 percent of shelters, and moderate in about one-third of them, while 27 percent of old shelters were rated as low secure. A comparison between old and new shelters utilizing Pearson Chi-square test revealed a statistically significant association between shelter type and security (p=.003, 2df), with new shelters being more secure than old shelters.

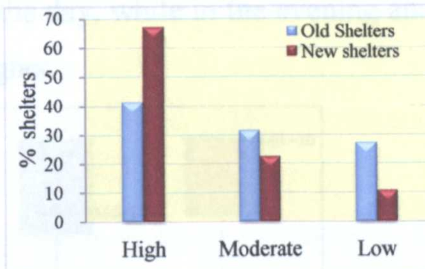


Figure 7.53: security level in shelters

7.7.4 Windows Effects on Indoor Environment

Windows design and their using have great effect on indoor environment including thermal, visual, and acoustic environments along with their influence on building security and indoor air quality. Times and reasons of opening and closing windows in SHC shelters were examined and analysed. Firstly, occupants were asked about the size of their shelters windows. In new shelters, about 77 percent of occupants stated that their windows` size is about right, while 21 percent stated that their windows are small. On contrast, windows size was recorded to be "small" in 79 percent of old shelters, while recorded to be "about right" in the remains shelters (21 percent). As presented in figure 7.54, windows were reported as "big" in a mere 2.4 percent of new shelters. A comparison between old and new shelters utilizing Pearson Chi-square test confirmed a statistically significant association between shelter type and windows` size (ρ<.001, 2df). Windows of new shelters are overall bigger than those of old shelters.

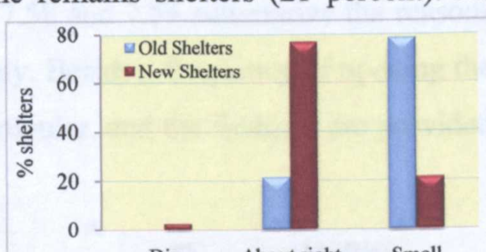


Figure 7.54: windows` size in shelters

a. Opening windows: Times of opening windows in summer were surveyed and presented in figure 7.55. In the morning, the percentage of occupants who opened windows rises gradually reaching peak of 97.6 in new shelters and 98.6 percent in old shelters at 10-12 am, where it approximately levelled off till 8:00 pm. Afterwards, occupants start closing windows as percent of opening windows starts to drop steadily reaching the minimum after midnight. There is almost no difference between old and new shelter in the percent of opening windows during the day, while in the evening and during the night opening windows in new shelters is higher.

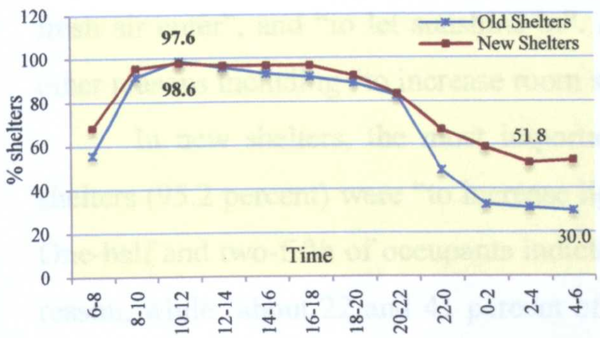


Figure 7.55: Times of opening windows in summer

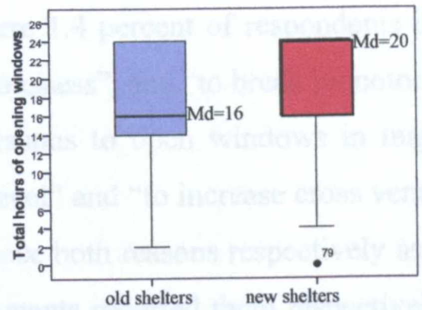


Figure 7.56: distribution of total hours of opening windows, in old & new shelters

Total hours of opening windows was computed revealing that the average was 16.8 hours in old shelters and 19.3 in new shelters, while the maximum was 24 hours in both types of shelter. Windows were opened all the day in over one-half of new shelters and in 30 percent of old shelters as well. Figure 7.56 shows the distribution for total hours in which windows are opened in old and new shelters. A Mann-Whitney U test revealed a significant difference in the total hours in old SHC shelters and that in new SHC shelters (ρ=.010), with a small effect size (r=.21). The median of total hours in old shelters (Md=16) is lower than the median of total hours in new SHC shelters (Md=24).

b. Reasons to open windows: SHC shelters\` occupants were asked to indicate the reasons for opening the windows in their shelters in summer and to mark the reasons in the order of their importance for them. Figures 7.58 and 7.59 summarize the reasons with their ranks for old and new shelters respectively. Besides, frequency of opening the windows for cross ventilation was examined in particular, and the findings are provided in figure (7.57).

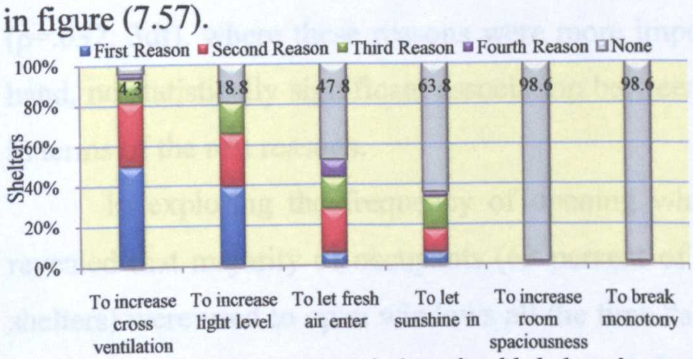


Figure 7.58: Reasons to open windows in old shelters in summer

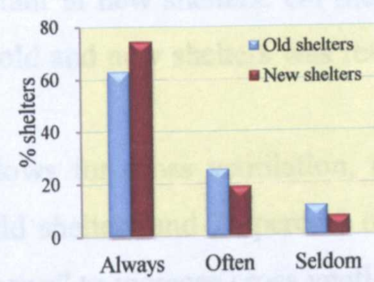


Figure 7.57: Frequency of opening windows for cross ventilation

In old shelters, overall, the most important reason to open windows in majority of shelters (95.7 percent) was "to increase cross ventilation", where about one-half of respondents indicated it as the first reason, one-third respondents indicated it as the second reason, and only 11.6 percent of respondents indicated it as the third reason. The next reason with the most important was "to increase light level", followed by "to let fresh air enter", and "to let sunshine in". A mere 1.4 percent of respondents indicated other reasons including "to increase room spaciousness", and "to break monotony".

In new shelters, the most important reasons to open windows in majority of shelters (95.2 percent) were "to increase light level" and "to increase cross ventilation". One-half and two-fifth of occupants indicted those both reasons respectively as the first reason, while about 22 and 41 percent of occupants reported them respectively as the second reason. The next reason with the most important as overall was "to let fresh air enter" (73.8 percent) followed by "to let sunshine in" (64.3 percent). The remains reasons which explained in figure 7.59 were reported for only 1.2 to 4 percent of respondents.

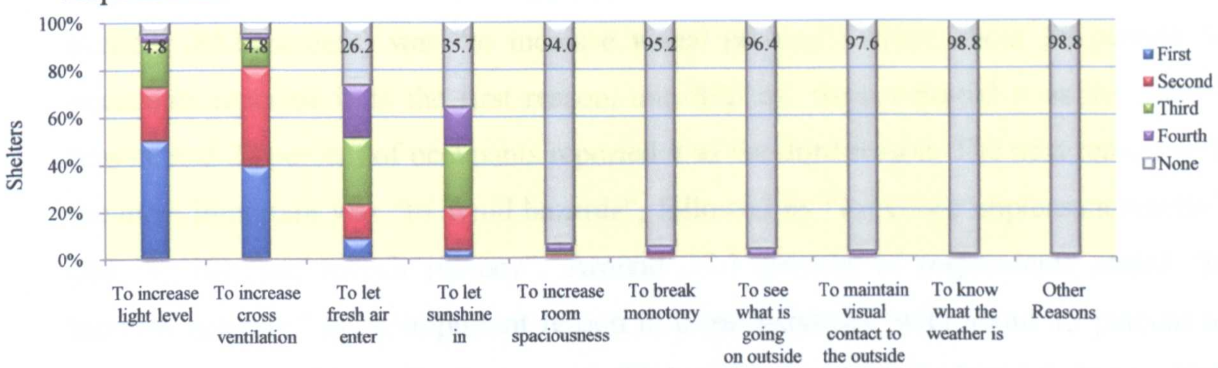


Figure 7.59: Reasons to open windows in new shelters in summer

A comparison between old and new shelters utilizing Pearson Chi-square test was conducted for each reason of opening windows. The test revealed statistically significant association between old and new shelters in three reasons; "to let sunshine in" ($p=.001$, 2df), "to let fresh air enter" (ρ=.006, 3df), and "to increase light level" (ρ=.032, 3df), where these reasons were more important in new shelters. On the other hand, no statistically significant association between old and new shelters was revealed in terms of the rest reasons.

In exploring the frequency of opening windows for cross ventilation, it was revealed that majority of occupants (63 percent of old shelters and 74 percent of new shelters) were used to open windows all the time "always" to increase cross ventilation. Besides, about 25 and 18 percent was recorded for "often" in new and old shelters respectively. There was not statistically significant association between old and new shelters in the frequency of opening windows for cross ventilation as indicated by Pearson Chi-square test (ρ=.309, 2df).

b. Reasons to close windows: SHC shelters` occupants were asked to indicate the reasons for closing the windows in their shelters in summer and to mark the reasons in order of their importance for them. Figures 7.60 and 7.61 summarize the reasons with their ranks for old and new shelters respectively.

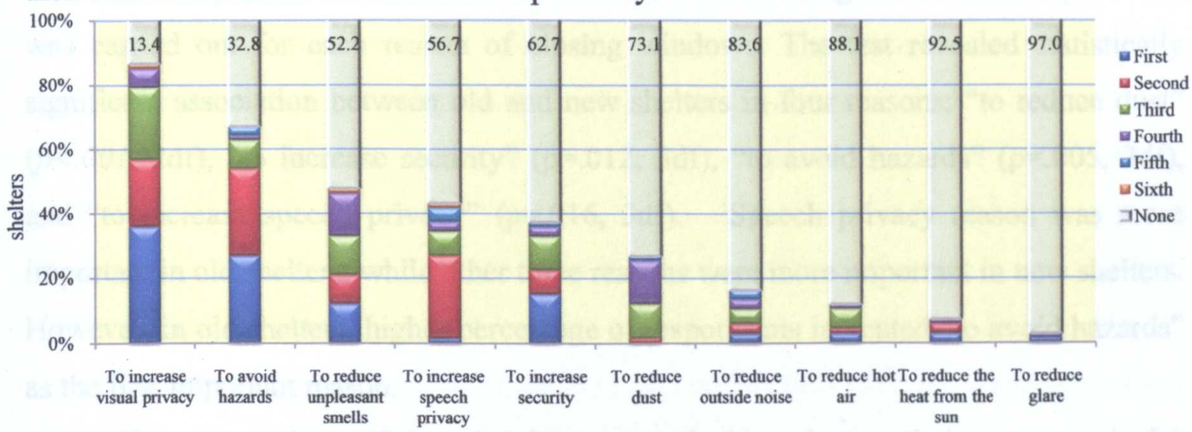


Figure 7.60: Reasons to close windows in old shelters in summer

In old shelters, the most important reason to close windows in the majority of shelters (86.6 percent) was "to increase visual privacy", where about 36 percent of occupants reported it as the first reason, one-fifth of them reported it as the second reason, and 22 percent of occupants reported it as the third reason. The next reason with the most important was "to avoid hazards", followed by "to reduce unpleasant smells", and "to increase speech privacy". Around 37.3 percent of respondents stated "to increase security" as an important reason to close windows, with about 15 percent of occupants reported it as the first reason. The remains reasons to close windows which presented in figure 7.60 were reported for 3 to 27 percent of respondents.

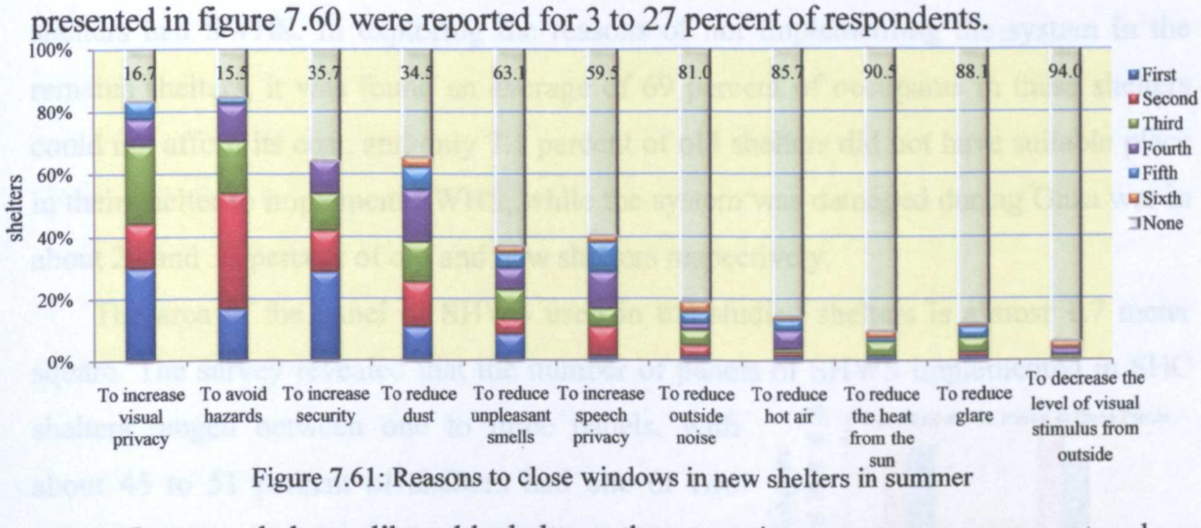


Figure 7.61: Reasons to close windows in new shelters in summer

In new shelters, like old shelters, the most important two reasons to close windows in majority of shelters were "to increase visual privacy", and "to avoid hazards". In approximately, 64 percent of respondents considered "to increase security" an important reason to close windows, with about 29 percent of occupants marked it the first reason. The next reasons as a total recorded responses were "to increase speech privacy" (40.5 percent), followed by "to reduce unpleasant smells" (37 percent), and "to reduce outside noise" (19 percent). The rest reasons to close windows in new shelters, as indicated in figure 7.61, were recorded by only 4 to 14 percent of respondents.

A comparison between old and new shelters utilizing Pearson Chi-square test was carried out for each reason of closing windows. The test revealed statistically significant association between old and new shelters in four reasons; "to reduce dust" ($p<.001$, 2df), "to increase security" (ρ=.012, 3df), "to avoid hazards" (ρ=.005, 3df), and "to increase speech privacy" (ρ=.016, 3df). Speech privacy reason was more important in old shelters, while other three reasons were more important in new shelters. However, in old shelters, higher percentage of respondents indicated "to avoid hazards" as the first important reason.

Few respondents (7.5 and 9.5 percent of old and new shelters respectively) stated "to reduce the heat from the sun" as a reason to close the windows in summer. This response matched with the frequency of closing the windows to reduce solar radiation shown in figure 7.62, where majority of occupants never close the windows for that reason.

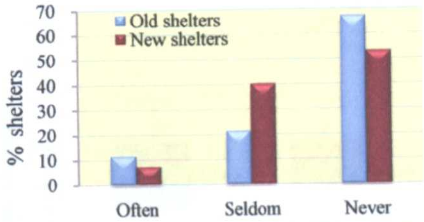


Figure 7.62: Frequency of closing windows to reduce solar radiation in summer

7.7.5 Solar Water Heating System (SWHS)

The survey revealed that there-quarter of new shelters and 60 percent of old shelters had SWHS. In exploring the reasons of not implementing the system in the remains shelters, it was found an average of 69 percent of occupants in these shelters could not afford its cost, and only 7.1 percent of old shelters did not have suitable place in their shelter to implement SWHS, while the system was damaged during Gaza war in about 28 and 33 percent of old and new shelters respectively.

The area of the panel of SHWS used in the studied shelters is almost 1.7 meter square. The survey revealed that the number of panels of SHWS implemented in SHC shelters ranged between one to three panels, with about 45 to 51 percent of shelters had one or two panels, while only 3.1 to 7.1 percent of shelters had three panels (see figure 7.63). As shown by Mann-

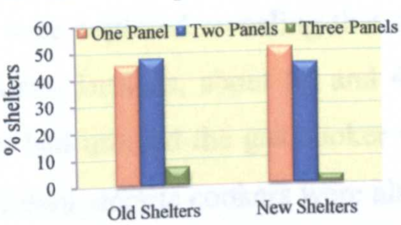


Figure 7.63: No of SHWS panels

Whitney U test, there is no significant difference in number of panels in old and new shelters (ρ=.428), with a very small effect size (r=.077).

The adequacy of SWHS is affected with various factors including, the efficiency of the system and the area of the panels relating to the occupants` demands. Besides, in refugee camps, the surrounding buildings generally cast shadows on the panels of SWHS which affect the adequacy of the system. In this study, the adequacy of SWHS in SHC shelters was investigated by asking the occupants to indicate the months through the year in which the system had provided them with adequate amount of hot water. As indicated in figure 7.64, in January and February, no cases in old shelters had adequate hot water, and only 4.7 percent of new shelters got sufficient amount of hot water from the system. The parentage of shelters starts to rise gradually in March reaching peak of 100 and 97.6 percent of new and old shelters respectively in July, then falls steadily to the minimum of 6.3 percent of new shelters and no cases of old shelters in November and December.

Figure 7.64: Months in which SWHS provides adequate amount of hot water

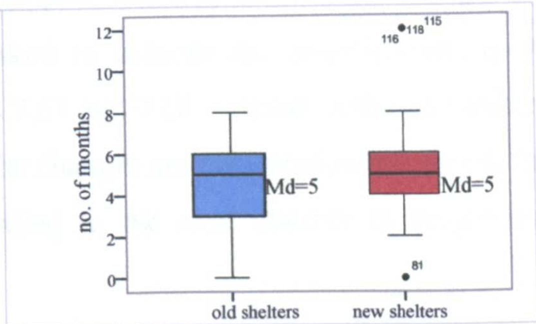


Figure 7.65: distribution of no. of months in which SWHS provides adequate amount of hot water

The average number of months in which the system provides sufficent amount of hot water in old and new shelters is 4.6 and 5.2 months respectively. The maximum number of months in which the system provides sufficent amount of hot water is 8 and 12 months in old and new shelters respectively. However, a mere 3.5 percent of new shelters got adequate hot water from SWHS all the year. Figure 7.65 provides the distributtion of total months in old and new shelters. Mann-Whitney U test revealed no statistically significant difference in number of months in which the system provides sufficent hot water in old and new shelters (ρ=.62).

Other means for heating water in SHC shelters were explored revealing that an average of 46 percent of shelters included electric heaters. Besides, about 53 and 43 percent of new and old shelters` occupants respectively had utilized the gas cooker to heat the water. Mini kerosen cooker, firewood, coal, and mini electric cookers were also utilized in few number of shelters to heat water (see figure 7.66)

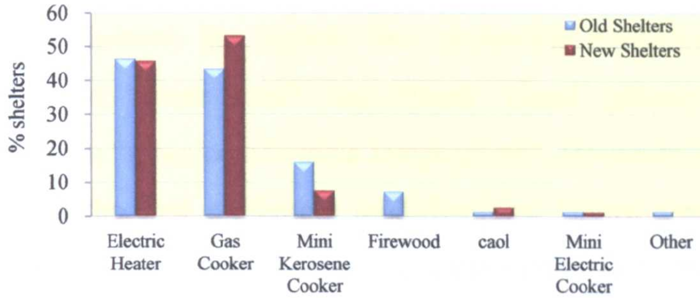


Figure 7.66: means for heating water in SHC shelters

7.8 GENERAL EVALUATION OF INDOOR ENVIRONMENT

The final section of the questionnaires was utilized to get general evaluation for the indoor conditions of SHC shelters and to allow the occupants to express any additional comments related to indoor environment of their shelters. Findings are analysed and presented in the following subsections.

7.8.1 The Preferable Changes

SHC shelters` occupants were asked to suppose that they could make changes to their overall shelter environment and were asked to indicate the modifications they would make in the order of preference. Figures 7.67 and 7.68 summarize the preferable changes in old and new shelters respectively. The changes are presented in the figures in the order (from the highest to lowest) according to the total number of responses recorded for each preferable change.

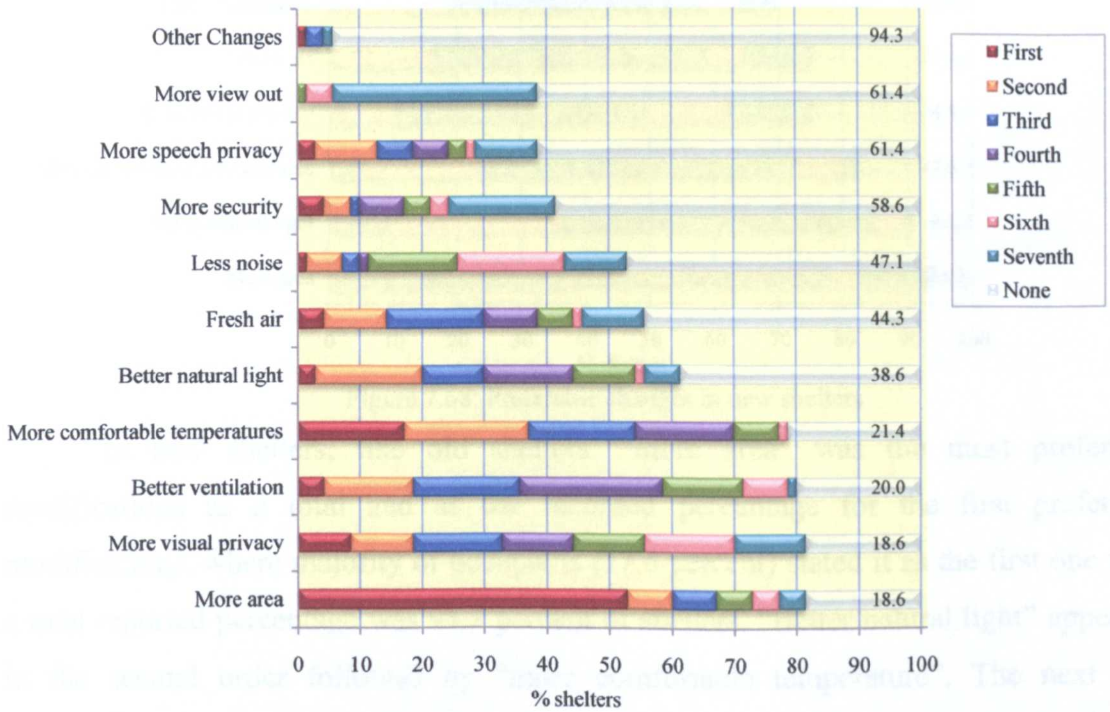


Figure 7.67: Preferable changes in old shelters

In old shelters, the highest four preferable modifications ordered as a total percentage were "more area" and "more visual privacy", followed by "better ventilation", then "more comfortable temperature". However, according to the recorded percentage for the first preferable modifications, "more area" was the highest (52.9 percent), followed by "more comfortable temperature" (17.1 percent), then "more visual privacy" (8.6 percent), and the least was "better ventilation" (4.3 percent). The next preferable modifications were "better natural light" and "fresh air", where the former was higher as a total percentage, but lower as the first preferable modifications. The next preferable modifications ordered as a total percentage were "less noise" followed by "more security" and "more speech privacy". Nevertheless, as the highest reported percentage for the first preferable modification, "more security" was the highest. The least reported among all modifications was "more view out". Besides, some respondents demonstrated modifications in their own words such as "making vertical extension for the shelter" and "making the size of windows bigger", and others stated that their shelters need reconstruction completely.

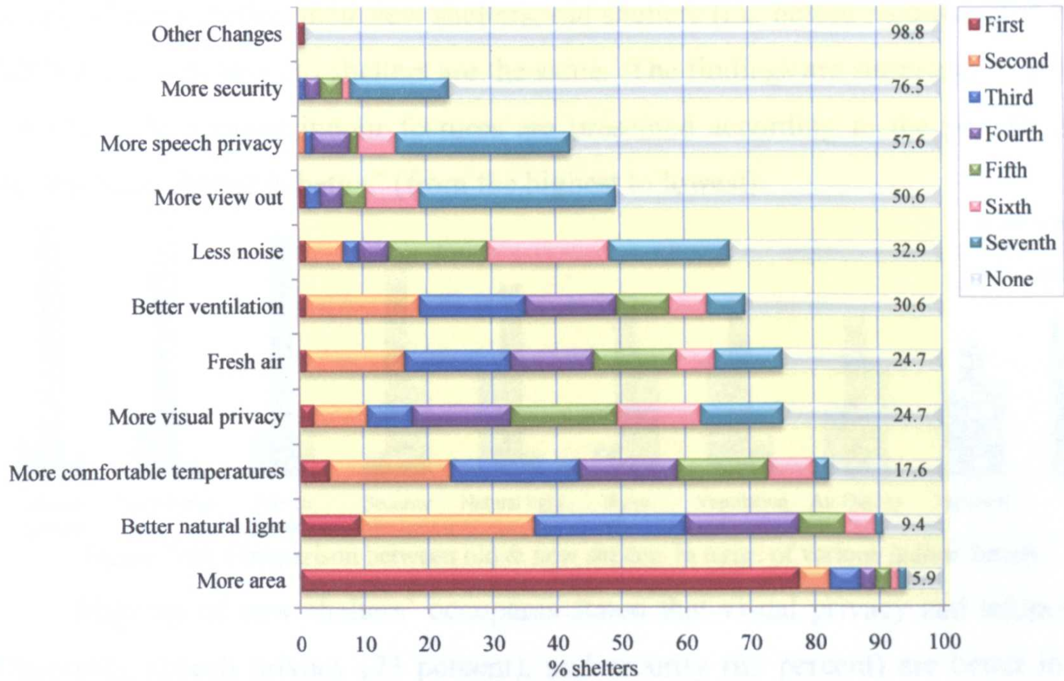


Figure 7.68: Preferable changes in new shelters

In new shelters, like old shelters, "more area" was the most preferable modifications as a total and as the recorded percentage for the first preferable modifications, where majority of occupants (77.6 percent) stated it as the first one with a total reported percentage was 94.1 percent of shelters. "Better natural light" appeared in the second order followed by "more comfortable temperature". The next two modifications with the same total percentage (75.3 percent) were "more visual privacy" and "fresh air", with the former had higher percentage as the first preferable modification. The following remains preferable modification were "less noise" followed by "more view out", and "more speech privacy", while the lowest across all modifications was "more security". Moreover, some occupants demonstrated modifications related to the arrangement of the internal spaces.

A comparison between old and new shelters utilizing Pearson Chi-square test was carried out for each modification. The test revealed statistically significant association between old and new shelters in five modifications; "better natural light" ($p<.001$, 5df), "more area" ($\rho=.009$, 3df), "more speech privacy" ($\rho=.006$, 3df), "more comfortable temperature" ($\rho=.045$, 5df), and "more security" ($\rho=.022$, 3df). The former two modifications were more preferable in new shelters, while the rest three modifications were more preferable in old shelters.

7.8.2 Which is Better: Old or New Shelters

In terms of various indoor features, occupants of new shelters were asked to indicate which is better; their new shelters, old shelters (i.e. before reconstructed by the UNRWA), or new and old shelters are the same. The findings are summarized in figure 7.69 where the various indoor features are presented according to the percent of the category "new shelter is better" (from the highest to lowest).

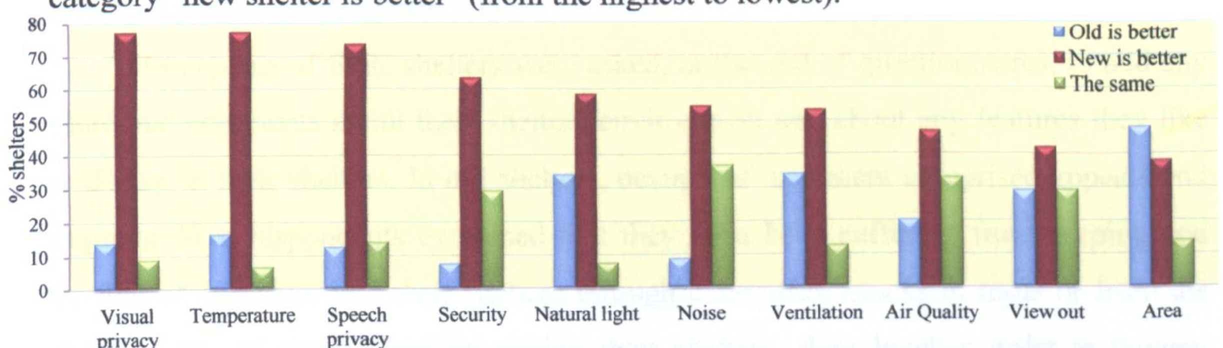


Figure 7.69: Comparison between old & new shelters in terms of various indoor factors

Majority of new shelters` occupants stated that visual privacy and temperature (77percent), speech privacy (73 percent), and security (63 percent) are better in their new shelters than old ones. In terms of natural light and ventilation, over one-third of occupants reported that old shelters were better, while over one-half of them reported that new shelters are better. Moreover, over one-half of respondents stated that their new shelters is better in terms of noise, while 37 percent reported that new and old shelters are the same, and only 9 percent reported the old shelters were better. The same percentages (29 percent) were reported for "old shelter is better" and "the same" in terms of view out, while 42 percent of respondents see that new shelters are better.

Furthermore, one-third of respondents see that air quality are the same in old and new shelters, one-fifth of respondents see that air quality in old shelters was better. On contrast, 47 percent stated that air quality is better in new shelter. On the other hand, in terms of area, the responses recorded for "old shelter is better" (48 percent) is somewhat higher than that recorded for "new shelter is better" (38 percent). It is worth noting that percentages recorded for "new shelter is better" are higher than those recorded for "old shelter is better" in terms of all indoor features except adequacy of space.

It can be concluded from the comparison between old and new shelters that there are enhancements carried out by the UNRWA in all indoor environment parameters with different range, excluding the amount of area. These results confirm the preferable changes in indoor environment presented earlier in figure (7.86), where "More Area" was the most preferable change for vast majority of occupants. In addition, the comparison indicates that there is a moderate improvement in natural light, but the amount of daylight is still insufficient where "Better natural light" comes in the second order as the most preferable changes to the occupants. Besides, it is noticed that, although of the great improvement in "temperature" and "visual privacy" (see fig 7.69), these two parameters still need more enhancement as indicated in (figure 7.68) where they come at the third and fourth place of the most preferable changes respectively.

7.8.3 Additional Comments

Occupants of SHC shelters were asked, at the end of questionnaires, to add any additional comments about their shelters environment and about any features they like or dislike in their shelters. In old shelters, occupants' comment comprised appeals and enquires. Five respondents explained that they have been suffering from seeping and flowing of rainwater into their shelters through courtyards, cracks in roofs or from the streets. Some of them asked for raising their shelters' floor level in order to prevent rainwater from flowing into their shelters. Others asked for replacing the asbestos roof by concrete slab in order to rid of moisture. Six of respondents claimed that their shelters are not fit for human habitation and some of them stated that the structural conditions of their shelters are unsafe and walls are crumbling. One of respondents certified that his/her shelter is very narrow with no ventilation. Other respondents complained the bad conditions of toilets and bathrooms.

In new shelters, the additional comments also included complains, enquiries, and demands. Respondents complained inflowing of water into kitchens, high moisture and humidity inside shelters, the extremely poor ventilation of bathrooms, and the bad quality of doors and windows. Other respondents requested repairs and improvement in their shelters such as the following:

- Improving the electrical wiring in the shelter
- Modifying sanitation services of the shelter
- Modifying baths and toilets conditions in the shelter
- Opening additional windows in the shelter
- Increasing the area of spaces such as living room
- Changing the location of bathroom and kitchen
- Improving the interior finishes of the shelter
- Solving the problem of water leakage through roofs
- Repairing rooms which were damaged during Gaza War

Furthermore, some respondents asked for some additions such as constructing a staircase, adding a kitchen, and implementing solar heating water system.

7.9 SUMMARY

This chapter offered an evaluation for the indoor conditions of the SHC shelters, both old and new, through interviews with a purposive convenience sample of 155 SHC families from Jabalia refugee camp. The quality of visual environment in SHC shelter was evaluated by inspecting daylight amount, visual comfort, occupants satisfaction, and visual amenity including view out and visual privacy. Survey revealed that the amount of daylight in old and new shelters is generally low particularly in winter, with being lower in new shelters than in old shelters. Besides, the quality of daylight is overall not sufficient enough to achieve visual comfort for occupants, and it is generally worse in new shelters than in old shelters. Subsequently, there is no satisfaction with visual comfort in the majority of shelters during winter and in around 40 percent of shelters during summer. Furthermore, the results indicate that electric lights are turned on through all the daytime in the vast majority of shelters in winter and in about one-fifth of new shelters and one-half of old shelter in summer. In terms of view out, the overall findings indicate that view outside SHC shelters is generally simple and limited, and restricted largely by surrounding buildings. Besides, window size and sill height restrict the outside view especially in old shelters. As an average, view out is moderately important for SHC shelters` occupants. In examining visual privacy in SHC shelters, it was found that occupants of new shelters who are satisfied with visual privacy are quite more than those who are not satisfied, while dissatisfaction in old shelters is significantly more than satisfaction.

The quality of the acoustic environment was then investigated and occupants' satisfaction with noise levels was explored as well, a line with surveying noise sources and speech privacy. In terms of noise level, the highest percentage of shelters was rated as "neutral", followed by "noisy". Further, speech privacy which was proved to be important for the occupants was insufficient for people desires.

Thermal environment, the main focus of this study, was examined and reasons of discomfort in summer and winter were explored as well. Energy consumption for heating and cooling purposes was also inspected. The results indicate that indoor thermal environment during summer and winter is not comfortable in both old and new shelters, with trends to be worse in old shelters. The large heat gain through roofs and walls, the poor ventilation, and the small area of shelters were the main reasons of discomfort in summer. The major factors which cause discomfort in old shelters during winter are the great heat loss through roofs and walls and the large infiltration. In new shelters, the most influence factors causing discomfort in winter in the majority of shelters are "large wall heat loss", followed by "the shelter is shaded by surrounding buildings", "very little sunshine comes in through windows", and "large roof heat loss". For cooling, vast majority of occupants have been utilizing natural ventilation and around 81 percent of them have been using electric fans as well. Almost one-half of shelters` occupants use electric fans 24 hours a day. For heating during winter, various means are used in SHC shelters including; electric fires, firewood, charcoal and kerosene fires, with an average ranged from 4 to 10 hours a day. However, over one-half of SHC shelters` occupants do not use any heating means which can be related to their financial conditions.

Various factors that could influence thermal comfort in SHC shelters were inspected. The survey revealed that the air is too humid in the majority of shelters in winter. Besides, the indoor solar radiation is generally poor in SHC shelters particularly in winter. The analysis revealed statistically significant moderate negative correlations between TSV_{summer} and air circulation, and between TSV_{winter} and air humidity. Through examining the effect of materials on thermal comfort, results showed that TSV in shelters with concrete block walls is lower than TSV in shelters with sand block walls, in both summer and winter. For roofing materials, although not significant statistically, the highest recorded TSV in summer is for corrugated iron shelters followed by asbestos sheets shelters and the lowest TSV recorded for concrete slap shelters. In winter, TSV in concrete slap shelters is generally higher than that of asbestos sheets shelters and the lowest TSV was reported for corrugated iron shelters. Furthermore, in winter, TSV for shelters with wooden windows is lower than TSV for shelters comprising glazing with external shutters windows. In investigating the effect of shelter height in new shelters, the statistical test revealed that one-floor shelters are colder than two-floor shelters in winter.

Other indoor environmental features were examined too. The results indicated that amount of area in SHC shelters is overall not adequate, with amount of area being less sufficient in new shelters. Indoor air was described as "dusty", "stuffy", and "stale smelling" in about 30 to 40 percent of old shelters. Occupants of old shelters who are dissatisfied with air quality are more than those who are satisfied. Security level in new shelters is overall better than in old shelters. The most important reasons to open windows were to increase cross ventilation and natural light, while the major reasons to close them were to increase visual privacy and to avoid hazards. Besides, three-quarter of new shelters and 60 percent of old shelters have SWHSs which provide adequate hot water in an average of about 5 months through the year.

At the end, general evaluation for the indoor conditions of SHC shelters was provided. Analysis revealed that the most preferable modifications were "more area", followed by "more comfortable temperature", "more visual privacy", "better ventilation", and " better natural light ". In the overall comparison between old and new shelters, it was revealed that responses recorded for "new shelter is better" are higher than those recorded for "old shelter is better" in terms of all indoor environment features excluding adequacy of space.

CHAPTER 8

SELECTION OF THERMAL MODELLING COMPUTER PROGRAMME

8.1 INTRODUCTION

Criteria for selection thermal software are developed in this chapter and the characteristics of the studied shelters, which have effect on the selection process, are highlighted. Then the results of several comparative tests conducted on two selected computer programmes (Ecotect and TAS) are clarified; comprising comparative tests for thermal mass, solar gain, ventilation, and external shading. At the end, a comparison between the two programmes, depending on the suggested criteria and the findings of the comparative tests, is discussed

8.2 CRITERIA FOR SELECTION THERMAL MODELLING PROGRAMME

As computers can run the most sophisticated calculations, computer simulation became a powerful tool to analyse dynamic thermal performance of buildings including predicting the hour-by-hour variations of internal conditions, heat fluxes, and energy usage in response to occupancy patterns, plant schedules, and weather conditions. Computer simulation is significantly constructive when measurement methods are too expensive or not available. However, the validity of the results of the simulation depends on the quality of the program used (Hyde, 2000). Several thermal modelling programmes are available in the market ranging from simple to comprehensive ones. Relatively simple programs have been produced which use basically the steady-state type calculations. A number of programs are based on the "admittance procedure" which analyse the dynamic thermal response, but in a strict sense. Other programmes use sophisticated calculation methods for dynamic thermal response. Besides, some computer modelling programmes are more suitable to simulate buildings with specific features, for instance; some programmes are designed for commercial buildings and others for air conditioning buildings. Therefore, the characteristics of the buildings could affect the selection of the most appropriate thermal modelling programme.

The characteristics of the studied shelters are identified as a first step as follows:

- Residential buildings (i.e. the buildings are occupied 24 hours a day)
- Naturally ventilated
- Located in crowded built environment (i.e. the studied shelters are shaded by neighbouring buildings)
- Located in hot humid climate

Afterwards, developed criteria are applied in choosing the most appropriate thermal modelling programme for this study. These criteria are as follows:

a- Required Outputs

The first and most important criterion in selecting thermal modelling programme is the capability of the programme to deal with the required application as well as to provide the basic needed outputs. In this study, the selected programme must at least be capable of predicting the internal conditions such as temperature and humidity, estimating the heating and cooling loads, assessing the thermal comfort, and examining the performance of alternative constructions to achieve better indoor thermal environments and lower energy consumption.

b- Accuracy

As a general strategy, it would seem reasonable to aim for a high level of accuracy. The accuracy of various programmes was checked through; identifying the thermal analysis calculation method on which a programme is based, considering the limitations of each programme, and assessing the level of modelling details demanded by the programme as input data. The levels of details required by various simulation programmes are different. Part of the input data of the simulation is sometimes fixed or hidden from the user. For example, in Hevacomp software some of thermal properties of construction materials which are provided in the fabric data interface are allowed to be edited, while other properties such as thermal conductivity and specific heat are hidden. For the purpose of this study, the main thermal properties of construction materials should be available to be controlled and edited in the data input interface.

c- Simplicity and Ease of Learn and Use

Building energy simulation tools require a great deal of time to learn (Kim and Stumpf, 2011). The ease of learning a programme is influenced with; the quality of its user's manual, the availability of a support system to answer questions, as well as the complexity of input procedures. After gaining sufficient experience, the need to obtain and enter a complex set of input data into simulation programs continues to consume the time. Many packages can access data libraries which assist in preparing the needed inputs. As several shelters (21 shelters) are to be entirely simulated in this study, simplicity to deal with the computer programme should be considered in selecting the appropriate one. However, it is impossible to achieve the optimum level of comprehensiveness and ease of use in the field of building thermal simulation (Clarke, 2001). Consequently, thermal modelling programme has been selected in this study with the intention of finding a balance between ease of application and comprehensiveness with emphasis on the minimum requirements mentioned earlier.

d- Access to Programme

In order for potential programme to be selected, demonstration versions of the programme should be obtained and run. Manuals for the most suitable programs were obtained and reviewed. Afterwards, demonstration versions of those programs were tried to be obtained in order to run some tests. Some of programmes had to be excluded from selection, not because of their capabilities, but because there is no free trial version available for students; IES VE is an example.

According to the main characteristics of the studied shelters and according to the above discussed criteria, three thermal modelling programmes are firstly selected for deep investigation and for comparative tests, which are; Ecotect V 5.60, TAS (Thermal Analysis Software) V9.1.4.1, and Bentley Hevacomp V8i. Training on using these programmes for simulation was taken place until sufficient experience was gained which enabled the researcher to carry out the required modelling. However, it was discovered that Hevacomp, although it is widely used, does not consider shading on opaque materials. This is clarified by a test conducted on a free running windowless cube (9*9*9 meter) surrounded by neighbouring cubes. The internal temperature and the fabrics loads of the cube were calculated once with external shadings and once without them. The results showed no difference between the two cases in terms of internal temperature, fabric load, or total load (see figure 8.1).

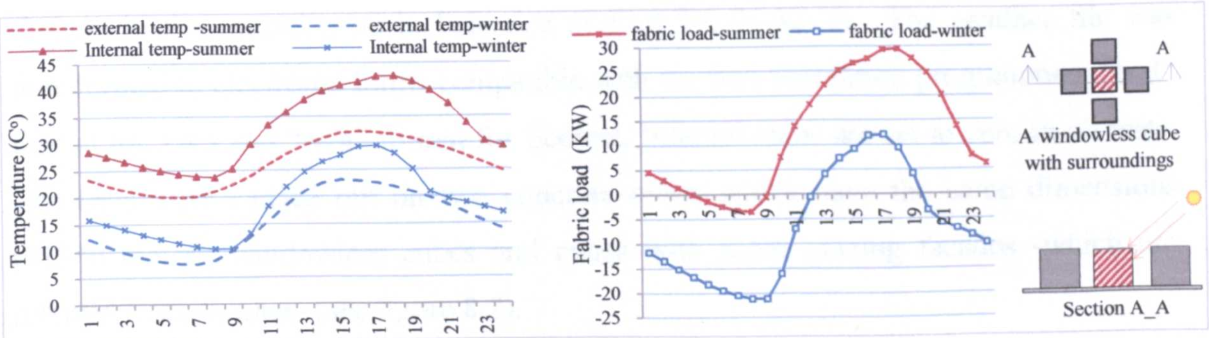


Figure 8.1: Temperature and fabric loads of a free running windowless cube, with and without surroundings

Therefore, the author of this thesis contacted the support team of Bently Hevacomp to ask whether the software considers external shading on opaque components of buildings. The technical support analyst at Hevacomp confirmed that "*The shadows object only affect the direct solar component on glazing*".

As the studied shelters are shaded by neighbouring buildings most of the time, the selected programme should consider shading on opaque and glazing components of the shelters as an absolute requirement, regardless of any other factors. Consequently, Hevacomp software was excluded, where comparative tests were conducting using Ecotect and TAS. Ecotect is a building design and environmental analysis tool that covers broad range of analysis functions including thermal and lighting simulation (Marsh, 2003). Ecotect is a highly visual building simulation tool which has been used by many researchers to evaluate the required design configurations in different types of buildings in various climatic regions. TAS is a software package for the thermal analysis of buildings which includes a 3D modeller, a thermal/energy analysis module, a systems simulator and a 2D CFD package. It is the most comprehensive thermal simulation tool of a building, and a powerful design tool in the optimization of a buildings environmental, energy and comfort performance (Marsh, 2011). TAS has been used by various researchers to assess thermal performance of buildings.

8.3 INPUT DATA FOR COMPARATIVE TESTS

Various specific tests are conducted to investigate and compare how the two selected programmes, Ecotect and TAS, consider thermal mass, ventilation, solar gain, and shading. The quality of the results of the comparative tests depends on supplying the two programmes with the same input data, particularly with regard to; climate, site, geometry, construction, ventilation, and internal gains. Therefore, the same weather file was used in both programmes, which was for a weather station close to the studied shelters in the coastal zone in Palestine at 32.0 °N, 34.82 °E. The weather file was transformed to electronic forms compatible with the two simulation programmes; "twd" format for TAS and "wea" format for Ecotect. Internal gains are set to zero in all tests. The tests were carried out on two concrete cubes which have the same dimensions (9*9*9 meter); windowless cubes and cubes with south glazing facades -which are referred to as ***Gcubes***- (see figure 8.2).

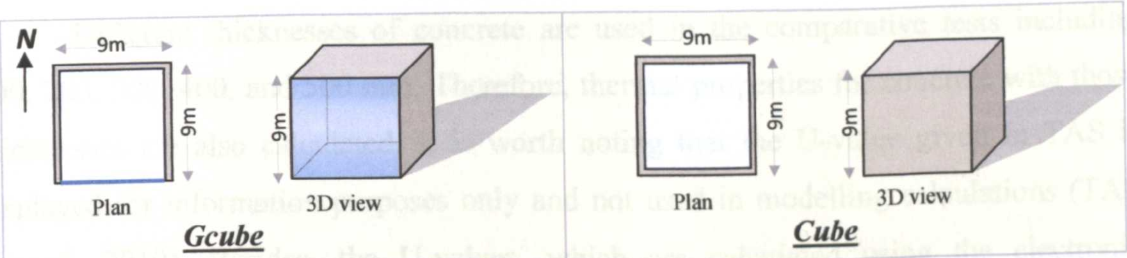


Figure 8.2: Drawings for cubes and Gcubes used in the comparative tests

The major obstacle was providing both programmes with the same properties for constructions. Description for opaque and transparent constructions used in the comparative tests is clarified in the following subsections.

8.3.1 Opaque Constructions

TAS and Ecotect are different in the required inputs for constructions, where some properties are required as input in one programme while not required in the other. In TAS, the layer properties can be edited by the user, while the construction properties cannot be edited as they are calculated with the software itself according to the layer properties. In Ecotect, both the layer and the construction properties should be edited by the user. In comparative tests, concrete was used with the characteristics explained in table 8.1. All the layer properties and some of the construction properties needed in Ecotect were obtained from TAS and edited in the data input interface of the Ecotect. Decrement factor, admittance, U-value, and time lag, which are required in Ecotect for the different building components, are calculated using "dynamic thermal property calculator V1.0" based on ISO13786.

Table 8.1: properties of concrete used in comparative tests

Layer Properties

Parameter		TAS	Ecotect
Width (mm)		100	100
Density (kg/m^3)		1800	1800
Conductivity (W/m.°C)		1.13	1.13
Specific heat (J/kg. °C)		1000	1000
Vapour diffusion factor		9999	....
Convection Coefficient		0.001	....
Solar Reflectance	External	0.3	....
	Internal	0.3	....
Light Reflectance	External	0	....
	Internal	0	....
Emissivity	External	0.9	....
	Internal	0.9	....

Construction Properties

Parameter		TAS	Ecotect
Emissivity	External	0.9	0.9
	Internal	0.9	0.9
Solar Absorption	External	0.7	0.7
	Internal	0.7	
Visible Transmittance (0-1)		....	0
Specularity		....	0
Colour [Reflect]		....	0.75
U-value (W/m^2.°C)	Roof (Ext-Up.)	4.376	4.376
	Wall (Ext-Ho)	3.869	3.869
	Floor (Ext-Do.)	3.35	3.35
Admittance (W/m^2.°C)	Roof	....	5.37
	Wall	....	4.65
	Gr floor	....	3.93
Decrement Factor	Roof	....	0.89
	Wall	....	0.87
	Gr floor	....	0.85
Time Lag (hrs)	Roof	....	2.37
	Wall	....	2.52
	Gr floor	....	2.67

Legend:
Black : Data provided by the software itself
Blue : Date taken from TAS and edited in Ecotect
Red : Data calculated using a calculator
Green: Data calculated using a calculator and which match TAS calculation.

Different thicknesses of concrete are used in the comparative tests including 100, 200, 300, 400, and 500 mm. Therefore, thermal properties for concrete with those thicknesses are also calculated. It is worth noting that the U-value given in TAS is displayed for information purposes only and not used in modelling calculations (TAS manual, 2010). Besides, the U-values, which are calculated using the electronic calculator, exactly match those provided in TAS.

8.3.2 Transparent Constructions

In some comparative tests, 6 mm single clear glazing material is also used for the south façade of the *Gcube*. The required parameters for the transparent materials in TAS and Ecotect are quite different. Table 8.2 provides the properties of glazing used in the comparative tests. As indicated in table 8.2, different expressions are displayed in both programmes for the same term. For instance, the "G value" provided in TAS and the "Solar heat gain coefficient SHGC" provided in Ecotect are two expressions for one term; where the former is commonly used in Europe and the later is used in the United States.

Table 8.2: properties of glazing used in comparative tests

Layer properties				Construction properties		
Parameter		Ecotect	TAS	Parameter	Ecotect	TAS
Width (mm)		*6*	*6*	*U value (W/m².°C)*	*5.74*	*5.74*
Conductivity (W/m.°C)		*1.05*	*1.05*	*Visible/Light Transmittance (0-1)*	*0.881*	*0.881*
Density (kg/m³)		2300	....	*G value/Solar heat gain coefficient SHGC*	*0.816*	*0.816*
Specific heat (J/kg. °C)		836.8	....	R value (m².°C /W)	....	0.174
Vapour diffusion factor		....	9999	Conductance (W/m².°C)	....	174.33
Convection Coefficient		....	0	Specularity	0	....
Solar Trans.		....	0.78	Colour [Reflect]	0.737	....
Light Transmittance		....	0.88	Refractive index of glass	1.74	....
Solar Reflectance	External	....	0.07	Alt. Solar Gain (heavywt)	0.47	....
	Internal	....	0.07	Alt. Solar Gain (lightwt)	0.64	....
Light Reflectance	External	....	0.08	Admittance	6	....
	Internal	....	0.08	Legend:		
Emissivity	*External*	*0.84*	*0.84*	Black: Data required in one programme		
	Internal	*0.84*	*0.84*	*Red : Data required in both programmes (TAS & Ecotect)*		

The following sections discuss comparative tests conducted to investigate how Ecotect and TAS consider thermal mass, ventilation, solar gain, and shading.

8.4 THERMAL MASS COMPARATIVE TESTS

Thermal mass comparative tests were conducted on concrete cubes with various thicknesses (comprising 100, 200, 300, 400, and 500 mm) and on both free running cubes (FR) and air conditioned cubes (AC). These tests investigated thermal mass of exposed and adjoining components. The internal gains, the infiltration rates, and the ventilation are set to zero in all cubes. In air conditioned cubes, lower temperature is set 18 °C, upper temperature is set 25 °C, and humidity is set 60%. The tests were done for a summer and a winter-day, and the results comprise outside and inside air temperatures, cooling and heating loads, as well as fabric loss/gain.

8.4.1 Free Running (FR) Cube with Various Thicknesses

8.4.1.1 Inside Air Temperature

a. In a summer-day: Figure (8.3) presents predicted air temperature by TAS and Ecotect in a summer-day in free running (FR) cubes of various fabric thicknesses. The results show that, the internal air temperature estimated by TAS is always higher than that estimated by Ecotect in all cubes with a maximum discrepancy of 10.3 °C. The difference of the internal air temperature between the two programmes increases with the increase of fabric thickness. In the case of 10cm cube, the internal temperature predicted by TAS simulation is quite comparable with that predicted by Ecotect simulation with a maximum discrepancy is 3.6 °C. While, the averages of discrepancies between the both programmes in other cases (20 cm, 30cm, 40cm, and 50cm cubes) are about 6.9°C, 8.9°C, 9.7°C and 10°C respectively. In addition, according to Ecotect results, the internal air temperature for all cubes, excluding 10cm cube, ranges from 17.6 to 24.4 °C, which means no need for cooling. In contrast, all cubes require cooling in accordance with TAS results as the inside air temperature ranges from 22.3 to 34.8 °C.

Although there is an observed significant difference between TAS and Ecotect results in terms of air temperature, the swings of temperature through the day are compatible in both programmes for each thickness, where the swings dampen with higher thicknesses with the influence of thermal storage. Besides, it is noted in both programmes` results that, although the average air temperature in cubes decreases with the increase of their thicknesses, this drop in temperature fades significantly with larger thermal mass until no observed difference in the average temperature is found between 40 and 50 cm cubes.

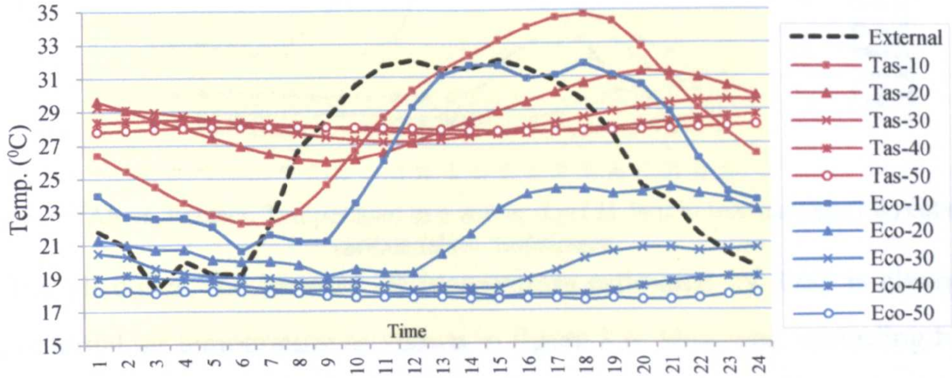


Figure 8.3: TAS vs. Ecotect: Temperature in a summer-day (21 July) in free running (FR) cubes of various fabric thicknesses

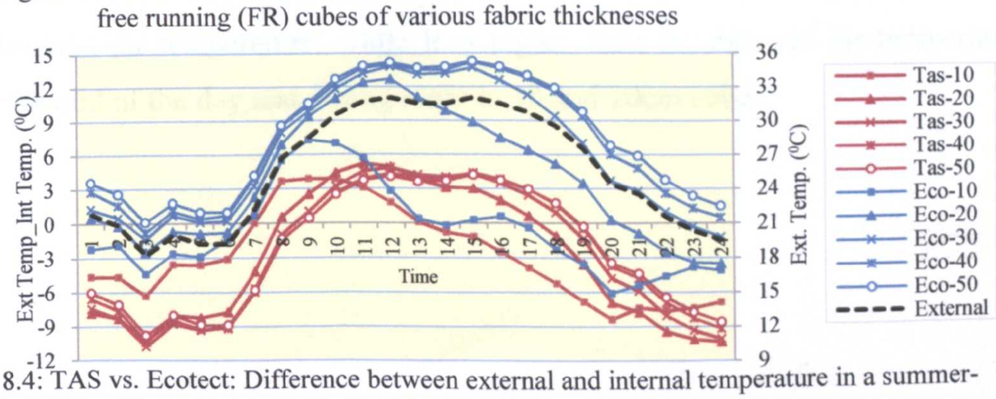


Figure 8.4: TAS vs. Ecotect: Difference between external and internal temperature in a summer-day (21 July) for free running (FR) cubes of various fabric thicknesses

By investigating the difference between the internal and the external air temperature, it is noted that the internal air temperature estimated by TAS is almost higher than the external air temperature during the day with a maximum of 3.8 °C, while it tends to be lower than the external air temperature during the night with a maximum difference of 10.8 °C (figure 8.4). In Ecotect results, the internal air temperature is almost lower than the external air temperature in the case of large thermal mass cubes (including 30, 40, and 50 cm cubes) with a difference reaches a peak of 14.3 °C at the mid of the day.

b. In a winter-day: The results for winter are similar to those for summer in that the internal air temperature predicted by TAS is higher than that predicted by Ecotect. Therefore, all cubes require heating according to Ecotect simulation, while there is almost no need for heating according to TAS results since the estimated air temperature is generally higher than 18 °C. As indicated in figure 8.5, the difference in the internal air temperature between the two programmes increases with the increase of fabric thickness and ranges from 2.9 to 8.6 °C. On the other hand, fluctuating of the internal air temperature through the day, for every fabric thickness, is similar in both programmes.

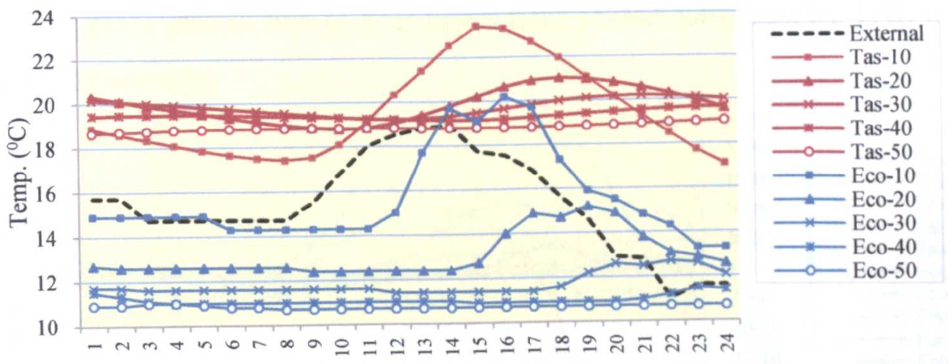


Figure 8.5: TAS vs. Ecotect: Temperature in a winter-day (21 Jan) in free running (FR) cubes of various fabric thicknesses

For all cubes, the internal air temperature estimated by TAS is always higher than the external air temperature as shown in figure 8.6. However, according to Ecotect modelling, the internal air temperature for 30, 40, and 50cm cubes is generally lower than the external air temperature, while it is higher than the external air temperature only after the mid of the day and during night in 10 and 20cm cubes.

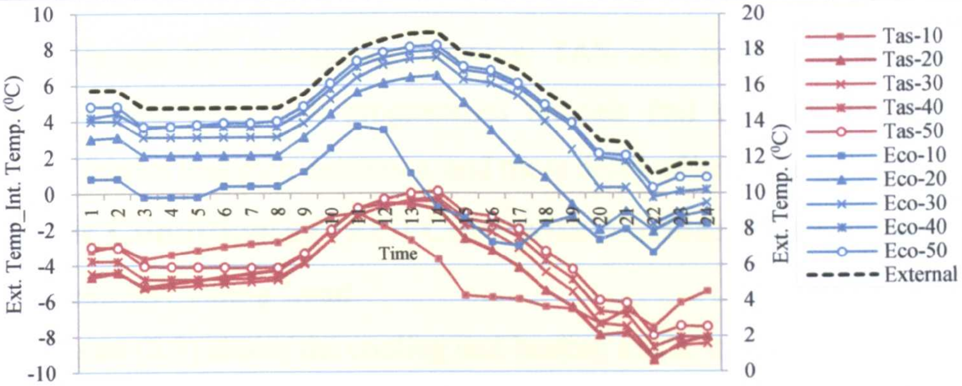


Figure 8.6: TAS vs. Ecotect: Difference between external and internal temperature in a winter-day (21 Jan) for free running (FR) cubes of various fabric thicknesses

8.4.1.2 Fabrics Gain/Loss

Heat gain and loss through fabrics were also examined in TAS and Ecotect for all cubes, in a summer and a winter day (figures 8.7 and 8.8). It was revealed a significant difference in fabrics loss/gain estimated by TAS and that estimated by Ecotect. For instance, the maximum fabric gain of 10cm cube in summer is 500 watt according to TAS simulation, while it is 25000 watt according to Ecotect simulation. Besides, the results show that, in both summer and winter, the total fabric loss equals the total fabric gain as estimated by TAS, while they are not equal as estimated by Ecotect with no fabric loss in summer. It is noted that the peak fabric gains estimated by Ecotect takes place almost two to four hours later of that estimated by TAS in summer and winter respectively.

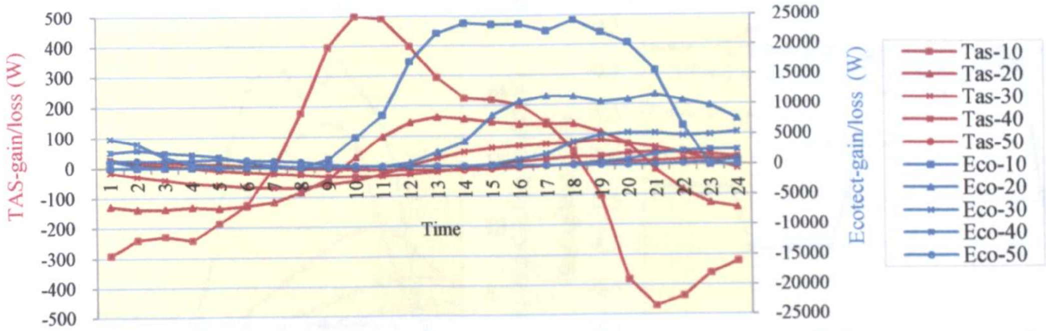


Figure 8.7: TAS vs. Ecotect: Fabric gain/loss in a summer-day (21 July) for FR cubes of various fabric thickness

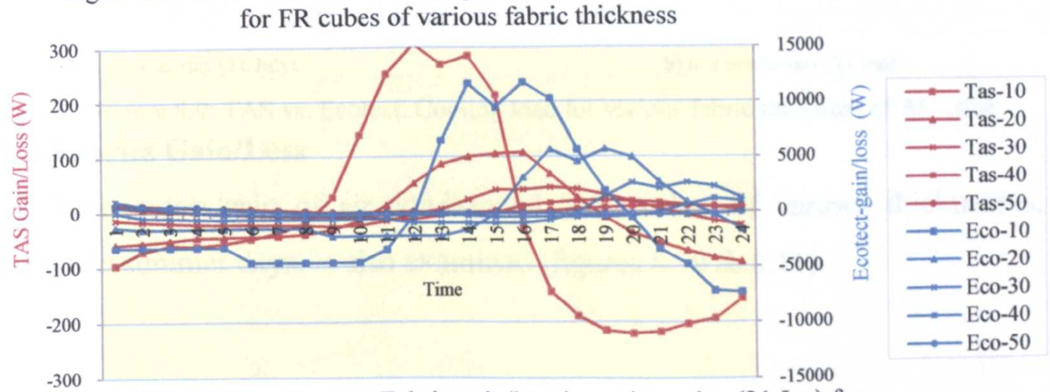


Figure 8.8: TAS vs. Ecotect: Fabric gain/loss in a winter-day (21 Jan) for FR cubes of various fabric thickness

Although the discrepancy between TAS and Ecotect in predicting fabrics loss/gain, results from both programmes indicate that with the increase of fabrics thickness, fabrics loss/gain decreases, and more delay of heat loss/gain takes place.

8.4.2 Air Conditioning (AC) Cube with Various Thicknesses

8.4.2.1 Heating/Cooling Load

Figure (8.9) shows the cooling and heating loads, in a summer and a winter day, of air conditioned cubes of various thicknesses. In summer, the cooling load for 20, 30, 40, and 50cm cubes is zero as estimated by Ecotect. This result is compatible with the internal air temperatures of FR cubes estimated by the programme, where temperatures fall almost between 18 and 25 °C, as discussed earlier. For 10cm cube, the cooling load estimated by Ecotect is significantly higher than that predicted by TAS, though the internal temperature of FR 10 cm cube predicted by Ecotect was slightly higher than that predicted by TAS.

In winter, there is no cooling loads in the cubes (excluding 10cm cube) as simulated by TAS which matching with the internal air temperatures of FR cubes estimated by the programme, where temperatures fall between about 18 and 25 °C, as shown earlier. In contrast, all cubes have heating loads according to Ecotect results, for instance, ranging from 3 to 7 kilo watts in 10cm cube.

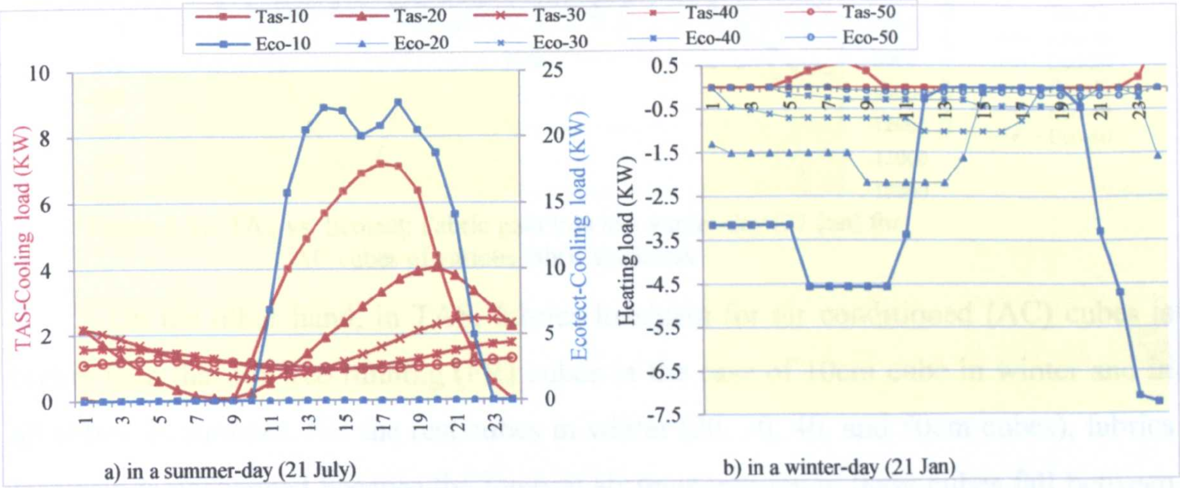


Figure 8.9: TAS vs. Ecotect: Cooling load for various fabric thickness of AC cube

8.4.2.2 Fabrics Gain/Loss

Fabrics loss/gain of air conditioned (AC) cubes of various thicknesses, in a winter and a summer days, is also examined (figures 8.10 & 8.11).

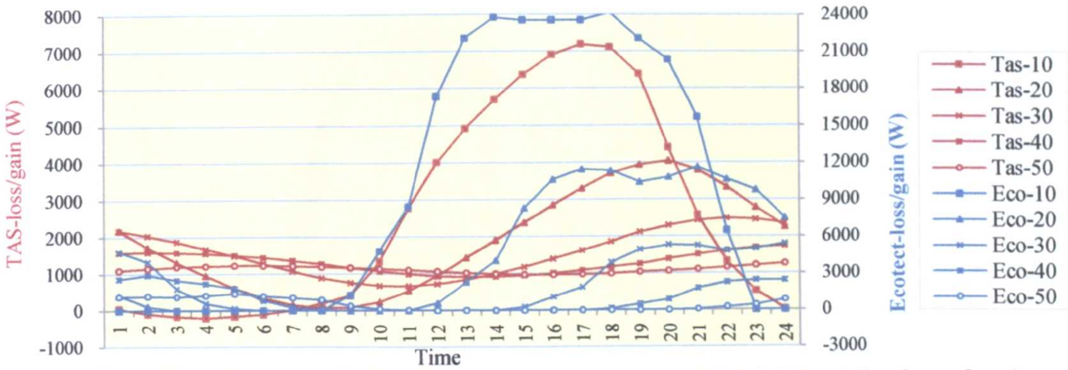


Figure 8.10: TAS vs. Ecotect: Fabric gain/loss in a summer-day (21 July) for AC cubes of various fabric thickness

Results revealed that fabrics loss/gains of AC cubes are the same as those of FR cubes according to Ecotect results, in both summer and winter. As clarified in chapter 4 of this thesis, heat flow through building fabrics is influenced with the internal air temperature. Therefore, Ecotect`s prediction for the fabric loss/gain is reasonable only in summer results of 20, 30, 40, and 50 cm cubes, as the internal temperatures of these cubes in summer stay the same in the case of free running and air conditioning. However, for all cubes in winter and for 10cm cube in summer, internal temperatures in these cubes in the case of air conditioning differ from those of free running.

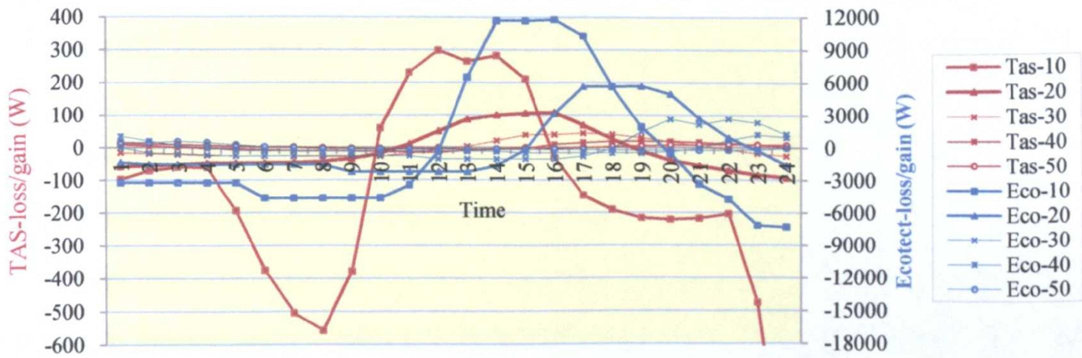


Figure 8.11: TAS vs. Ecotect: Fabric gain/loss in a winter-day (21 Jan) for AC cubes of various fabric thickness

On the other hand, in TAS, fabrics loss/gain for air conditioned (AC) cubes is higher than that for free running (FR) cubes in the case of 10cm cube in winter and in all cubes in summer. For the rest cubes in winter (20, 30, 40, and 50cm cubes), fabrics loss/gain is unchanged because the internal air temperatures in these cubes fall between 18 and 25, i.e. do not change with air conditioning.

8.4.3 Ecotect- Fabrics Gain/Loss of FR Cube with Various Comfort Band

It was observed that, in Ecotect simulation, even for free running buildings, the lower and the upper comfort bands must be entered by the user into the zone settings interface. Therefore, the effect of various comfort bands on air temperature and fabric loss/gain is examined (figure 8.12).

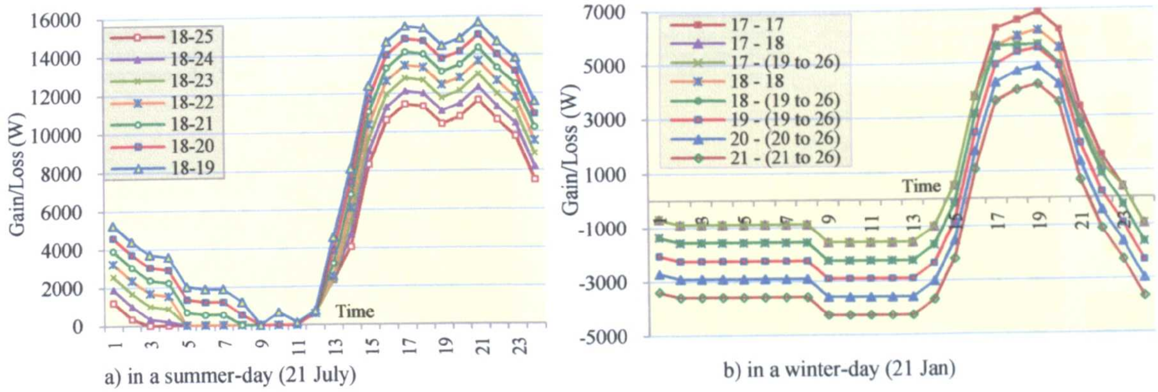


Figure 8.12: Fabrics loss/gain for FR cube (20cm) with various comfort bands

The results revealed that the predicted internal air temperatures of free running cubes at various comfort bands are the same, while fabric loss/gain is influenced with the comfort bands. Lower fabric gain is associated with high comfort bands, and lower fabric loss is associated with low comfort bands. For instance, the total fabric gains of FR 20cm cube in a summer day are about 181KW and 111KW when comfort bands are set at (18-19 °C) and (18-25 °C) respectively.

It is worth noting that comfort bands are required in Ecotect to be entered by the user for natural ventilation buildings too. However, the thermal performance of natural ventilation and free running buildings should not be influenced with the comfort bands. Therefore, it is not reasonable for Ecotect to involve comfort bands for buildings without heating or cooling system.

8.4.4 Thermal Mass of Adjoining Walls

This test is intended to demonstrate the effect of thermal mass of adjoining walls on building thermal performance. The test conducted on a cube adjoined on one side, a cube adjoined in three sides, and a cube adjoined on three sides and corners. The internal air temperature in these cubes were estimated for three thicknesses of adjoin elements (10, 30, and 50cm), while the exposed walls, roofs and floors remain 10cm thick.

As provided in figure (8.13), the results from both programmes indicate that with increase of the thicknesses of adjoining walls, the internal air temperature slightly falls, where drop in temperature is slightly larger in TAS simulation. Besides, it was shown that the drop in temperatures in cubes adjoined on three sides is greater than that in cubes adjoined on one side. However, no difference was found in the internal air temperatures of cubes adjoined on three sides and those of cubes adjoined on three sides and corners.

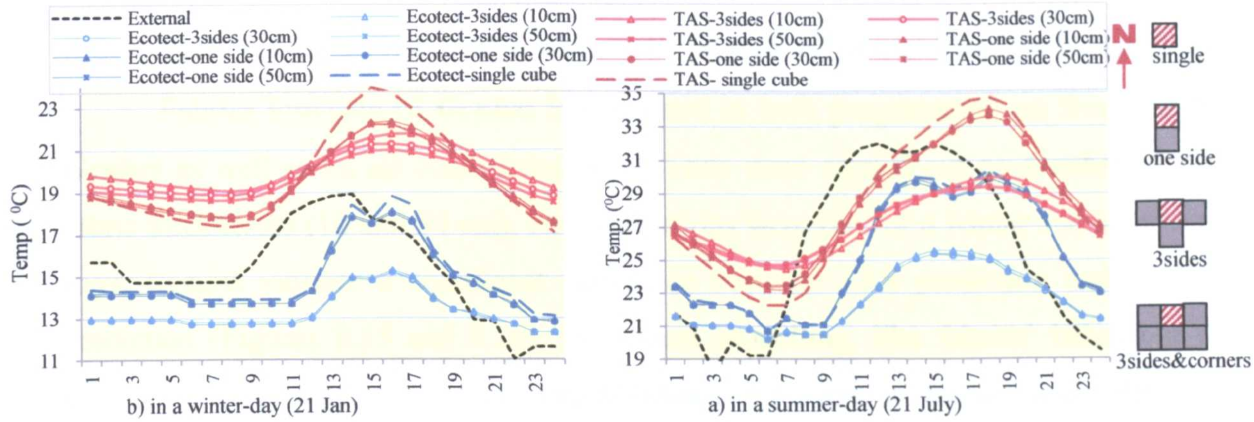


Figure 8.13: Temperature in FR cubes of various thicknesses of adjoining walls

8.5 SOLAR GAIN COMPARATIVE TESTS

These tests are intended to demonstrate how TAS and Ecotect consider the solar gain through glazing elements and its impact on the internal air temperature, and fabrics behaviour. The effect of fabrics` properties such as internal solar absorption on solar gain was also examined on both programmes. The tests were conducted on cubes have south glazing facades (*Gcubes*).

8.5.1 Temperature in Cube with South Glazing Façade (Gcube)

According to both TAS and Ecotect simulations, the internal air temperatures in ***Gcubes*** in winter are overall higher and with greater swings than those in cubes, particularly with large thermal mass (see figure 8.14). However, discrepancy between ***Gcubes*** and cubes in terms of the internal air temperature in winter is greater in TAS modelling than in Ecotect modelling.

On the other hand, results from both TAS and Ecotect show that the internal air temperature of all ***Gcubes*** (10 and 30 cm) in summer is higher than that in all cubes during the daytime and lower than it during the night. However, there is no difference between the average daily temperature in 10cm cubes and that in 10cm ***Gcubes***, and the average daily temperature is slightly higher in 30cm ***Gcubes*** than in 30cm cubes.

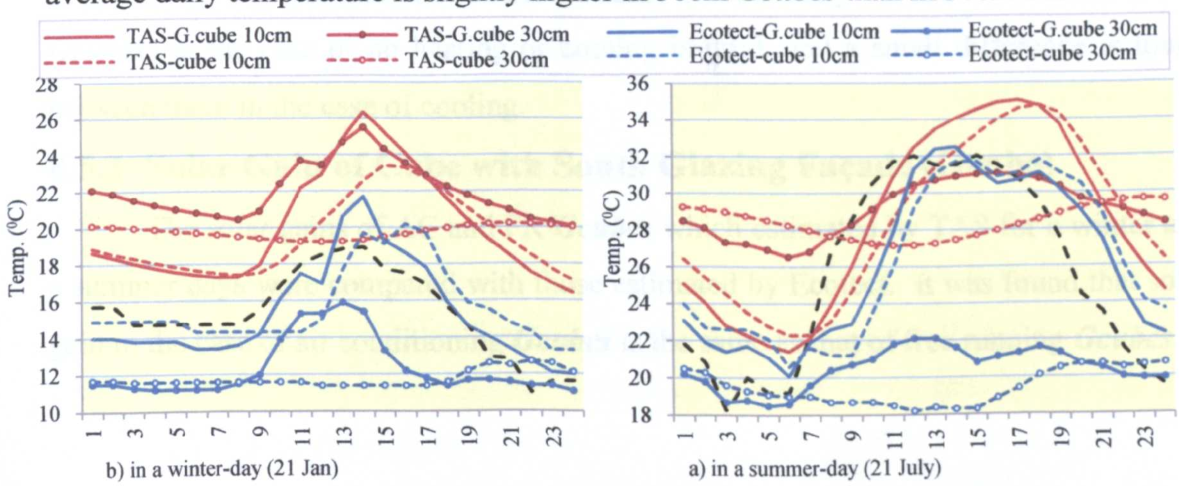


Figure 8.14: TAS vs. Ecotect: Temperature of FR *Gcubes* (10&30 cm thickness)

8.5.2 Fabrics Loss/Gain of Cube with South Glazing Façade (Gcube)

Fabrics loss/gain of ***Gcubes*** is examined in both programmes; on free running ***Gcubes*** as well as on air conditioned ones. Tests were carried out on ***Gcubes*** of two fabric thicknesses (10 and 30 cm), and simulations were run for a winter and a summer days. Results indicate a significant difference between TAS prediction and Ecotect prediction (Figures 8.15 and 8.16). In Ecotect modelling, like fabrics` behaviour of cubes, fabrics loss/gain of free running ***Gcubes*** is the same as that of air conditioning ***Gcubes***, while in TAS they are different. Besides, there is no heat loss through fabrics in summer according to Ecotect estimation, while there is no fabric gain in the case of free running, according to TAS estimation. It is worth noting that, in TAS simulation, in free running buildings, the total heat loss should equal the total heat gain. Thus, fabrics loss estimated by TAS which presented in figure 8.15 is approximately equal solar gain through south glazing facade.

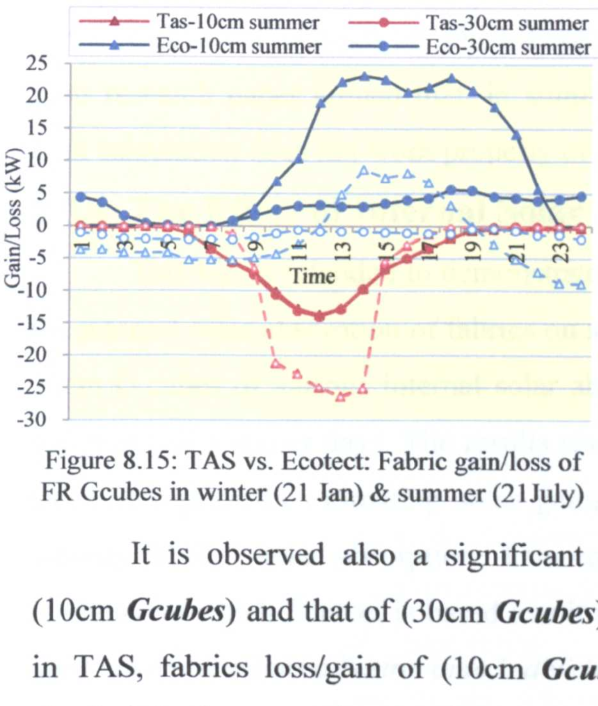


Figure 8.15: TAS vs. Ecotect: Fabric gain/loss of FR Gcubes in winter (21 Jan) & summer (21July)

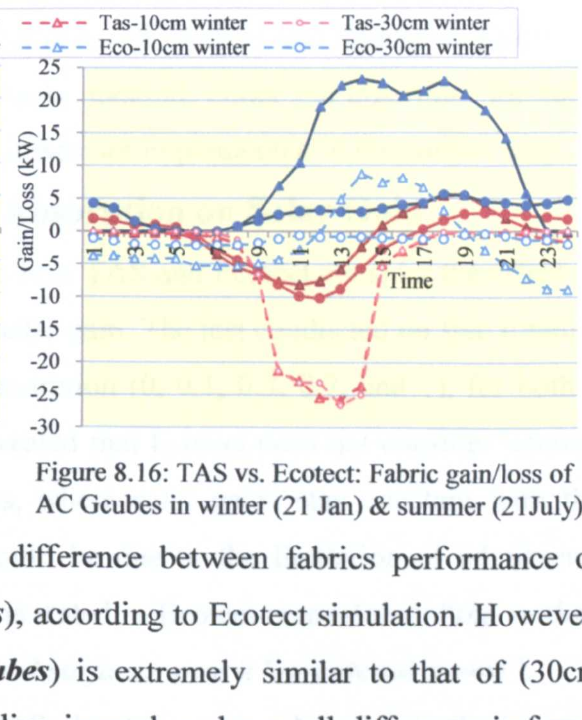


Figure 8.16: TAS vs. Ecotect: Fabric gain/loss of AC Gcubes in winter (21 Jan) & summer (21July)

It is observed also a significant difference between fabrics performance of (10cm ***Gcubes***) and that of (30cm ***Gcubes***), according to Ecotect simulation. However, in TAS, fabrics loss/gain of (10cm ***Gcubes***) is extremely similar to that of (30cm ***Gcubes***) in the case of no heating or cooling is used, and a small difference is found between them in the case of cooling.

8.5.3 Solar Gain of Cube with South Glazing Façade (Gcube)

The solar gains of AC and FR ***Gcubes*** which estimated by TAS for a winter and a summer days were compared with those estimated by Ecotect. It was found that solar gain in the case of air conditioning ***Gcubes*** is the same as that of free running ***Gcubes***.

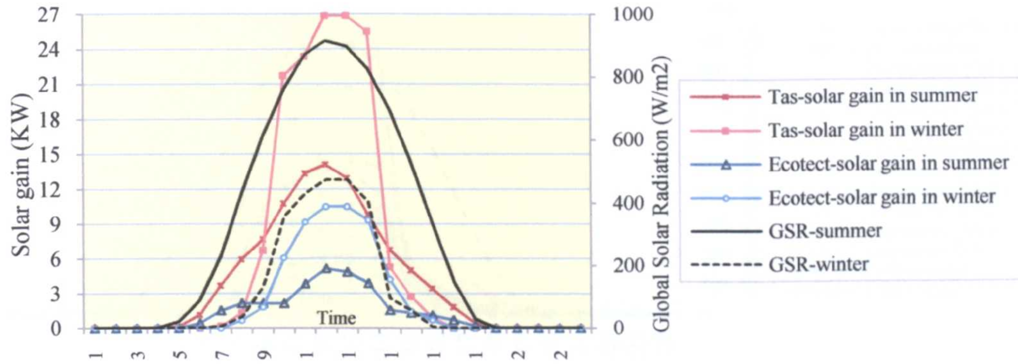


Figure 8.17: TAS vs. Ecotect: Solar gain in a winter and a summer days of FR Gcube

As shown in figure 8.17, in both programmes solar gain in winter is greater than that in summer. Besides, results are similar in the times in which solar gains reach the peak and stop. However, results are dissimilar in the time of starting of solar gain, where it starts one hour later in Ecotect, in both summer and winter. Moreover, the magnitude of solar gain estimated by TAS is almost two times that estimated by Ecotect in both summer and winter. The difference in the results could be due to the limitation of the admittance methods on which Ecotect is based. Hensen and Radosevic (2004) in their research paper argued that, in admittance method, either the algorithm for solar gain calculation does not work properly or it was not implemented in the correct way.

8.5.4 The Effect of Internal Solar Absorption on Solar Gain

This test is intended to demonstrate how TAS and Ecotect consider the effect of the internal solar absorption of fabrics on solar gain. The test conducted on free running 10cm G.cubes of various internal solar absorption (0, 0.1, 0.3, 0.7, and 1), for both a summer and a winter days. The results revealed that Ecotect does not consider internal solar absorption in estimating solar gains, where solar gains stay constant with the various fabrics` solar absorption. This could be due to the limitation of admittance methods on which Ecotect is based ; as it is stated in Ecotect manual that; *"the method does not track solar radiation onto individual surfaces once it has entered a zone"*.

On the other hand, according to TAS simulation, any changing in the internal solar absorption affects the magnitude of solar gain, where higher internal solar absorption of fabrics is associated with greater solar gain, in both summer and winter (figure 8.18). It is also observed that; as the internal solar absorption rises, the magnitude of increasing in solar gain decreases. For instance, a discrepancy in solar gain in winter between two ***Gcubes*** with 0.0 and 0.1 internal solar absorption reaches a peak of 9.5 KW, while the maximum discrepancy between two ***Gcubes*** with 0.7 and 1.0 internal solar absorption is only 1.5 KW.

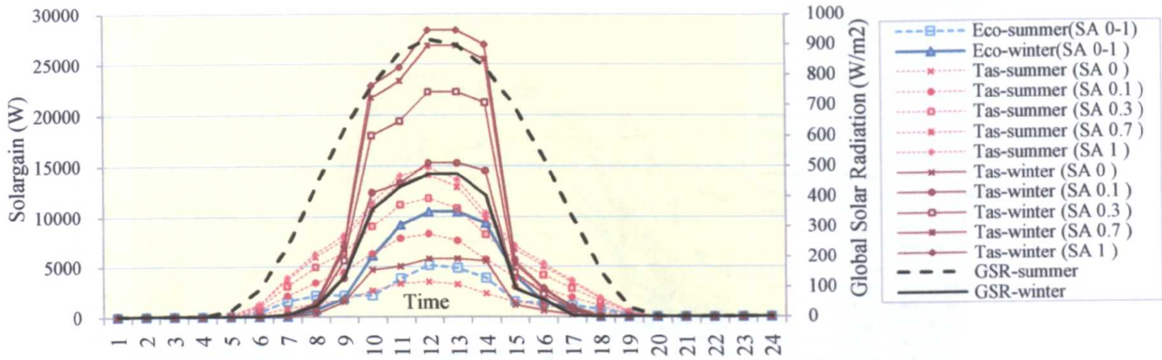


Figure 8.18: Solar gains of *Gcubes* with various Solar Absorption (SA) in a winter & a summer days

8.6 VENTILATION COMPARATIVE TESTS

These tests are aimed to compare TAS with Ecotect in terms of considering the ventilation in predicting the internal air temperature, the ventilation load, and the fabrics loss/gain. Therefore, the tests were carried out on free running cubes with two thicknesses (10 and 30 cm) with various air change rates (0, 1, 10, 20, 30, and 40 acr). The tests were also conducted for both a summer and a winter days. The results from TAS and Ecotect are discussed and compared in the subsections below.

8.6.1 The Effect of Various Air Change Rates (acr) on Temperature

a. In a summer-day: In light thermal mass (10cm thickness), with the increase of acr from 0 to 40, the average internal air temperature slightly drop, with more drop in TAS results (2.6 °C) than in Ecotect results (0.8 °C) (figure 8.19). In heavy thermal mass (30cm thickness), several observations are noticed with the increase of acr from 0 to 40. First, the internal air temperature rises during the day with a maximum increase occurs at the mid of the day according to TAS as well as Ecotect simulation. Second, during the night, the internal air temperature falls according to TAS simulation while it does not change according to Ecotect simulation. Third, the average internal air temperature in TAS falls from (28.4 °C to 25.8 °C), while it rises from (19.4 °C to 24.3°C) in Ecotect. However, the difference between the internal and the external temperature decreases gradually in both programmes. Fourth, the swing in the internal air temperature increases significantly until it becomes similar with the swing of the external temperature, particularly in TAS simulation. From above observations and in accordance with TAS results, it could be argued that night ventilation might be an effective cooling strategy in summer in the case of high thermal mass.

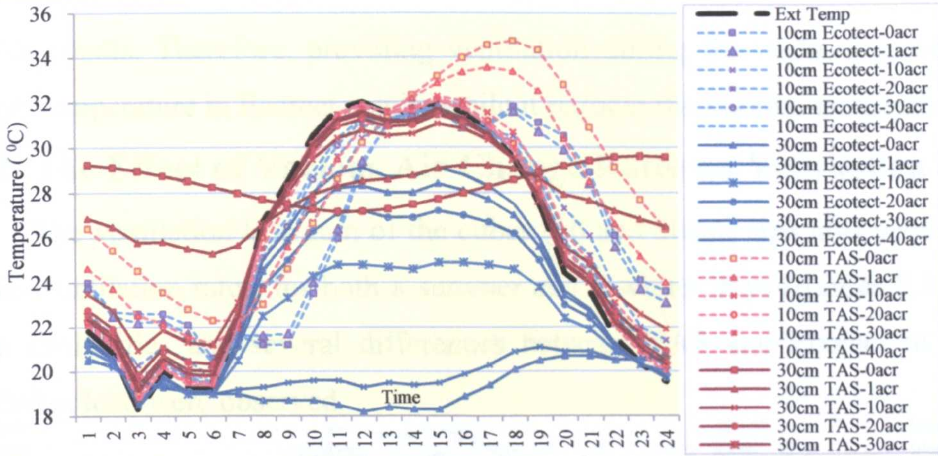


Figure 8.19: Ecotect vs. TAS: Temperature in FR cubes (10cm & 30cm thickness) with various air change rates (acr) in a summer-day (21 July)

b. In a winter-day: In light thermal mass (10cm thickness), like in summer, the average internal air temperature slightly drops with the increase of acr from 0 to 40, with more drop in TAS results (3.9 °C) than in Ecotect results (0.3 °C) (figure 8.20). In heavy thermal mass (30cm thickness), the average internal air temperature falls in TAS from (19.8 to 15.6 °C) and rises in Ecotect from (11.8 to 14.6 °C) as acr increases, until it becomes similar to the outside air temperature. In other words, the difference between the internal and the external temperature decreases gradually in both programmes.

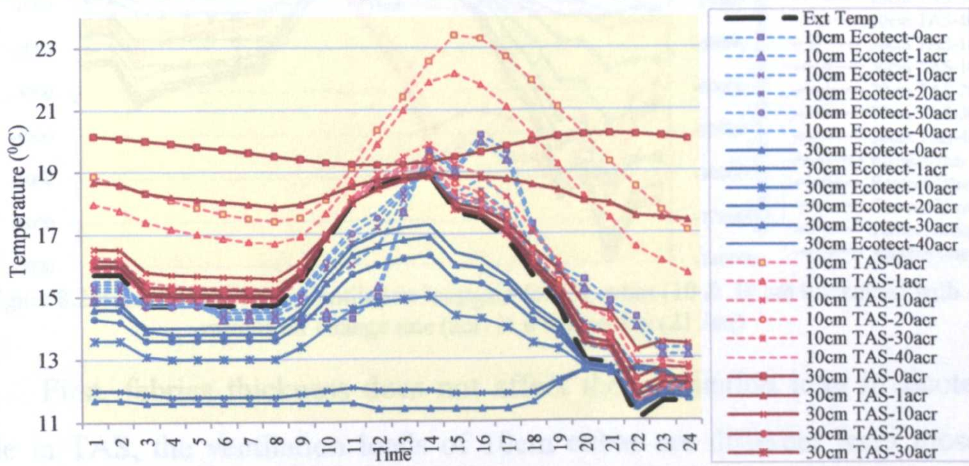


Figure 8.20: Ecotect vs. TAS: Temperature in FR cubes (10cm & 30cm thickness) with various air change rates (acr) in a winter-day (21 Jan)

It was observed that the magnitudes of the increase or the drop in the internal air temperature generally fade with greater acr according to the simulations of both programmes for summer and winter. It is worth noting that the discrepancies in TAS and Ecotect results clarified above are not because each programme considers ventilation differently, but because both programmes are initially different in estimation the internal air temperature with zero acr. For instance, during the night and with no ventilation, the internal air temperature is almost equal the external temperature in summer according to Ecotect while it is higher than the external temperature according to TAS results. Therefore, providing ventilation during the night does not affect the internal temperature in Ecotect results while it reduces the internal temperature in TAS.

8.6.2 The Effect of Various Air Change Rates on Ventilation Load

The ventilation loss/gain of the cubes (10 and 30cm) was also demonstrated for various ventilation rates, for both a summer and a winter days (figures 8.21 and 8.22). Some similarities and several differences between TAS and Ecotect in considering ventilation load were observed.

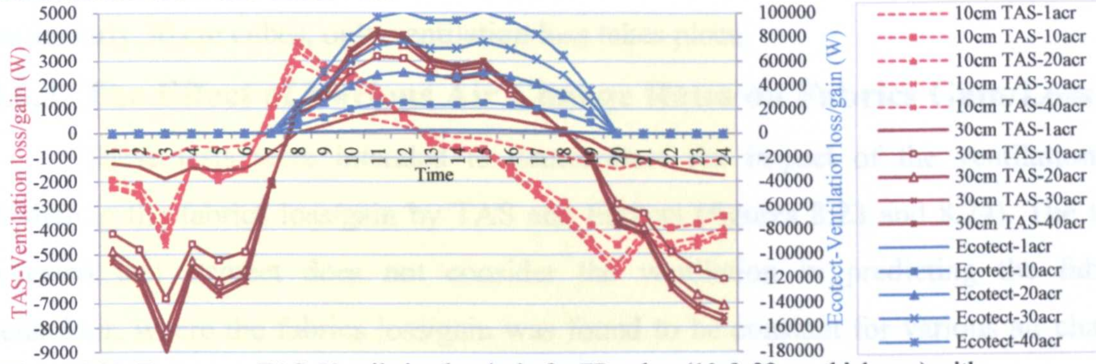


Figure 8.21: Ecotect vs. TAS: Ventilation loss/gain for FR cubes (10 & 30 cm thickness) with various air change rate (acr) in a summer-day (21 July)

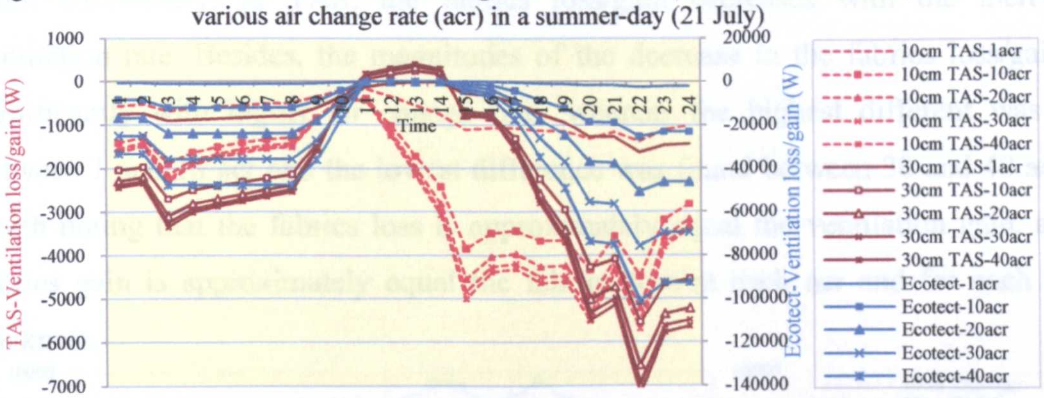


Figure 8.22: Ecotect vs. TAS: Ventilation loss/gain for FR cubes (10 & 30 cm thickness) with various air change rate (acr) in a winter-day (21 Jan)

First, fabrics thickness does not affect the ventilation load in Ecotect results, while in TAS, the ventilation loads of 10cm cubes are different from those of 30cm cubes for each ventilation rate. Second, higher ventilation rate is associated with greater ventilation load in both programmes. However, in Ecotect, the ventilation load rises steadily with the increase of the ventilation rate, while in TAS, the magnitude of increase in the ventilation load fades significantly with higher ventilation rate, where the greatest difference in the ventilation load was found between 1 and 10 acr and the lowest was found between 30 and 40 acr. Third, the ventilation loss in Ecotect in winter is extremely higher than that in TAS, and the ventilation gain in Ecotect in summer is extremely higher than that in TAS (see figures 8.23 and 8.24, where different Y-axis scales are used for TAS and Ecotect results). Fourth, the ventilation gain in summer takes place during the daytime, in both programmes, where the external temperatures rising up. However, the ventilation loss in summer takes place, according only to TAS results, during the night where the external temperature going down. No ventilation loss in summer occurs according to Ecotect during the night as the internal temperature estimated by Ecotect is almost equal to the external temperature. Fifth, in winter, the ventilation loss/gain in TAS is influenced also by the difference between the internal and the external temperatures. On the other hand, in Ecotect, although the internal temperature estimated by the programme is almost lower than the external temperature, particularly 30 cm cubes, only ventilation loss takes place.

8.6.3 The Effect of Various Air Change Rates on Fabrics Gain/Loss

These tests were intended to demonstrate the impact of the ventilation on predicting the fabrics loss/gain by TAS and Ecotect (figures 8.23 and 8.24). The tests revealed that Ecotect does not consider the ventilation in predicting the fabrics behaviour, where the fabrics loss/gain was found to be constant for various air change rates. Conversely, in TAS, the fabrics loss/gain decreases with the increase of ventilation rate. Besides, the magnitudes of the decrease in the fabrics loss/gain fade significantly with higher air change rate; whereas the highest different was found between 1 and 10 acr and the lowest difference was found between 30 and 40 acr. It is worth noting that the fabrics loss is approximately equal the ventilation gain, and the fabrics gain is approximately equal the fabrics loss at each acr and for each fabrics thickness.

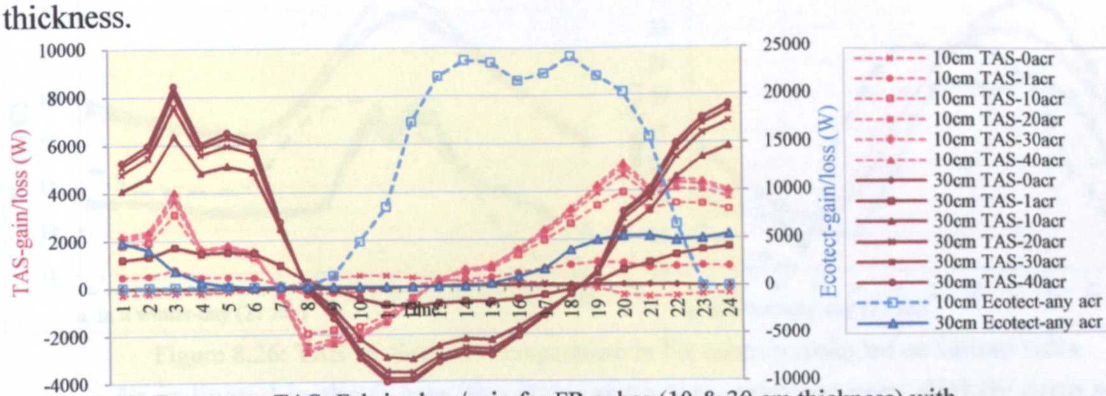


Figure 8.23: Ecotect vs. TAS: Fabrics loss/gain for FR cubes (10 & 30 cm thickness) with various air change rate (acr) in a summer-day (21 July)

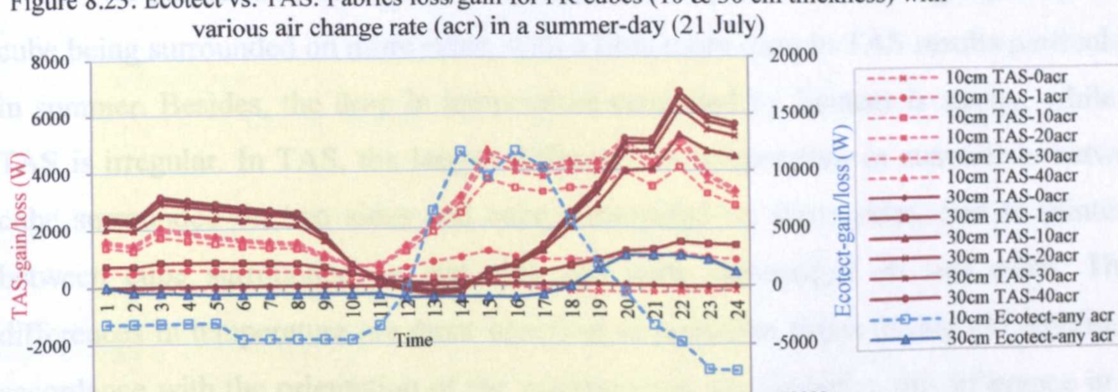


Figure 8.24: Ecotect vs. TAS: Fabrics loss/gain for FR cubes (10 & 30 cm thickness) with various air change rate (acr) in a winter-day (21 Jan)

8.7 EXTERNAL SHADING COMPARATIVE TESTS

These tests are intended to compare TAS and Ecotect in terms of considering the external shading in simulating the building thermal behaviour. The tests were conducted on free running cubes surrounded with various numbers of cubes on different sides; surrounded on one side, two sides, three sides, four sides, and four sides and corners (figure 8.25). The surrounding cubes are with the same dimensions and the same fabrics of the studied cubes in the middle. The internal air temperature and the fabrics loss/gain of studied cubes are predicted and compared using TAS and Ecotect. Findings are discussed below.

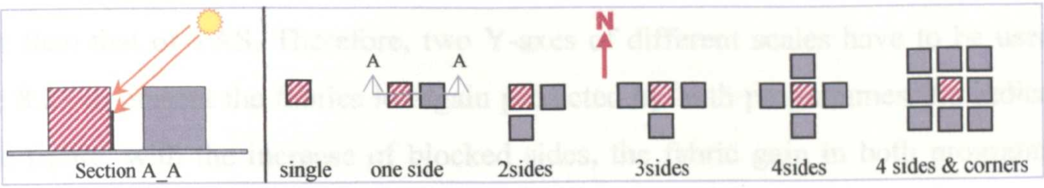


Figure 8.25: Studied cubes in external shading comparative tests

8.7.1 The Effect of External Shading on Temperature

It was revealed that both programmes consider the external shading in estimating the internal air temperature. Figure 8.28 provides the internal air temperature in a summer and in a winter days of a single cube and cubes surrounded on various sides.

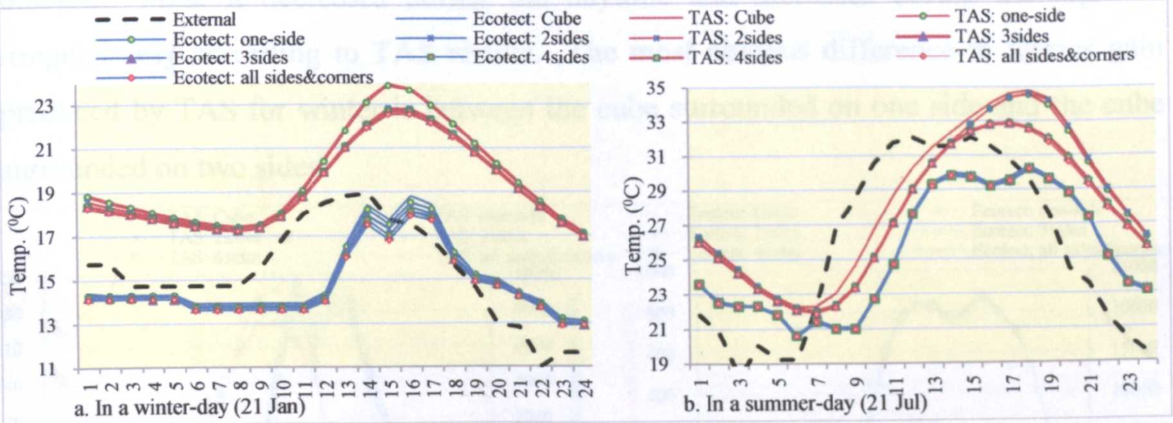


Figure 8.26: TAS vs. Ecotect: Temperature in FR cubes surrounded on various sides

As indicated in the figure, the internal air temperatures very slightly drop as the cube being surrounded on more sides, with a little more drop in TAS results particularly in summer. Besides, the drop in temperature estimated by Ecotect is steady, while by TAS is irregular. In TAS, the largest difference in temperature in summer is between cube surrounded on two sides and cube surrounded on three sides, and in winter is between cube surrounded on one side and cube surrounded on two sides. These differences in temperature are more observed at particular times during the daytime in accordance with the orientation of the surroundings. For instance, the difference in the internal air temperature during summer, between the single cube and the cube surrounded on one side is more obvious at about (8:00am–2:00pm) as the cube is blocked from the east. The difference in the internal air temperature between the cube surrounded on two sides and the cube surrounded on three sides is more obvious at (4:00pm–9:00 pm) as the later is additionally blocked from the west.

8.7.2 The Effect of External Shading on Fabrics Gain/Loss

Figure 8.27 provides the fabrics loss/gain, in a winter and a summer days, for a FR single cube and cubes surrounded on various sides. It should be highlighted that, as clarified earlier, the fabric loss/gain estimated by Ecotect for a single cube is extremely higher than that of TAS. Therefore, two Y-axes of different scales have to be used in figure 8.27 to present the fabrics loss/gain predicted by both programmes. As indicated by the figure, with the increase of blocked sides, the fabric gain in both programmes generally decreases in summer, where it drops gradually during the daytime and remains almost constant during the night according to Ecotect. However, the fabrics gain predicted by TAS for summer varies in accordance with the direction of the blocking. On the other hand, in winter, with the increase of the number of blocked sides, the fabric gain also decreases gradually according to Ecotect particularly at (1:00pm-6:00pm), while it decreases during the daytime and increases during the night in irregular way according to TAS results. The most obvious difference in fabrics gain predicted by TAS for winter is between the cube surrounded on one side and the cube surrounded on two sides.

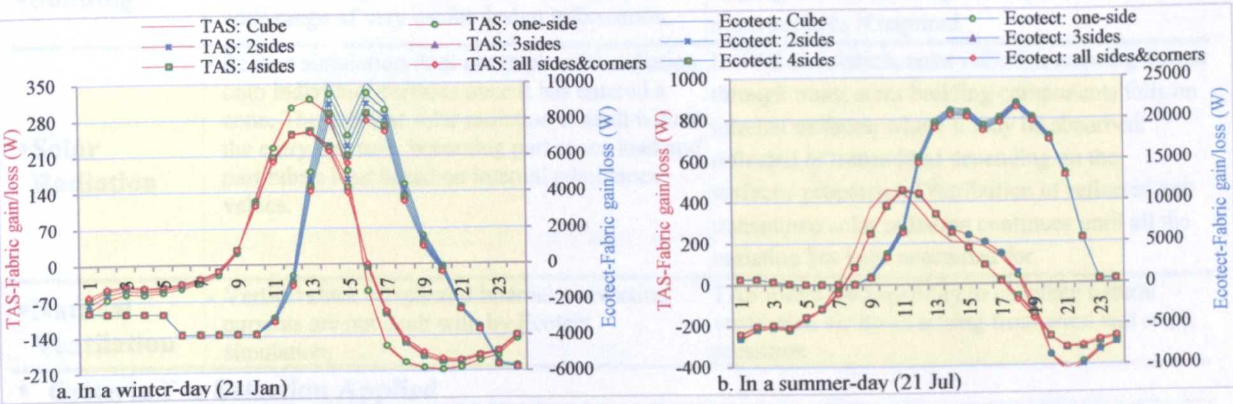


Figure 8.27: TAS vs. Ecotect: Fabrics loss/gain of FR cubes surrounded on various sides

8.8 SELECTION OF THERMAL MODELLING PROGRAMME

After running the comparative tests, a clear picture about the capabilities of TAS and Ecotect, particularly in conducting the required tasks in this study, is gained. The discrepancies between the programmes` results were revealed and the limitations were discovered. Then, a final comparison between the both programmes was carried out according to the criteria discussed earlier in section 8.2 and depending on the comparative tests' findings. Table (8.3) summarizes the comparison procedures that applied between Ecotect-V 5.60 and TAS-V9.1.4.1.

Table 8.3: Comparison between TAS and Ecotect- continued

Contents	Ecotect-V 5.60	TAS-V9.1.4.1
▪Main Functions	Ecotect is a building design and environmental analysis tool that covers broad range of analysis functions including thermal and lighting simulation. Ecotect is a highly visual building simulation tool which has been used by many researchers to evaluate the required design configurations in different types of buildings in various climatic regions Ecotect can be used to do the following: - Display complex shadows and reflections - Overshadowing analysis - Incident solar radiation on any surface and its percentage shading - Daylight factors and artificial lighting levels - Monthly heat loads and hourly temperature - Schedules of material costs - Trace the paths of acoustic particles and rays	TAS is a comprehensive thermal simulation tool of a building, and a powerful design tool in the optimization of a buildings environmental, energy and comfort performance. The main applications of the program are in assessment of environmental performance, natural ventilation analysis, prediction of energy consumption, plant sizing, analysis of energy conservation options and energy targeting.TAS provides the following output: - Air temperature & Mean radiant temperature - Resultant temperature - Surface temperatures - Humidity - Condensation risk - Sensible and latent loads - Energy consumption - Required plant size
▪Suitable Application Area	- For the purposes of design decision-making, Ecotect is a good choice. It has no restrictions on building geometry or the number of thermal zones that can be simultaneously analysed. - Ecotect is most suitable in situations where temperature swings and energy inputs are changing steadily throughout the day. It is less suitable in situations where there are large sudden changes in parameters, such as when a large heater or cooler is turned on.	Simulation by TAS allows the influences of the numerous thermal processes occurring in the building, their timing, location and interaction, to be properly accounted for. It traces the thermal state of the building through a series of hourly snapshots, providing the user with a detailed picture of the way the building will perform.
▪Shading	- Ecotect is very quick to calculate shading and overshadowing and can be used to display a wide range of very useful design information.	In TAS, the option exists to model external shading and the tracking of sun patches around room surfaces if required.
▪Solar Radiation	- Ecotect simulation does not track solar radiation onto individual surfaces once it has entered a zone. The incident solar radiation is dealt with at the entry aperture, becoming part space load and part fabric load based on internal admittance values.	In TAS simulation, solar radiation entering a zone through transparent building components falls on internal surfaces, where it may be absorbed, reflected or transmitted depending on the surfaces' properties. Distribution of reflected and transmitted solar radiation continues until all the radiation has been accounted for.
▪Natural Ventilation	- Vertical stack effects and internal convection currents are not dealt with by Ecotect simulation.	TAS offers the capability to calculate natural ventilation air flows arising from wind and stack pressures.
▪ Criteria For Selection Applied		
a. Required Outputs		
-Temperature	DBT	DBT & MRT & RT
-Humidity	......	Relative humidity-humidity ratio
-Heating & cooling loads	√	√
-Thermal comfort	Monthly discomfort	PMV & PPD for any period of time
-Fabrics loss/gain	Total for all components together	Total and breakdown for every component (wall, floor, roof, & windows).

Table 8.3: Comparison between TAS and Ecotect

Contents	Ecotect-V 5.60	TAS-V9.1.4.1
b. Accuracy		
-Calculation Method	Admittance method	A method derived from response factor technique
-Limitations	▪ Fabrics loss/gain for AC & FR building is the same ▪ Air change rate does not affect fabrics loss/gain ▪ Comfort bands are required for FR & NV buildings, and affect fabrics loss/gain ▪ Direct solar gain is not influenced with fabrics thickness. ▪ Internal solar absorption is not considered in estimating solar gain.	....
b. Simplicity		
-Complexity of Input	simple	More complex
-User Manual	good	Comprises very helpful video tutorial
-Data Library	Poor construction library	Rich construction library
c. Access to Programme	Available at the university & free annual licence available from Students Autodesk	Free trial version for 8 weeks & a student licence is available to be purchased

As provided in table 8.3, TAS is more comprehensive in providing the required outputs, particularly estimating heat loss/gain for each component in the building separately. Besides, TAS is based on a calculation method which is more accurate than that of Ecotect. The comparative tests revealed some limitations of Ecotect which part of them could be related to the admittance method which the programme is based on. Moreover, TAS database (especially the construction database), is richer than that in Ecotect. On the other hand, input process in TAS is more complex and more time consuming than in Ecotect, and no free student licence is available for TAS.

In view of that, although TAS is more complex, it is selected in this study as it is overall more comprehensive and more accurate.

8.9 SUMMARY

Criteria for selection thermal software are developed, which comprise the required outputs, the accuracy, the simplicity and the ease of use, and the access to the programme. Afterwards, various specific tests are conducted to investigate and compare how both selected programmes (Ecotect and TAS) consider thermal mass, ventilation, solar gain, and shading. As the quality of the comparative tests depends on supplying the two programmes with the same input data, input data applied are clarified first.

Comparative tests for thermal mass revealed that the internal air temperature predicted by TAS is higher than that of Ecotect particularly with large thermal mass. Besides, it was observed a significant difference in the fabrics loss/gain estimated by TAS and that estimated by Ecotect for various fabrics thicknesses; in both the cases of FR and AC. Further, the results showed that fabrics loss/gain of AC tested cubes is the same as that of FR cubes, according to Ecotect results.

Comparative tests for solar gain indicate that the solar gains predicted by both programmes are similar in times in which the solar gains reach the peak and end. However, results are dissimilar in the time of starting of solar gain, where it starts one hour later in Ecotect, in both summer and winter. Moreover, the magnitude of solar gain estimated by TAS is almost two times that estimated by Ecotect. Morover, the results revealed that Ecotect does not consider the internal solar absorption in estimating the solar gains, where the solar gains stay constant with the various fabrics` solar absorption. On the other hand, according to TAS simulation, greater solar gain is associated with higher internal solar absorption of fabrics.

Ventilation comparative tests were conducted on cubes (10 & 30cm thickness) with various air change rates (acr). The tests showed that, in both programmes, the difference between the external and the internal temperature fades as acr rises. However, the fabrics thickness does not affect the ventilation load estimated by Ecotect, while in TAS; the ventilation loads of 10cm cubes are different from those of 30cm cubes. Moreover, the ventilation load according to Ecotect rises steadily with the increase of the ventilation rate, while in TAS; the magnitude of increase in the ventilation load fades significantly with higher ventilation rate. Further, the ventilation load estimated by Ecotect is extremely higher than that estimated by TAS. The tests revealed also that Ecotect does not consider the ventilation in predicting the fabrics behaviour, where the fabrics loss/gain was found to be constant for various air change rates. Conversely, in TAS, the fabrics loss/gain decreases with the increase of ventilation rate.

The shading comparative tests showed that both TAS and Ecotect consider the external shading in predicting building thermal performance. It was found that the internal air temperatures slightly drop as the cube being surrounded on more sides, with a little more drop in TAS results particularly in summer. However, the drop in temperature estimated by Ecotect is steady, while by TAS is irregular. In addition, with the increase of the blocked sides, the fabric gains decrease according to Ecotect, while it varies through the daytime and the night as estimated by TAS in accordance with the direction of the blocked sides.

A final overall comparison between both programmes was carried out according to developed criteria and depending on the comparative tests` findings. In view of that, TAS is selected in this study as it is more comprehensive and more accurate, despite that it is more complex.

CHAPTER 9

THERMAL SIMULATION & ANALYSIS OF SHC SHELTERS USING TAS

9.1 INTRODUCTION

This chapter represents the second phase of the shelters` evaluation, which is carried out by using the thermal modelling programme TAS V9.1.4.1. Exploring shelters' thermal behaviour is necessary to predict occupants` comfort and to examine alternate enhancements for achieving better indoor thermal environments and energy efficient shelters. Because of time constraints, the analysis is conducted on a sample of 20 shelters (10 old shelters and 10 new shelters). The strategy of drawing this sample is provided in details in chapter 5 of this thesis (section 5.6.3). Thermal performance for the shelters during summer and winter is assessed and a comparison between shelters` performances is accomplished. Thermal comfort is also predicted in these shelters along with investigation for parameters that could affect indoor thermal environment such as floor level, and roof materials. Comparisons, between the fieldwork survey results (questionnaires) and the computer modelling results (TAS), is conducted and discussed.

9.2 INPUT DATA FOR SIMULATION

The accuracy of the results of the simulations changes as a function of the quality of the input data and basic assumptions supplied (Hyde, 2000, Clarke, 2001, and CIBSE, 2006). TAS was used for analysis of SHC shelters considering all possible sources of input data that required for the simulation. The difficulties in obtaining model inputs for SHC shelters are a major obstacle particularly; shelters` geometry, construction materials, internal gains, and weather data. Many of required data for modelling are gathered during fieldwork stage-three, as clarified earlier in section (5.6.3), including shelters` site and geometry, construction materials, equipment used, and schedules for apertures.

- ***Construction materials*** of shelter`s elements comprising walls, roofs, floors, windows, and doors were identified in the survey, and their main thermal properties were obtained from UNRWA reports and Palestinian Code of Energy Efficient Buildings (Ministry of Local Government, 2004)

- ***Internal gains:*** Over/under estimation of total internal gains and occupancy levels can seriously affect results (Bartholomew, et al., 1997). Internal gains in the studied shelters were estimated as watt per meter square as required by TAS. Internal gains include occupants gain, equipment gain and lighting gain. Average occupants gain was estimated using occupant gains provided by CIBSE (2006) for seated moderate work activity. Afterwards, occupants gain was calculated by multiplying the number of each shelter's occupants (gathered by the questionnaire) with the estimated average occupant gain (83.6W sensible and 46.4 W latent) then divided by each shelter's area.

Besides, any equipment used in each space in the shelters such as TV, refrigerator, cooker, etc, was reported during the survey. Usage ratio for each machine was estimated, taking the number of occupants into consideration. Then usage ratio was multiplied with the sensible and the latent heat gain for each machine which provided by CIBSE (2006, P6-11) and Kreider (2001, P6-19). Equipment gain for each space in the shelter was calculated by dividing the total gain by the area of that space.

For lighting gain, it was found that the most common types of light bulbs used in SHC shelters are 80-100W tungsten lamp, and fluorescent tube lamp. In addition, circular globes and compact fluorescent lamps are used in some rooms in few shelters particularly the new SHC shelters. By considering these types of light bulbs and the area of the shelters, lighting gain was set at 10 W/m^2 as an average. Schedules for turning on lights during summer and winter are established and applied for every shelter depending on the data obtained by the questionnaire.

- ***Apertures schedules*** for all windows and doors in the shelters are one of the required input data for the simulation using TAS. Schedules for both summer and winter were prepared and entered in the programme for each shelter. The schedules include the times of opening every window and door through 24 hours, and the percentage of opening. These data are gathered through the stage-three of fieldwork.

- ***Weather data*** were obtained for Bayt Dajan weather station 32°N 34.82°E which is located in the north of Jabalia camp in the coastal area in Palestine. The available weather file includes hourly data recorded in one year for global solar radiation, diffuse solar radiation, cloud cover, dry bulb temperature, relative humidity, wind speed, and wind direction. According to mean temperature of thirty years recorded weather data, the coldest month is January while July and August are the hottest months, where solar radiation is greater in July than in August (climatic analysis is provided earlier in chapter 2). Therefore, the coldest day in January and the hottest day in July, in terms of average temperature, are selected to represent the coldest and hottest day respectively. In view of this, from the obtained weather file of Bayt Dajan, the eighth of January and the twentieth of July are found to be the coldest and the hottest day and are used in this study to represent a winter and a summer day respectively.

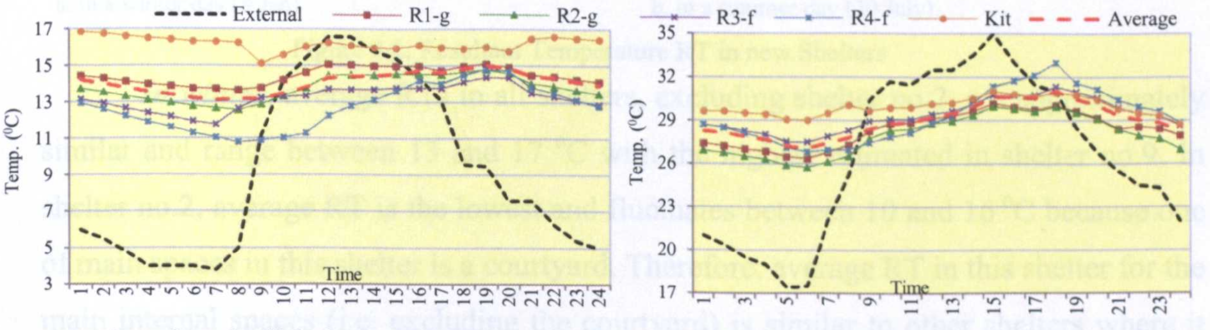
9.3 NEW SHELTERS THERMAL PERFORMANCE

Thermal performances of the 10 selected new shelters were simulated and analysed through the prediction for; internal temperature and humidity, predicted mean vote PMV, loads breakdown, and fabrics load. The analysis results of each shelter are provided in at least seven figures which could not be all presented in this chapter. Therefore, the analysis results of one shelter, as an example, is presented and discussed in details. Then, the analysis results of the 10 shelters are gathered in figures in a brief manner and discussed together. The results of shelter no.7 (Sh7) is presented in this chapter as it is selected later (according to criteria discussed in the next chapter) for applying fabrics modification. The results of some other shelters are provided in appendix C.

It should be mentioned that shelter no.7 (Sh7) is a two-floor shelter with a total area of about 124 m^2 (each floor is about 62 m^2). The shelter comprises four rooms, a kitchen, a bathroom, a toilet, and a staircase. The ground floor includes two rooms (R1-g and R2-g) and the kitchen, while the first floor includes two rooms (R3-f and R4-f).

9.3.1 Temperature

As mentioned earlier in the literature review of this thesis (chapter4), air temperature is considered as the most significant ambient factor which affects the level of human comfort; and mean radiant temperature has also a significant effect on human thermal comfort. Therefore, resultant temperature (which is equal 0.5 mean radiant temperature + 0.5 dry bulb temperature) for main spaces in each shelter is predicted in a summer and winter day. Figure 9.1 provide resultant temperature RT for shelter no.7.



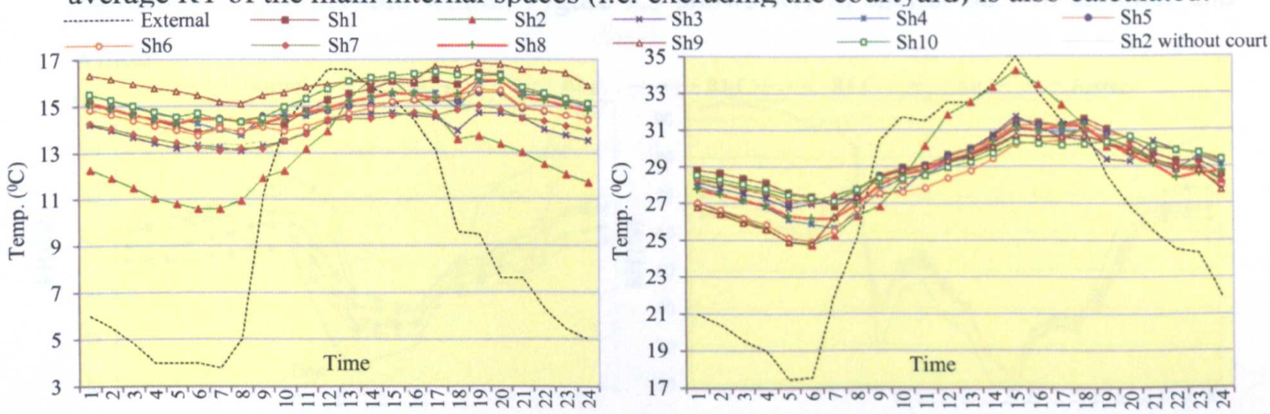
a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.1: Resultant Temperature RT in shelter no.7

In winter, the results indicate that RT in all spaces of shelter no.7 ranged almost from 11 to 17 °C. The highest estimated RT is for the kitchen (due to its greater internal gain), while the lowest is estimated for the rooms in the first floor (R3-f and R4-f) due to their greater fabrics heat loss. The average RT for all spaces ranges from about 13 to 15 °C, while the external temperature ranges from about 4 to 16 °C. Magnitude of RT temperature swing is slight, where it is greater in the first floor spaces (maximum of about 4°C) than in the ground floor spaces (maximum of about 2°C). This can be explained by the exposing of the ceiling of the first floor spaces to the external environment, while the ceiling of the ground floor spaces is internal and not exposed to external environment

In summer, the average RT for all spaces of shelter no.7 ranges from about 27 to 31 °C, where it is slightly higher in the first floor rooms than in the ground floor rooms. The highest average RT is estimated for the kitchen, about 30 °C. However, the lowest temperature swing is predicted in kitchen (2.3 °C), and the greatest was recorded for room 4 (about 6.2 °C).

Resultant temperatures for the main spaces of the rest new shelters are also simulated for a winter and a summer days. The average resultant temperatures of the main spaces are then calculated at every hour of a summer and winter for each shelter (figure 9.2). For shelter no.2 (Sh2), which is the only shelter comprise a courtyard, the average RT of the main internal spaces (i.e. excluding the courtyard) is also calculated.



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.2: Resultant Temperature RT in new Shelters

In winter, average RTs in all shelters, excluding shelter no.2, are approximately similar and range between 13 and 17 °C with the highest estimated in shelter no.9. In shelter no.2, average RT is the lowest and fluctuates between 10 and 16 °C because one of main spaces in this shelter is a courtyard. Therefore, average RT in this shelter for the main internal spaces (i.e. excluding the courtyard) is similar to other shelters where it ranges between 12.8 and 15.4 °C. Comparing with external temperature, average RT in all shelters is slightly lower or similar to external temperature at the mid of the day, approximately between 10:00hr and 16:00hr, while it is higher than the external temperature during the rest of the day and during the night.

In summer, average RTs in all shelters range between about 25 and 34 °C, with the lowest estimated in shelter no.9 and the highest in shelter no.1. The maximum swing in average RT (about 10 °C) is found in shelter no.2 (Sh2), while swing in the other shelters ranges from about 4 to 6 °C. This can be explained by the fact that Sh2 includes a courtyard which is an open space. The maximum swing in RT of the courtyard, as simulated by TAS, is about 19 °C. Comparing with external temperature, average RT in all shelters is lower than external temperature during the daytime, approximately between 9:00hr and 18:00hr, while it is higher than the external temperature during the night. The maximum difference between external temperature and RT is about 4 °C during the daytime and about 10 °C during the night.

Overall, internal temperature in the 10 shelters is out of the comfort zone; where the shelters are cold in winter and hot in summer.

9.3.2 Humidity

The high relative humidity in hot-humid regions is a typical climatic problem in this sort of regions and it is one of the environmental factors that affects human thermal comfort. Therefore, relative humidity RH for the main spaces in the shelters is also estimated in summer and winter. Figure 9.3 shows RH in shelter no.7 in summer and winter.

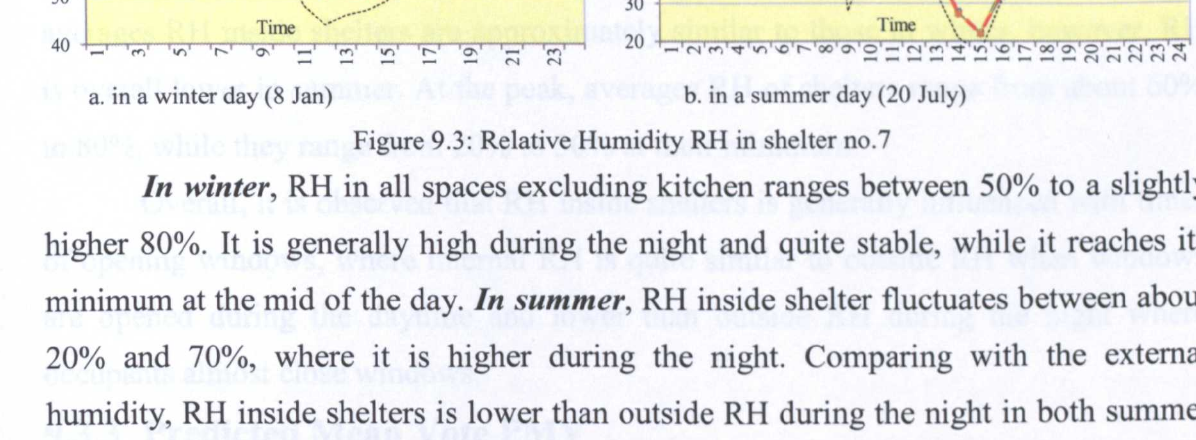


Figure 9.3: Relative Humidity RH in shelter no.7

In winter, RH in all spaces excluding kitchen ranges between 50% to a slightly higher 80%. It is generally high during the night and quite stable, while it reaches its minimum at the mid of the day. ***In summer***, RH inside shelter fluctuates between about 20% and 70%, where it is higher during the night. Comparing with the external humidity, RH inside shelters is lower than outside RH during the night in both summer and winter. However, it is approximately similar to outside RH during the daytime, approximately between 9:00-17:00hr in winter, and between 8:00-20:00hr in summer. As mentioned earlier in section 9.1 that apertures schedules for shelters which gathered during fieldwork were entered as input data for the simulation. It is observed that RH inside shelter no.7 is generally influenced with times of opening windows, where internal RH is similar to outside RH when windows are opened during the daytime and differ from outside RH during the night where occupants close windows.

RH inside the rest shelters are also predicted during a summer and a winter-day. Figure (9.4) summarizes RH status inside the shelters by providing averages RH of the main spaces which are calculated for each shelter for summer and winter.

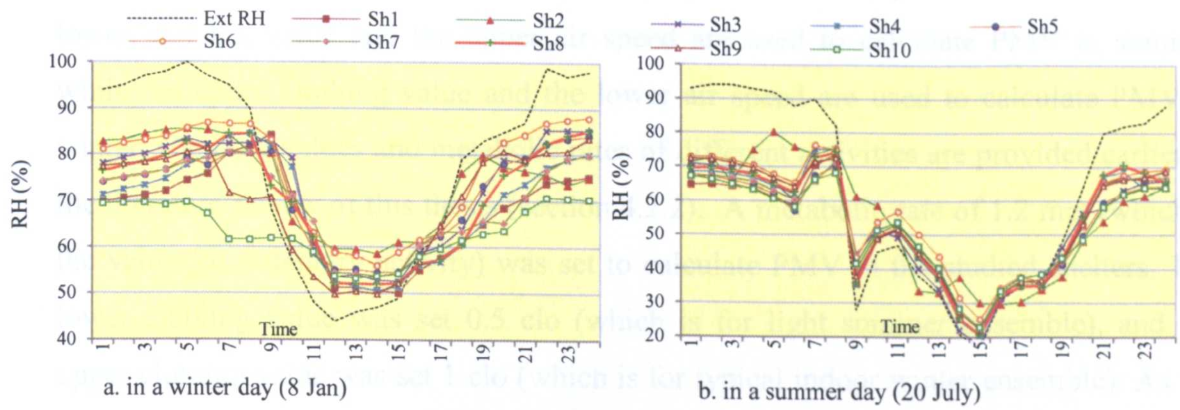


Figure 9.4: Relative Humidity RH in new Shelters

In winter, averages RH of shelters overall range from about 70% to 90% during the night and range from 50% to 60% at the mid of the day. RH is almost stable during the night, while it falls sharply during the daytime reaching its minimum at the mid of the day, then rises up. The highest estimated RH is found in shelter no.6, and the lowest is found in shelter no.10. Comparing with outside RH, averages internal RH of the shelters are almost higher than outside RH during the daytime between about 9:00-16:00hr, while they are lower than outside RH during the night. Besides, discrepancy between inside and outside RH is more obvious during the night. ***In summer***, trends of averages RH inside shelters are approximately similar to those in winter, however, RH is overall lower in summer. At the peak, averages RH of shelters range from about 60% to 80%, while they range from 20% to 30% at their minimum.

Overall, it is observed that RH inside shelters is generally influenced with times of opening windows, where internal RH is quite similar to outside RH when windows are opened during the daytime and lower than outside RH during the night where occupants almost close windows.

9.3.3 Predicted Mean Vote PMV

Predicted mean vote (PMV) was calculated for the main spaces in the shelters using TAS. The parameters of metabolic rate, air velocities, and clothing are required to be entered by the user of the programme for calculating the PMV, where other parameters such as temperature and humidity are calculated by the TAS itself.

A single value is required to be set for metabolic rate and a range of two values are required to be set for air velocities and clothing. It is worth noting that in estimating PMV by TAS, two PMV values are calculated (one using the lower air speed and upper clothing value, the other using the upper air speed and the lower clothing value) and the better of the two in terms of thermal comfort is provided as outputs. This means that the lower clothing value and the upper air speed are used to calculate PMV in summer while the upper clothing value and the lower air speed are used to calculate PMV in winter. Clothing values and metabolic rates of different activities are provided earlier in the literature review of this thesis (section 4.2.2). A metabolic rate of 1.2 met (which is the value for sedentary activity) was set to calculate PMV in the studied shelters. The lower clothing value was set 0.5 clo (which is for light summer ensemble), and the upper clothing value was set 1 clo (which is for typical indoor winter ensemble). As the studied shelters are located in a crowded built environment, internal air speed was set 0.1 to 0.3 m/s, where 0.1 m/s is classified as "not noticeable airflow" and 0.3 m/s is classified as "barely noticeable airflow" (Natural Frequency, 1994).

Figure (9.5) provides hourly PMV through a year in the main spaces of shelter no.7.

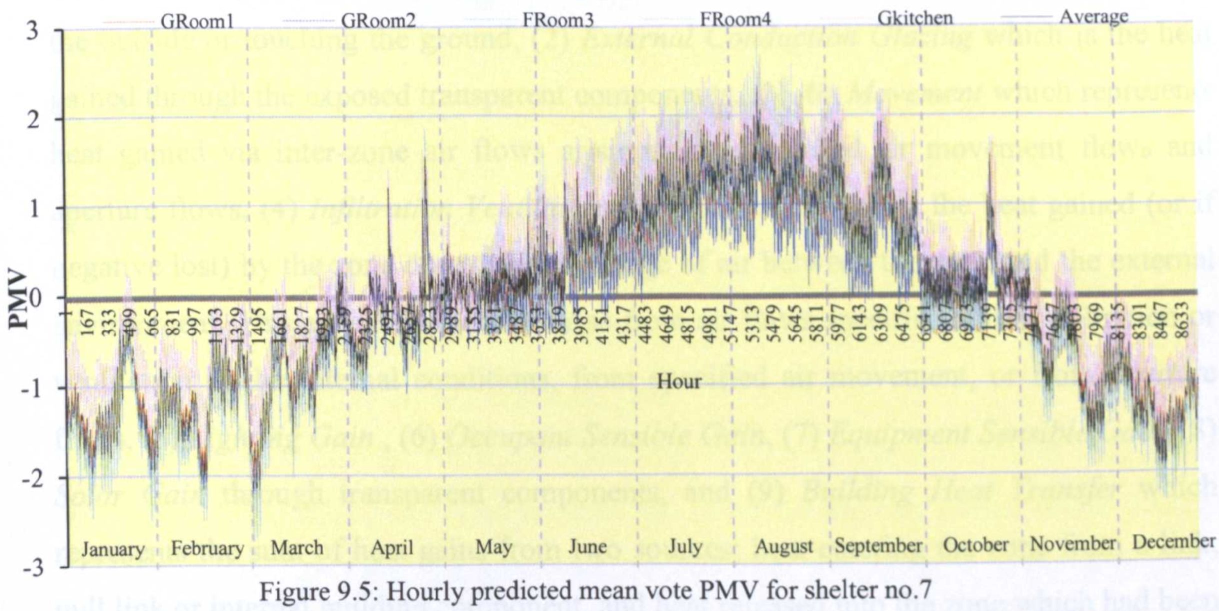


Figure 9.5: Hourly predicted mean vote PMV for shelter no.7

As indicated in the figure, the maximum PMV is overall estimated in summer, while the minimum PMV is estimated in winter. PMV ranges from (-0.5 to 0.5) in almost one third of the total hours through the year. Besides, spaces on average are estimated to be comfort ($-1 \leq PMV \leq 1$) during about 60 percent of the year; with the greatest number of hours is estimated for room1 in ground floor and the lowest is for room3 in first floor. Due to internal equipment gains in kitchen, PMV in kitchen is almost higher than PMV in other rooms through the whole year, where kitchen is generally warm in summer and slightly cool in winter

Figure (9.6) provides the maximum and minimum PMV estimated through a whole year in the main spaces of each shelter. The results revealed that the maximum calculated PMV in the shelters ranges from (+1.8) to (+3), and the minimum PMV ranges from (-1.7) to (-3). The minimum and the maximum PMV of all spaces are estimated in winter and summer respectively.

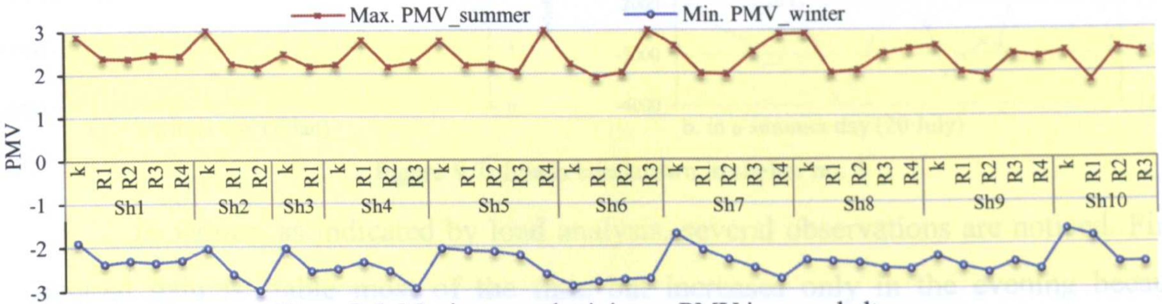


Figure 9.6: Maximum and minimum PMV in new shelters

9.3.4 Loads Breakdown

Load is breakdown by TAS into nine types as following: (1) *External Conduction Opaque* which is the heat gained through opaque components exposed to the outside or touching the ground, (2) *External Conduction Glazing* which is the heat gained through the exposed transparent components, (3) *Air Movement* which represents heat gained via inter-zone air flows arising from specified air movement flows and aperture flows, (4) *Infiltration Ventilation Gain* which represents the heat gained (or if negative lost) by the zone due to the exchange of air between the zone and the external environment. This air exchange may arise from air flows specified under infiltration or ventilation in the internal conditions, from specified air movement, or from aperture flows, (5) *Lighting Gain* , (6) *Occupant Sensible Gain*, (7) *Equipment Sensible Gain*, (8) *Solar Gain* through transparent components, and (9) *Building Heat Transfer* which represents the sum of heat gains from two sources; heat entering the zone from a link, null link or internal building component, and heat released into the zone which had been temporarily stored in the air.

Loads breakdown is analysed for every shelter, in both a summer and a winter days. All types of internal gains including lighting, occupants, and equipments are gathered under *Internal Gain* category. Further, External Conduction Opaque and External Conduction Glazing are gathered under *Fabric Gain* category. By this, loads breakdown is presented in a simpler manner (in six categories instead of nine categories). Figure 9.7 provides loads breakdown of shelter no.7, in a winter and a summer days.

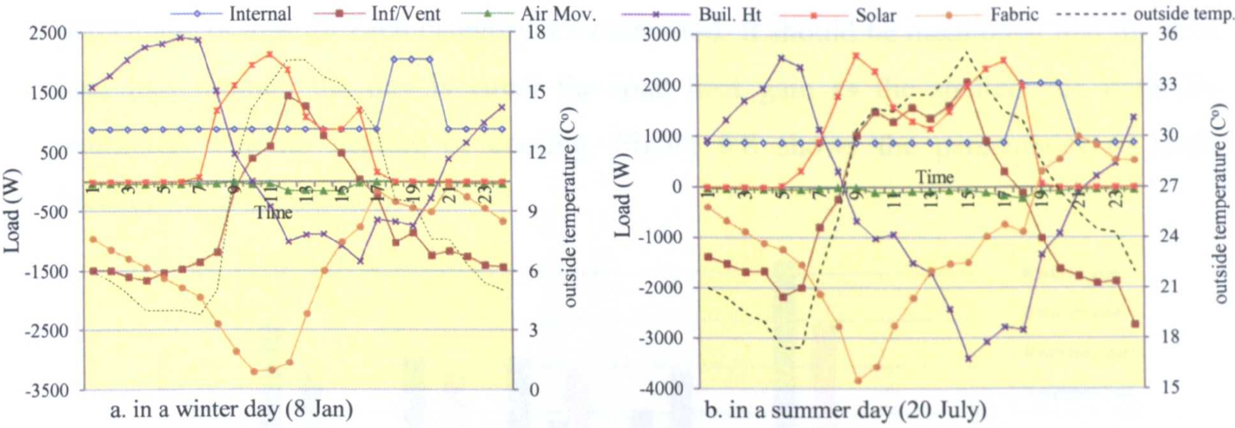


Figure 9.7: Loads breakdown in shelter no. 7

In winter, as indicated by load analysis, several observations are noticed. First, internal gain is stable most of the time but increases only in the evening because occupants turn on lights. Second, infiltration ventilation (Inf/Vent) gain takes place in the morning (after 9:00hr) and rises up reaching its peak at the mid of the day, then falls down and ends in the afternoon at 16:00hr. Afterwards, Inf/Vent loss takes place where it increases gradually during the night and then declines in the early morning. The magnitude of total Inf/Vent loss is greater than that of Inf/Vent gain. It is also observed that the trend of Inf/Ven load is quite parallel with the trend of outside temperature. Third, a very slight air movement loss takes place at the mid of the day. Fourth, solar gain starts in the morning (after 7:00hr) and rises up to its peak, then declines and ends at 18:00hr. Fifth, there is no fabric gain, while heat loss through fabrics occurs all the day and reaches its maximum at the mid of the day. It is worth mention that at any hour of the day, total heat loss equals total heat gain.

In summer, loads trends are somewhat similar to those in winter with some differences. First, solar gain is greater than that in winter and stay longer where it starts two hours earlier and ends one hour later. Second, heat gain through fabric takes place in the evening and during the night, while there is no fabric gain in winter. Besides, the magnitude of fabric loss is greater in summer. Third, magnitude of Inf/Ven loss and gain is higher in summer, and gain stays longer where it starts one hour earlier and ends one hour later.

To get a clearer picture about loads breakdown, the percentages of loads breakdown are computed for every shelter in both a summer and a winter days as follows. From the hourly loads which are provided by TAS, positive values (heat gain) of loads and negative values (heat loss) of loads are summated separately for each category of load. Then the total heat gain and the total heat loss in a winter and a summer days are calculated. By this, the percentage of gain for each category and the percentage of loss for each category are computed. It should be mentioned that the total heat loss through the day is equal the total heat gain as the shelters are naturally ventilated with no heating or cooling. Figure 9.8 shows the percentages of loads breakdown in shelter no.7.

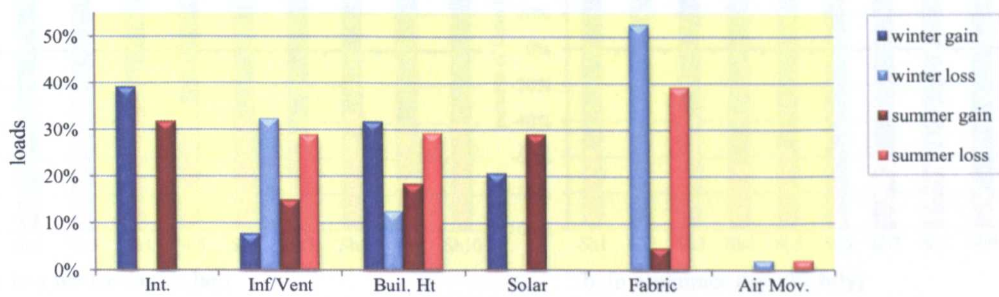


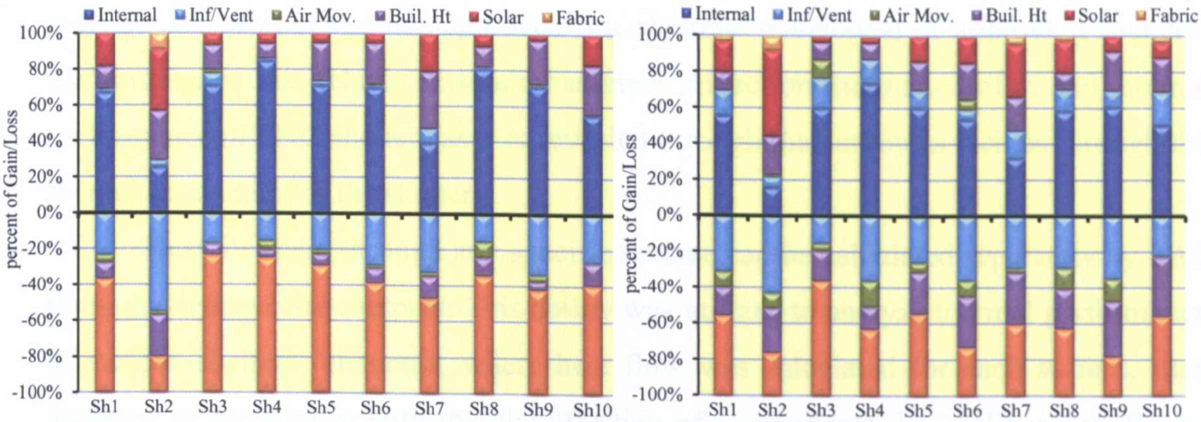
Figure 9.8: Percentage of loads breakdown in a summer and a winter day for shelter no.7

In winter, it is observed that more than one half of heat loss in winter is through *Fabrics*. Besides, almost one third of heat loss in winter is caused by *Infiltration/Ventilation*. In terms of heat gain in winter, the highest source of heat gain in winter is the *Internal Gain* (39.2 percent), followed by *Building Heat Transfer* gain (32 percent), *Solar gain* (20.8 percent), *Infiltration/Ventilation* gain (15.3 percent) and the lowest source of heat gain is *Fabric* gain (4.9 percent).

In summer, almost one third of heat gain is *Internal*, followed by *Solar* gain (29 percent), while *Infiltration/Ventilation* causes about 15 percent of heat gain. The smallest percentage of heat gain is through *Fabric* (4.9 percent). In terms of heat loss in summer, percentage of loss through *Fabrics* (39.3 percent) is the highest among the other types of heat loss, followed by *Building Heat Transfer* loss and *Infiltration/Ventilation* loss (29 percent) and the lowest source of heat loss is *Air Movement* (2.2 percent).

Percentages of loads breakdown in all shelters in both a summer and a winter days is provided in (figure 9.9). Several observations from the figure can be concluded about thermal performance of the new shelters.

In winter: The highest percentage of heat loss in all shelters, excluding Sh2, is *Fabrics* loss, which ranges from 53% to 76%, followed by *Infiltration/Ventilation* loss (16% to 34%). Excluding Sh2, *Internal* gains generate the greatest percentage of heat gain in all shelters which ranges from 39% to 85%, followed by *Building Heat Transfer* gain (8% to 32%), and *Solar* gain (3% to 21%), except Sh1 where *Solar* gain (18%) is slightly higher than *Building Heat Transfer* gain (13%). Loads breakdown of shelter no.2 is different from that of other shelters because one of its zones is a courtyard, i.e. external zone. Therefore, shelter no.2 has the greatest solar gain and greatest ventilation loss among the other shelters in both summer and winter.



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 9.9: Percentage of loads breakdown in new shelters

In summer: The highest percentage of heat gain in all shelters, excluding Sh2, is the *Internal* gain, which ranges from 32% to 73%. Besides, *Infiltration/Ventilation* gain in all shelters represents only 6% to a maximum of 18% of total gain, and *Building Heat Transfer* gain ranges from 10% to 21%. The highest percentage of *Solar* gain (48%) is found in Sh2, followed by Sh7 (29%), while *Solar* gain in other shelters ranges from merely 3% to 18%. *Fabric* gain is found in seven shelters and represents only 1% to 8% of the total heat gain in these shelters. Further, *Air Movement* gain is found in just two shelters and represents 5% and 10% of heat gain. In terms of heat loss in summer, *Fabric* loss ranges from 22% to 64% of heat loss in all shelters, and represents the highest percentage of heat loss in seven shelters. In addition, *Infiltration/Ventilation* loss ranges from 15% to 43% of heat loss in all shelters, and represents the highest percentage of heat loss in three shelters (Sh2, Sh6, and Sh9). Percentage of *Building Heat Transfer* loss (13% to 33%) is almost comes after Inf/Ven loss. The lowest percentage of heat loss in all shelters, is *Air Movement* loss (2% to 14%), excluding in Sh4 where *Building Heat Transfer* loss (13%) in this shelter is slightly lower.

To sum up, fabrics loss almost represents the highest percentage of heat loss in winter in vast majority of shelters and about 22 to 64 percent of heat loss in summer. A slight fabrics gain takes place in some shelters in summer representing only a maximum of 8% of heat gain. Besides, internal gain represents the highest percentage of heat gain in vast majority of shelters in both summer and winter.

9.3.5 Fabrics Loss/Gain

In-depth analysis on fabrics loss/gain is conducted in order to help in proposing enhancements in the shelters` envelopes which is discussed in the next chapter. The main reason of selecting this approach (i.e. shelters` envelopes) of improving shelters` environment is that fabrics loss/gain has great impact on thermal comfort and thermal performance of SHC shelters as it is revealed through the survey as well as through the thermal simulation of the shelters.

Heat loss/gain through any specific surface can be calculated separately by TAS through *Surface Filter* outputs. This ability was utilized to analyze thermal performance of various shelters` elements, where heat flow was calculated for each surface, then gathered in accordance with the classification of components, i.e. walls, roofs, floors, and windows. In addition, thermal performance of windows is analysed through calculating solar gain as well as glazing conduction. Figure 9.10 provides heat loss/gain through the various exposed components of shelter no.7, during both a summer and a winter day. Findings are clarified below.

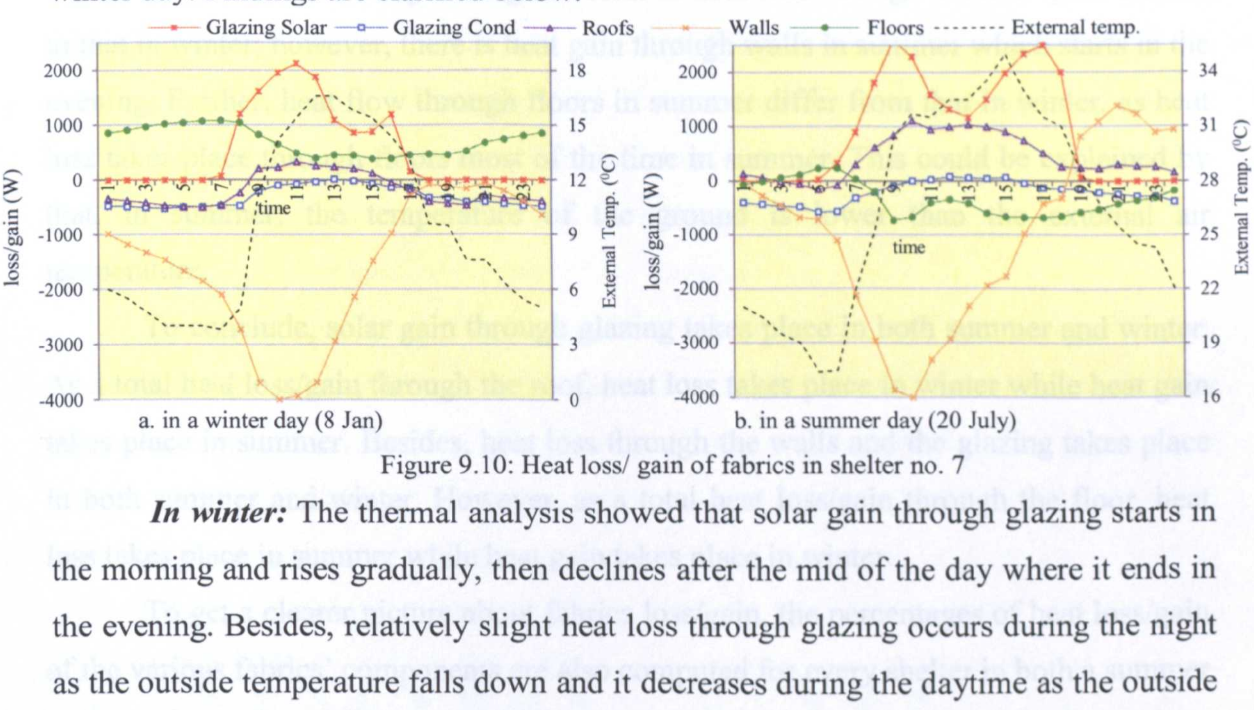


Figure 9.10: Heat loss/ gain of fabrics in shelter no. 7

In winter: The thermal analysis showed that solar gain through glazing starts in the morning and rises gradually, then declines after the mid of the day where it ends in the evening. Besides, relatively slight heat loss through glazing occurs during the night as the outside temperature falls down and it decreases during the daytime as the outside temperature rises up. The small amount of heat flow through the windows is due to the small size of the windows, where the area of the windows in Sh7 is about 13 m^2 which represents about 5% of the external walls` area. In addition, there is relatively small heat gain and heat loss through the roof. Heat gain through roof starts in the morning (at 9:00hr) as the roof exposes to solar radiation and ends in the afternoon (at 16:00hr); then heat loss takes place as the outside temperature falls down. Further, the analysis showed a great heat loss through walls which increases gradually reaching its peak at the mid of the day, then declines and approximately ends in the evening.

The thermal analysis also revealed that heat gain through floors occurs all the time, where it is quite stable during the night and slightly declines in the morning. This means that the internal surface temperature of the floors is lower than the external surface temperature of the floors (i.e. the surface which is exposed to the soil). This could be explained by the fact that, in winter, the temperature of the ground is higher than the external air temperature. It should be mentioned also that in TAS calculations the external surface temperature of the ground floor is assumed to be equal to the groundwater temperature. Therefore, in the simulation by TAS a layer of 1000mm soil should be considered in the composition of the floor which is placed on the ground.

In summer: Thermal behaviour of glazing in summer is quite similar to that in winter, however, solar gain through glazing is higher and heat loss through it is lower. In addition, heat gain through roof occurs most of the times which increases during the daytime and declines during the night. Trend of heat loss through walls is quite similar to that in winter; however, there is heat gain through walls in summer which starts in the evening. Further, heat flow through floors in summer differ from that in winter, as heat loss takes place through floors most of the time in summer. This could be explained by that, in summer, the temperature of the ground is lower than the external air temperature.

To conclude, solar gain through glazing takes place in both summer and winter. As a total heat loss/gain through the roof, heat loss takes place in winter while heat gain takes place in summer. Besides, heat loss through the walls and the glazing takes place in both summer and winter. However, as a total heat loss/gain through the floor, heat loss takes place in summer while heat gain takes place in winter.

To get a clearer picture about fabrics loss/gain, the percentages of heat loss/gain of the various fabrics' components are also computed for every shelter in both a summer and a winter days as follows. From the hourly fabrics loss/gain of the various components which are computed above, positive values (heat gain) of fabrics loads and negative values (heat loss) of fabrics loads are summated separately for each fabrics' component. Then the percentages of both heat gain and heat loss for each element are computed relating to the total fabrics gain and the total fabrics loss respectively. It should be mentioned that, in all shelters, the magnitude of total fabrics loss in both a summer and a winter days is significantly greater than the total fabrics gain. Figure 9.11 shows percentages of fabrics heat loss/gain in shelter no.7.

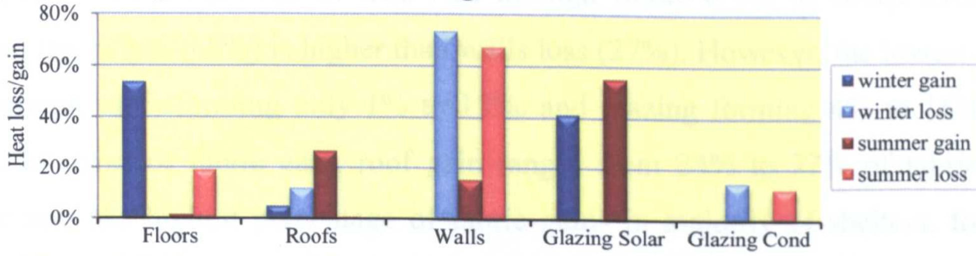
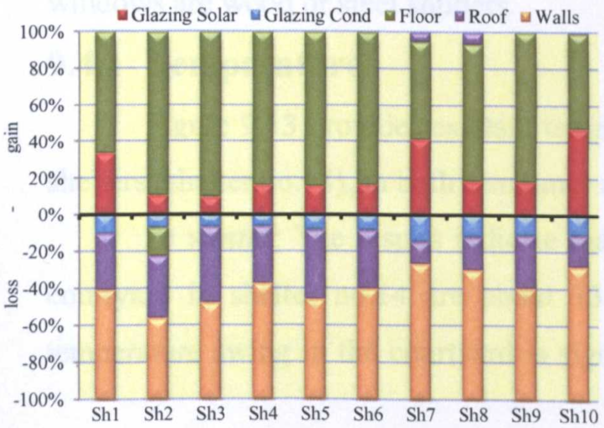


Figure 9.11: Percentage of fabrics loss/gain of shelter no.7 in a summer and a winter day

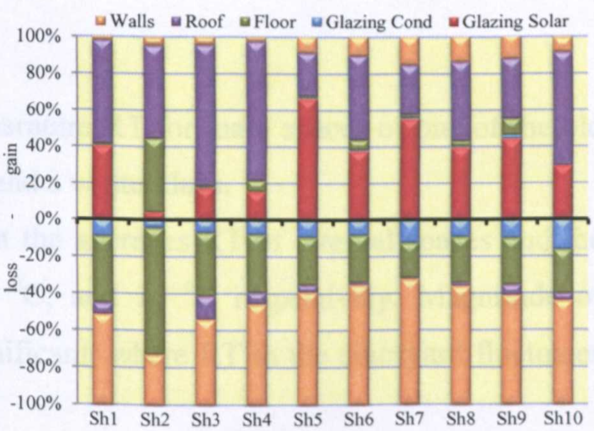
It is observed that more than one half of heat gain in winter flows through floors (53.7 %), followed by solar heat gain (41.2%), and small amount of heat gain flows through roofs (5.1%). In terms of heat loss in winter, walls loss represents the majority of heat (73.4%), followed by glazing (14.6%), and roofs (12%). In summer, more than one half of heat gain is solar gain (55.3 %), followed by roofs gain (26.7%), and walls gain (15.7%), and the lowest percentage of heat gain is through floors (only 1.6%). However, the majority of heat loss in summer flows out through walls (67.6%), followed by floors (19.3%), glazing (12.4%), and only less than one percent of heat loss occurs through roofs.

The percentages of loss and gain of the various fabrics` components of the all shelters are presented in figure 9.12. It should be noted that the negative percentage in the figure means the heat loss. Several observations from the figure can be concluded about thermal performance of fabrics in new shelters.

In winter: Results revealed that heat loss through walls is the highest in all shelters and represents 44% to 71% of total fabric loss, followed by heat loss through roofs (17% to 41%), except in Sh7 where glazing loss is higher. Besides, glazing loss ranges from about (1.7 to 7.6 KW) which represents 7% to 15% of total fabric loss. In terms of fabric gain, floors gains are the highest in all shelters and represent 54% to 90% of total fabric gain, followed by solar gain which forms 10% to 48% of fabric gain.



a. in a winter day (8 Jan)



b. in a summer day (20 July)

Figure 9.12: Percentage of fabrics loss/gain in new shelters

In summer: Heat loss through walls is the highest and represents 46% to 68% of total fabric loss, followed by heat loss through floors (19% to 36%), except in Sh2 where floors loss (68%) is higher than walls loss (27%). However, the lowest fabric loss is through roofs forming only 1% to 13%, and glazing forming 4% to 16% of fabric loss. In terms of fabric gain, roof gain ranges from 24% to 77% of fabric gain and represents the highest percentage of fabric gains in majority of shelters, followed by solar gain through glazing (4% to 64%) which represents the highest percentage of fabric gain in three shelters (Sh5, Sh7, and Sh9). Further, the lowest fabric gains are walls gain (2%-16%) and floors gain (0.0% - 9%), excluding in Sh2 where floors gain represents 40% of total fabric gain in this shelter. As mentioned earlier, thermal behaviour of Sh2 is dissimilar to other shelters as one of its main zones is a courtyard, therefore, it has greater fabric loss and greater fabric gain through floors in both summer and winter.

9.4 OLD SHELTERS THERMAL PERFORMANCE

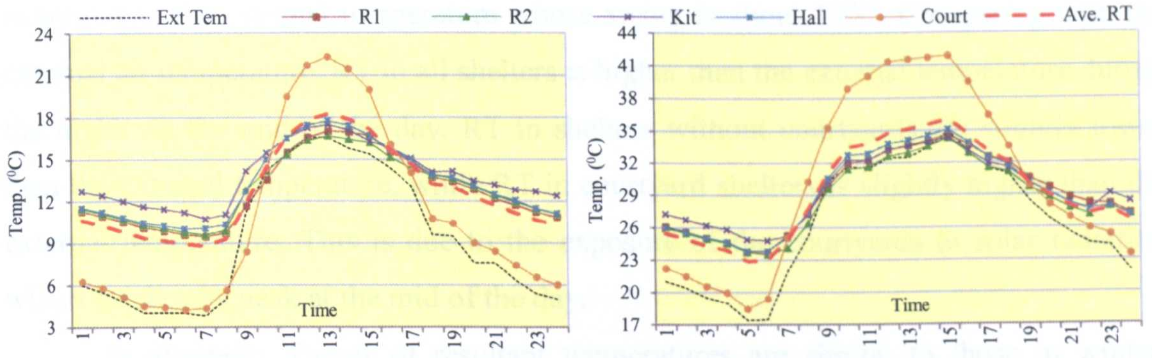
Thermal performances of the 10 selected old shelters were also simulated and analysed through prediction for; internal temperature, internal relative humidity, PMV, loads breakdown, and fabrics loss/gain. The analysis results of each shelter are provided in at least seven figures which could not be all presented in this chapter. Therefore, the analysis results of one shelter (shelter no.14) are presented in details as an example. Then, the analysis results of the 10 shelters are gathered in figures in a brief manner and discussed together.

It should be mentioned that Sh14 is a one-floor shelter with a total area of about 127 m^2. The shelter comprises two rooms (R1 and R2), a kitchen, a bathroom, a toilet, and a hall, in addition to a courtyard whose area is about 42 m^2. The shelter includes concrete block walls and sand block walls while the roof is mainly asbestos panels. The windows are wood or steel shutters.

9.4.1 Temperature

Figure 9.13 provide resultant temperature RT for main spaces of one of the old shelters (shelter no.14), in both a summer and a winter days.

In winter: The results indicate that the averages RT of internal spaces and the courtyard in shelter no.14 are about 13 °C, and 10 °C respectively. Magnitude of temperature swing in the courtyard is significant, where RT in the courtyard fluctuates between 4 °C and 22 °C. However, temperature swing of internal spaces is smaller (from 9 -18 °C).

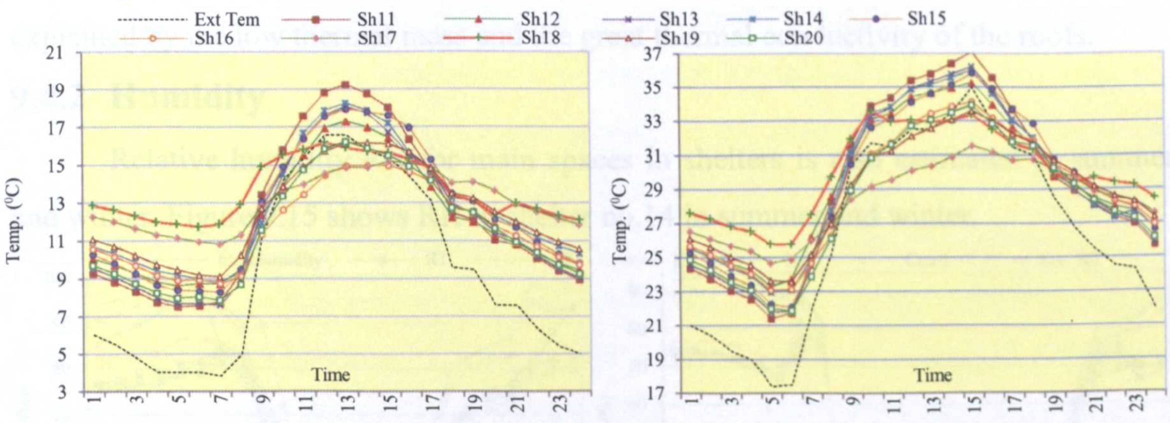


a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.13: Resultant Temperature RT in shelter no.14

In summer: The averages RT of internal spaces and the courtyard are similar (about 29 °C and 30 °C respectively); however, temperature swing in the courtyard is significant and higher. The average resultant temperature RT for internal spaces ranges between about 23 °C and 34 °C, while RT in the courtyard ranges between 18 °C and 41 °C. Comparing with outside air temperature, RT of the courtyard is higher than external temperature during the daytime, especially at the mid of the day, while it almost similar to outside air temperature during the night.

Figure (9.14) provides the average resultant temperatures of the main spaces, including the courtyards, for each shelter for summer and winter.



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.14: Resultant Temperature RT in old shelters

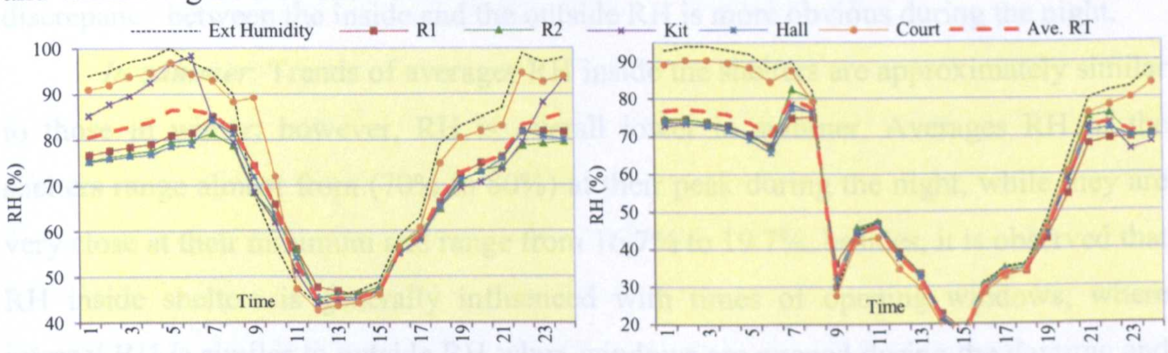
In winter: Resultant temperatures in all shelters are quite similar with a maximum discrepancy is about 4°C. It is observed that temperature swing in the old shelters is relatively high and range from about 4-18 °C. This can be explained by the low thermal mass in old shelters particularly the roofs where the roof materials are almost asbestos or corrugated iron sheets, in addition to the great thermal conductivity of the corrugated iron sheets. The results also indicate that swings in shelters without courtyards (Sh16, Sh17, Sh18, Sh19, and Sh20) (from about 4 to 8 °C) are lower than those in shelters comprising courtyards (Sh11, Sh12, Sh13, Sh14, and Sh15) (from about 9 to 18 °C). This is due to that the courtyard is an open space and its temperature is similar to the external temperature whose swing is about 13°C. Comparing with the external air temperature, RT in all shelters is higher than the external temperature during the night. At the mid of the day, RT in shelters without courtyards are slightly lower than the external temperature, while RT in courtyard shelters is slightly higher than the external temperature. This is due to the exposure of the courtyards to solar radiation which reaches its peak at the mid of the day.

In summer: Trends of resultant temperatures are similar to those in winter. Average RT in each shelter is higher than the average external temperature with about 2 to 4°C. Besides, resultant temperatures in shelters comprising courtyards are higher than the external temperature all the times, with higher discrepancy during the night. However, in shelters without courtyards, the internal temperature is higher than the outside temperature during the night and slightly lower than the outside temperature during the daytime.

Overall, internal temperature in old shelters ranges from about 7-18°C in winter and from about 21- 37°C in summer. This means the shelters are cold in winter and hot in summer as the temperature is out of the comfort zone most of the time. Besides, internal temperature in the old shelters fluctuates significantly which is mainly explained by the low thermal mass and the great thermal conductivity of the roofs.

9.4.2 Humidity

Relative humidity RH for main spaces in shelters is also estimated in summer and winter. Figure 9.15 shows RH in shelter no.14 in summer and winter.



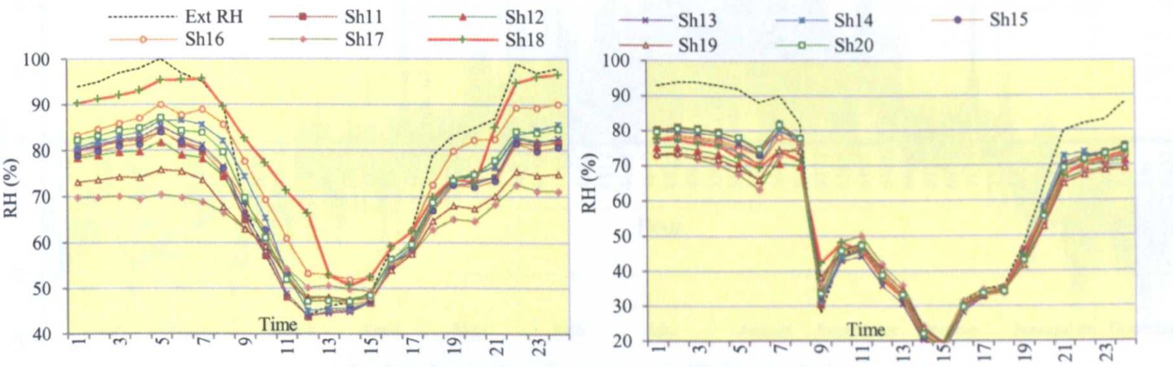
a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 9.15: Relative Humidity RH in shelter no.14

In winter: Average RH of the main spaces of Sh14 ranges from about 45% to 85%, where it is higher during the night and declines to its minimum at the mid of the day. Relative humidity in the main spaces are similar during the daytime, while RH in the courtyard and in the kitchen is higher than RH in other spaces almost during the night. ***In summer***: Average RH ranges from about 20% to 80%, where it is high during the night and low at the mid of the day. Comparing with external humidity, RH in the main spaces of the shelter, excluding the courtyard, is lower than outside RH during the night in both summer and winter. However, it is approximately parallel with outside RH during the daytime, approximately between 9:00-17:00hr in winter, and 8:00-20:00hr in summer.

Figure (9.16) summarizes RH status inside the shelters by providing averages RH which are calculated for the main spaces in each shelter, including the courtyards, for summer and winter.



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.16: Relative Humidity RH in old shelters

In winter, averages RH of the shelters overall range from about 70% to 95% at their maximum during the night, and range from 45% to 55% at their minimum at the mid of the day. RH inside the shelters is almost stable during the night, while it falls sharply during the daytime reaching its minimum at the mid of the day, then rises up. Comparing with the outside RH, the averages RH of the shelters are almost close to the outside RH between 9:00-16:00 and lower than the outside RH the rest times. Besides, discrepancy between the inside and the outside RH is more obvious during the night.

In summer: Trends of averages RH inside the shelters are approximately similar to those in winter; however, RH is overall lower in summer. Averages RH of the shelters range almost from (70% to 80%) at their peak during the night, while they are very close at their minimum and range from 16.7% to 19.7%. besides, it is observed that RH inside shelters is generally influenced with times of opening windows, where internal RH is similar to outside RH when windows are opened during the daytime and lower than outside RH during the night where occupants almost close windows.

9.4.3 Predicted Mean Vote PMV

Predicted mean vote (PMV) was also calculated for main spaces of the old shelters, excluding courtyards, because PMV is used for estimating thermal comfort of internal spaces. Figure (9.17) provides hourly PMV through the year in main spaces of shelter no.14. As indicated in the figure, the maximum PMV is overall estimated in summer season, while the minimum PMV is estimated in winter season. It was found that, PMV in Sh14 ranges from (-0.5 to 0.5) in about 38 percent of the total hours through the year, with the greatest number of hours is estimated for room2. Besides, it is observed that hourly PMV fluctuates significantly. This is due to the significant swings in temperature and RH inside shelters as discussed earlier.

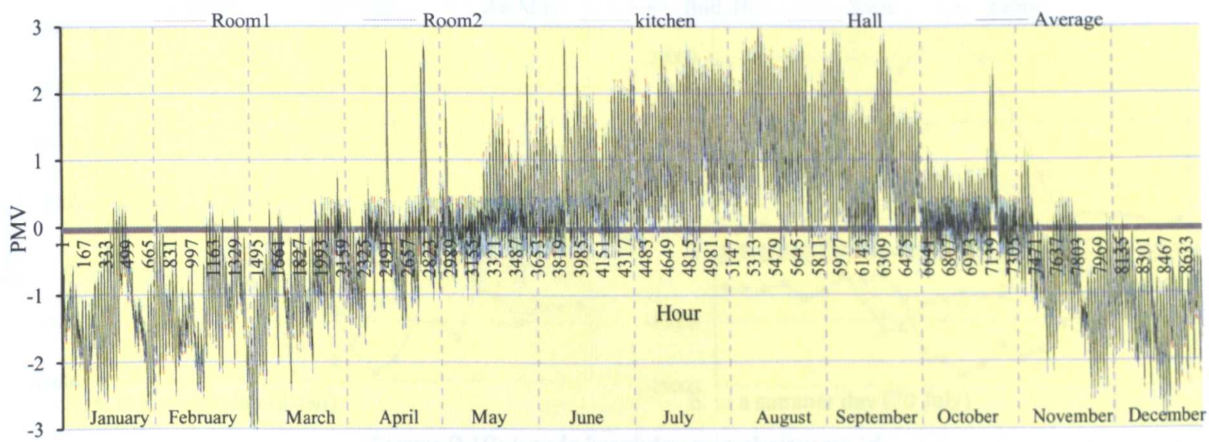


Figure 9.17: Hourly predicted mean vote PMV for shelter no.14

Figure (9.18) provides the maximum and minimum PMV estimated through a whole year in the main spaces of each shelter.

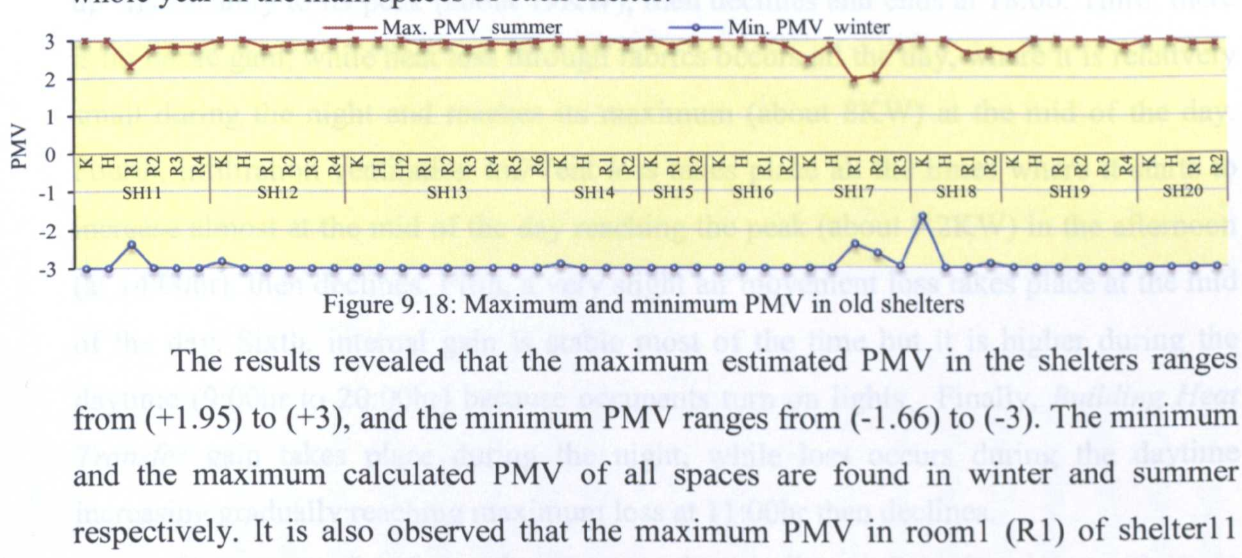


Figure 9.18: Maximum and minimum PMV in old shelters

The results revealed that the maximum estimated PMV in the shelters ranges from (+1.95) to (+3), and the minimum PMV ranges from (-1.66) to (-3). The minimum and the maximum calculated PMV of all spaces are found in winter and summer respectively. It is also observed that the maximum PMV in room1 (R1) of shelter11 (SH11), and in R1 and R2 of SH17 is relatively lower than that of the other spaces, and the minimum PMV in these rooms is higher than that in the other spaces. This could be explained by that the roof of these rooms is concrete slap whose thermal conductance (3.1 W/m^2.^{o}C) is significantly lower than that of the corrugated iron roofs (999.99 W/m^2.^{o}C) and the asbestos sheets roofs (72 W/m^2.^{o}C) which are used to cover the other spaces. In addition, it is observed that the minimum PMV in the kitchen (K) of shelter18 (SH18), is relatively higher than that of the other spaces. This could be due to that no wall of this kitchen is exposed to the external environment and the kitchen has no window. In addition, the equipment sensible gain inside this kitchen is relatively high (about 154 W/m^2) as the area of the kitchen is small (about 2 m^2).

9.4.4 Loads Breakdown

Loads breakdown is analysed for every shelter, in both a summer and a winter days. Figure 9.19 provides loads breakdown of shelter no.14, in a winter and a summer day. As indicated by load analysis, several observations are noticed.

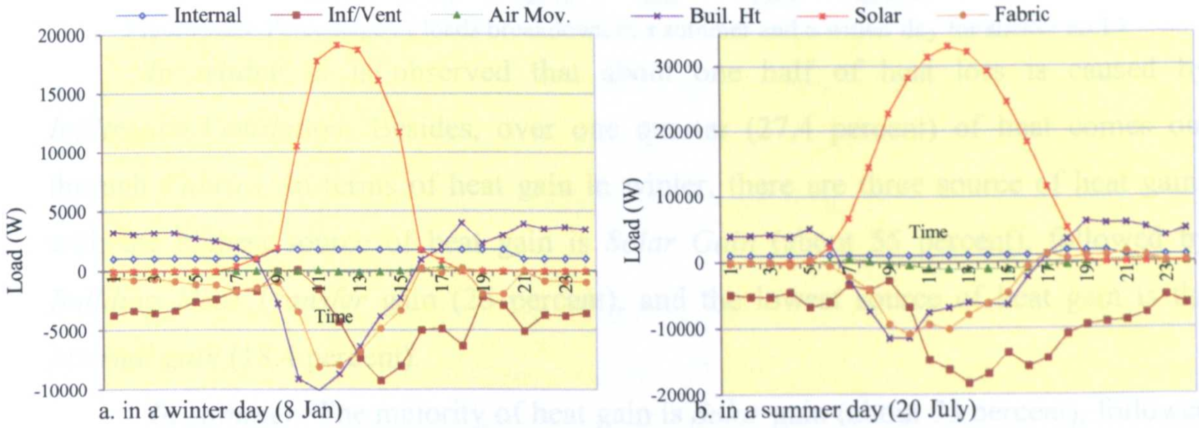


Figure 9.19: Loads breakdown in shelter no.14

In winter: First, it should be mentioned that at any hour of the day, total heat loss equals total heat gain. Second, solar gain starts in the morning (after 7:00) and rises up significantly to its peak (about 19KW), then declines and ends at 18:00. Third, there is no fabric gain, while heat loss through fabrics occurs all the day, where it is relatively small during the night and reaches its maximum (about 8KW) at the mid of the day. Fourth, infiltration ventilation Inf/Vent loss takes place all the times where it starts to increase almost at the mid of the day reaching the peak (about 9.2KW) in the afternoon (at 14:00hr), then declines. Fifth, a very slight air movement loss takes place at the mid of the day. Sixth, internal gain is stable most of the time but it is higher during the daytime (9:00hr to 20:00hr) because occupants turn on lights. Finally, *Building Heat Transfer* gain takes place during the night, while loss occurs during the daytime increasing gradually reaching maximum loss at 11:00hr then declines.

In summer: Loads trends are somewhat similar to those in winter with some differences. First, solar gain is greater (its peak is 33KW) than that in winter and stay longer, where it starts two hours earlier and ends one hour later. Second, heat gain through fabric takes place in the evening and during the night, while there is no fabric gain in winter. Third, magnitudes of fabric loss and Inf/Ven loss are greater in summer. Fourth, internal gain is stable most of the time but it is higher only during the evening (17:00hr to 21:00hr), where occupants turn on lights.

The percentages of loads breakdown are also computed for every shelter in both a summer and a winter days. Figure 9.20 shows the percentages of loads breakdown in shelter no.14.

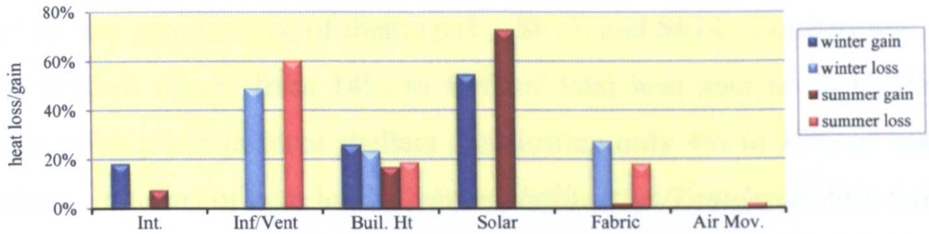


Figure 9.20: Percentage of loads breakdown in a summer and a winter day for shelter no.14

In winter: It is observed that about one half of heat loss is caused by *Infiltration/Ventilation*. Besides, over one quarter (27.4 percent) of heat comes out through *Fabrics*. In terms of heat gain in winter, there are three source of heat gains with the highest source of heat gain is *Solar Gain* (about 55 percent), followed by *Building Heat Transfer* gain (26 percent), and the lowest source of heat gain is the *Internal gain* (18.4 percent).

In summer: The majority of heat gain is *Solar* gain (about 73 percent), followed by *Building Heat Transfer* gain (17 percent), *Internal gain* (7.5 percent), and the lowest source of heat gain is through *Fabrics* (2.1 percent). In terms of heat loss in summer, percentage of *Infiltration/Ventilation* loss (60 percent) is the highest among the other types of heat loss, followed by *Building Heat Transfer* loss (19 percent) and *Fabrics* loss (18.4 percent) and the lowest percentage of heat loss is *Air Movement* loss (2.1 percent).

Percentages of loads breakdown in all shelters in both a summer and a winter days is provided in (figure 9.21). Several observations from the figure can be concluded about the thermal performance of old shelters.

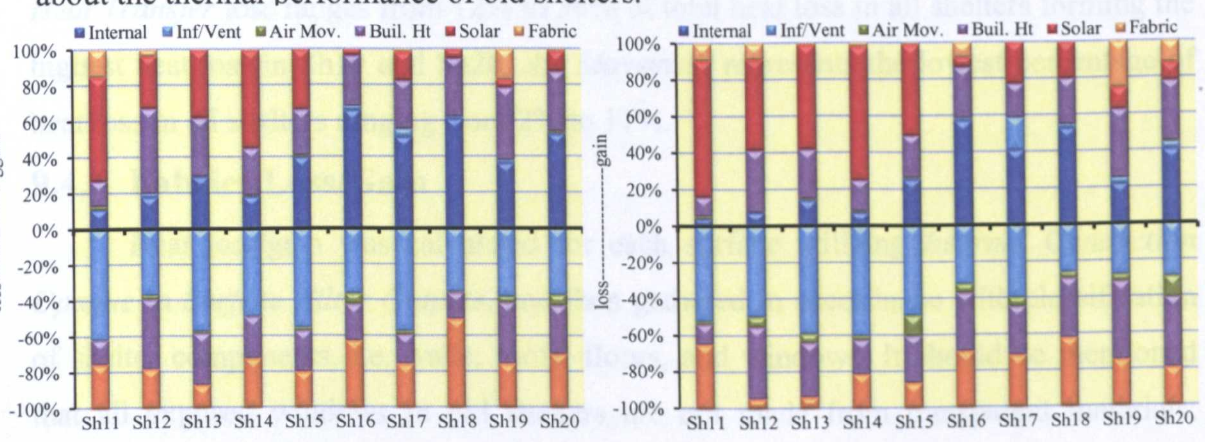


Figure 9.21: Percentage of loads breakdown in old shelters

In winter: The highest percentage of heat gain in the shelters without courtyards (Sh16, Sh17, Sh18, Sh19, and Sh20) is the *Internal* gain, which ranges from 37% to

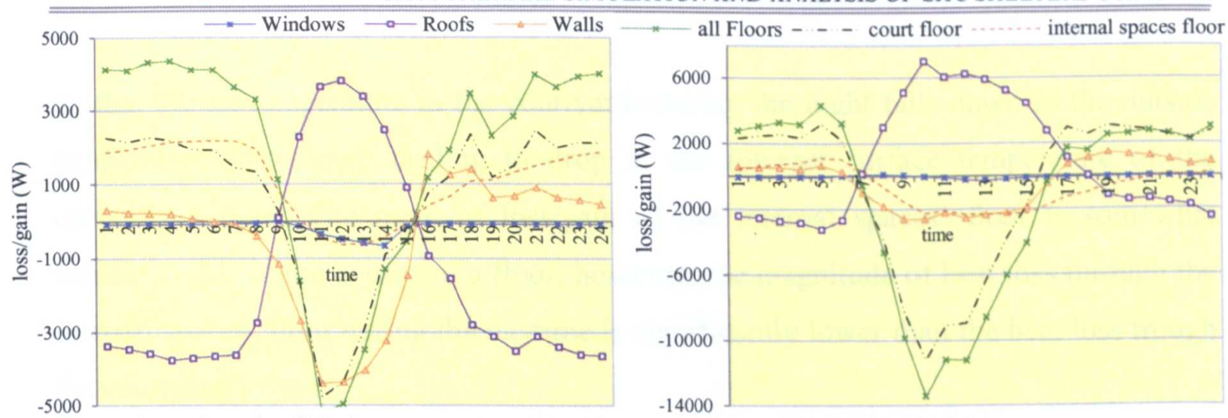
66% of total heat gain in these shelters. Besides, *Solar* gain in these shelters is low and represents 3% to 16% of heat gain. In contrast, *Solar* gain ranges from 29% to 57% of heat gain in the rest shelters which comprise courtyards, and represents the highest percentage of heat gain in three of them (Sh11, Sh13, and Sh14). Furthermore, *Building Heat Transfer* gain ranges from 14% to 47% of total heat gain in all shelters, while *Fabrics* gain takes place in three shelters constituting only 4% to 17% of heat gain in theses shelters. In terms of heat loss in winter, *Infiltration/Ventilation* loss ranges from 30% to 62% of heat loss in all shelters and forms the highest percentage of heat loss in six shelters. Besides, heat loss through *Fabrics* ranges from 12% to a maximum of 49% and represents the highest percentage of heat loss in Sh16 and Sh18. *Building Heat Transfer* loss ranges from 14% to 39% of total heat loss in all shelters forming the highest heat loss in Sh12.

In summer: The highest percentage of heat gain in the shelters comprising courtyards is *Solar* gain, which ranges from 49% to 74% of total heat gain in these shelters. In contrast, *Solar* gain forms only 5% to 22% of heat gain in the rest shelters without courtyards, while *Internal* gain generates the highest percentage of heat gain in four of them ranging from 40% to 57%. Furthermore, *Building Heat Transfer* gain ranges from 10% to 37% of the total heat gain in all shelters, while *Fabrics* gain takes place in five shelters constituting only 8% to 25% of heat gain in theses shelters. In terms of heat loss in summer, *Infiltration/Ventilation* loss ranges from 26% to 59% of heat loss in all shelters and forms the highest percentage of heat loss in seven shelters including courtyards shelters. Besides, heat loss through *Fabrics* ranges from 5% to a maximum of 38% and represents the highest percentage of heat loss in Sh18. *Building Heat Transfer* loss ranges from 12% to 39% of total heat loss in all shelters forming the highest heat loss in Sh19 and Sh20. *Air Movement* represents the lowest percentage of heat loss in all shelters ranging from 2% to 11%.

9.4.5 Fabrics Loss/Gain

Heat loss/gain was calculated for each surface utilizing *Internal Conduction Opaque* in *Surface Filter Outputs*, and then gathered in accordance with classification of shelter components, i.e. walls, roofs, floors, and windows. It should be mentioned that all exposed windows in old shelters are not made from transparent materials; therefore there is no solar gain through windows.

Figure 9.22 provides heat loss/gain through various exposed components of shelter no.14, during both a summer and a winter days. Findings are clarified below.



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.22: Heat loss/ gain of fabrics in shelter no.14

In winter: Analysis revealed a slight heat loss through the windows occurs at the mid of the day. The small amount of heat flow through the windows is due to the small size of the windows, where the area of the windows in Sh14 is about 2 m^2 which represents about 4% of the external walls` area. Besides, there is a great heat loss through roofs during the night (as the outside temperature drops down) which falls sharply in the morning ending at 9:00hr. Then, heat gain through roofs starts and increases reaching its peak at the mid of the day as the roof is exposed to solar radiation, then declines and ends in the evening. Thus, the total heat loss through the roof in a winter-day is greater than the total heat gain through the roof. In contrast, walls heat loss takes place during the daytime with a maximum of about 4.4KW, while slight heat comes in through walls in the evening and during the night. Thus, the total heat loss through the walls in a winter-day is greater than the total heat gain through the walls. The thermal analysis also revealed a great heat gain through floors during the night which falls sharply in the morning and ends after 9:00hr. Afterwards, heat loss through floors takes place and increases reaching its peak at the mid of the day, then declines and ends approximately in the evening. However, the total heat gain through the floors in a winter-day is greater than the total heat loss through the floors. To explain the thermal performance of the floor, the trends of loss/gain for both the courtyard`s floor and the internal spaces` floor are presented separately. The analysis revealed a great heat loss through the courtyards floor during the daytime which means that the internal surface temperature of the courtyard`s floor is higher than the external surface temperature of the courtyard`s floor (i.e. the surface which is exposed to the soil). This could be explained by that the courtyards during the daytime is exposed to solar radiation which raises the internal surface temperature of the courtyard`s floor. In contrast, the results revealed a great heat gain through the courtyards floor during the night which means that the internal surface temperature of the courtyard`s floor is lower than the external surface temperature of the courtyard`s floor. This could be explained by that the air temperature in the courtyards during the night falls down as the outside temperature falls down leading to drop in the internal surface temperature of the courtyard`s floor. The trend of loss/gain of the internal spaces` floor is somewhat similar to that of the courtyard`s floor, however, the magnitude of heat loss through the internal spaces` floor during the daytime is significantly lower than the heat loss trough the courtyard`s floor.

In summer: Trend of fabrics loss/gain is quite similar to that in winter, with differences in magnitudes. Heat losses through windows and walls are smaller than those in winter. However, the total heat loss through the walls in summer is greater than the total heat gain. Besides, heat gain through roof is greater in summer than that in winter and stays longer time. However, heat loss through floors in summer is greater than heat gain through floors.

To sum up, as a total heat loss/gain through the roof, heat loss takes place in winter while heat gain takes place in summer. Besides, heat loss through the walls and the windows takes place in both summer and winter. However, as a total heat loss/gain through the floor, heat loss takes place in summer while heat gain takes place in winter.

Percentages of heat loss/gain of various components are also computed for every shelter in both a summer and a winter-day. Figure 9.23 shows percentages of fabrics heat loss/gain in shelter no.14.

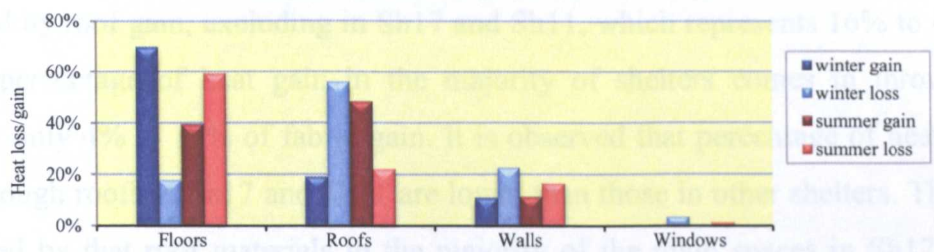
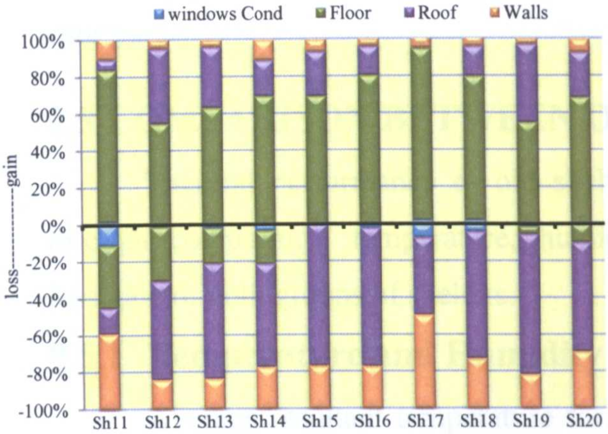


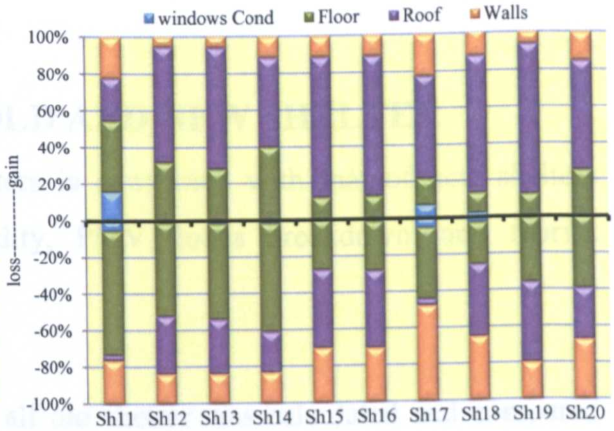
Figure 9.23: Percentage of fabrics loss/gain of Sh14 in a summer & a winter day

It is observed that the majority of heat gain in winter flows in through floors (about 70%), followed by roof gain (19.2%), and the lowest amount of heat gain flows through walls (11%). In terms of heat loss in winter, more than one-half of heat (about 56%) comes out through roofs, followed by walls loss (22.7%), floors loss (17.9%), and lowest percentage of heat flows out through windows (3.6%). In summer, around one half of heat gain is roof gain (49%), followed by floor gain (40%), and the lowest percentage of heat gain comes in through walls (about 11%). In terms of heat loss in summer, the majority of heat loss in summer flows out through floors (59%), followed by roof loss (22.4%), walls loss (16.7%), and only less than two percent of heat flows out through windows.

The percentages of loss and gain of the various fabrics` components of all shelters in both a summer and a winter days are provided in (figure 9.24). Several observations from the figure can be concluded about thermal performance of fabrics.



a. in a winter day (8 Jan)



b. in a summer day (20 July)

Figure 9.24: Percentage of fabrics loss/gain in old shelters

In winter: Heat loss through roofs is the highest in the shelters, excluding Sh17 and Sh11, and represents 50% to 77% of total fabrics loss, while walls loss forms 16% to 51% and represents the highest percentage of fabrics loss in Sh17 and Sh11. Besides, floor loss takes place in six shelters forming 1% to 34% of fabrics loss in these shelters, and heat loss through windows takes place in half of shelters representing only 2% to 11% of fabrics loss in these shelters. In terms of fabrics gain in winter, floor gain forms the majority of fabric gain in all shelters representing from 55% to 98% of fabric gain, followed by roof gain, excluding in Sh17 and Sh11, which represents 16% to 42%. The lowest percentage of heat gain in the majority of shelters comes in through walls forming only 4% to 12% of fabric gain. It is observed that percentage of heat loss and gain through roofs in Sh17 and Sh11 are lower than those in other shelters. This can be explained by that roof materials in the majority of the main spaces in Sh17 and of a room in Sh11 are hollow concrete slabs, while roof materials of all main spaces in the rest shelters are corrugated iron sheets or asbestos sheets.

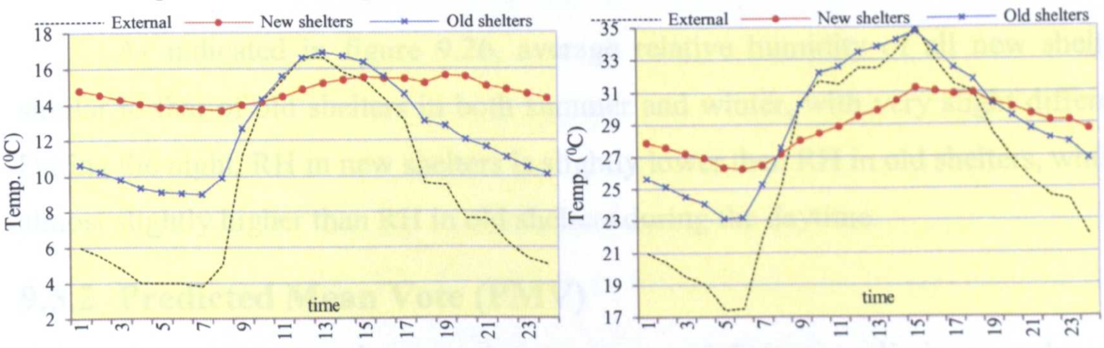
In summer: Overall, heat loss through floors ranges from 23% to 68% and represents the highest percentage of fabric loss in half of the shelters. Besides, roofs loss ranges from 3% to 44% representing the highest percentage of fabric loss in four shelters, while walls loss ranges from 16% to 52% of total fabric loss representing the highest percentage of fabric loss in Sh17. In terms of fabric gain in summer, the majority of heat comes in through roofs in all shelters, excluding Sh11, constituting 49% to 82% of fabric gain in these shelters. Further, heat loss through floors and walls ranges from (11% to 40%) and from (6% to 22%) of total fabric loss respectively. The lowest percentage of heat loss comes out through windows in only three shelters (Sh11, Sh17, and Sh18) ranging from 2% to 16% of fabric loss in these shelters. It is also observed that heat loss and gain through floors are almost greater in shelters comprising courtyards.

9.5 COMPARISON BETWEEN OLD AND NEW SHELTER

Thermal performance of old shelters is contrasted with that of new shelters through comparing temperature, humidity, PMV, loads breakdown, and fabrics loss/gain of both groups of shelters.

9.5.1 Temperature and Humidity

Average resultant temperature for all old shelter was calculated and compared with average resultant temperature of all new shelters (see figure 9.25).



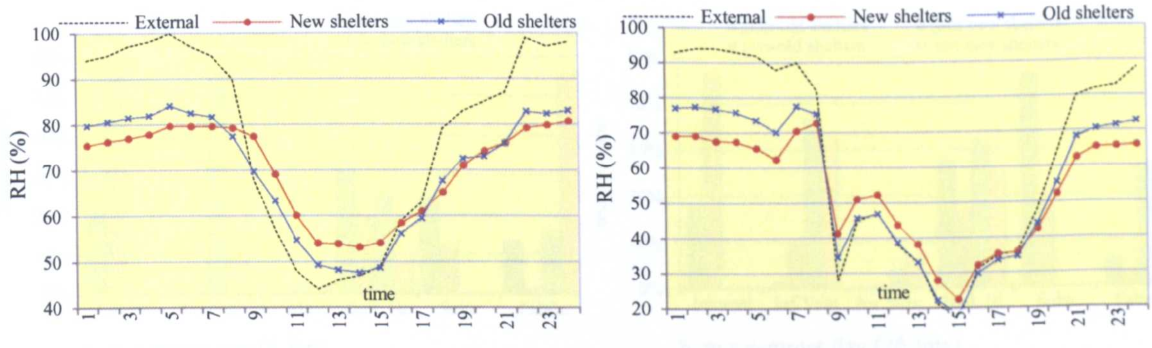
a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.25: Average resultant temperature of all old and new shelters

In winter: As indicated in figure 9.25, resultant temperature in new shelters fluctuates between about 13.7 °C and 15.7 °C, while it fluctuate between 9 °C and 17°C in old shelters. This means that the maximum swings in temperatures in new shelters (about 2 °C) is lower than that in old shelters (8 °C), while maximum swings in outside temperatures is 12.8 °C. Besides, temperature in old shelters is higher than temperature in new shelters between 10:00hr and 16:00hr, while temperature in old shelters is lower in remain hours, i.e. in the morning, evening, and night. As a daily average, mean temperature of new shelters in a winter-day (14.7 °C) is higher than that of old shelters (12.4 °C) with about 2.3 °C difference.

In summer: Resultant temperature in new shelters fluctuates between about 26.3 °C and 31.3 °C, i.e. the maximum swings in temperatures is 5 °C. In old shelters, temperature fluctuates between about 23.1 °C and 34.7 °C, i.e. the maximum swings in temperatures is 11.6 °C. Besides, temperature in old shelters is parallel with outside temperature and higher than temperature in new shelters during the day (between 8:00hr and 18:00hr), while temperature in old shelters is lower during the night. As a daily average temperature, mean temperature of new shelters in a summer-day is 28.9 °C which is very slightly lower than that of old shelters which is about 29.1 °C.

Average relative humidity RH for all old shelter was also calculated and compared with average RH of all new shelters (see figure 9.26).



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.26: Average relative humidity RH of all old and new shelters

As indicated in figure 9.26, average relative humidity of all new shelters is similar to that of old shelters in both summer and winter, with very slight differences. During the night, RH in new shelters is slightly lower than RH in old shelters, while it is almost slightly higher than RH in old shelters during the daytime.

9.5.2 Predicted Mean Vote (PMV)

For a comparison between the two groups of shelters, preliminary analyses were performed first to examine the normality of PMV in summer and winter for the both samples of old and new shelters. The normality test revealed that PMVs of old shelters are not normally distributed; therefore, non-parametric test Mann-Whitney U is applied to compare PMV in old shelter with PMV in new shelters.

The test revealed a statistically significant difference in PMV for old SHC shelters (n=50) and PMV for new SHC shelters (n=49), in both summer and winter ($\rho<.001$) with large effect size (r= 0.64 and 0.8 respectively). In summer, PMV for old shelters (Md=2.93) is higher than PMV for new shelters (Md=2.36). In winter, PMV for old shelters (Md=-3) is lower than PMV for new shelters (Md=-2.38). See figure 9.27.

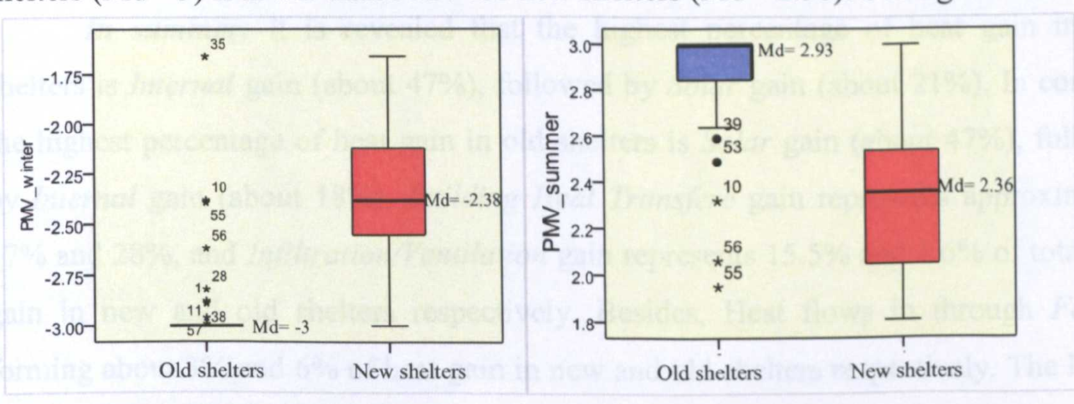
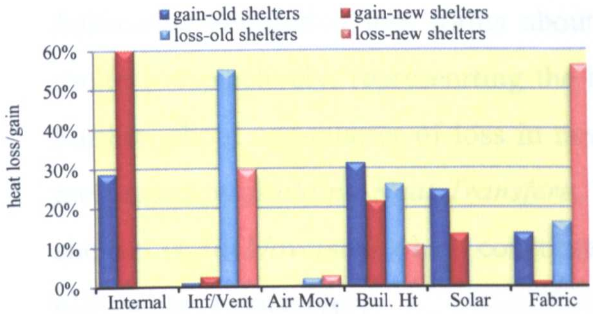


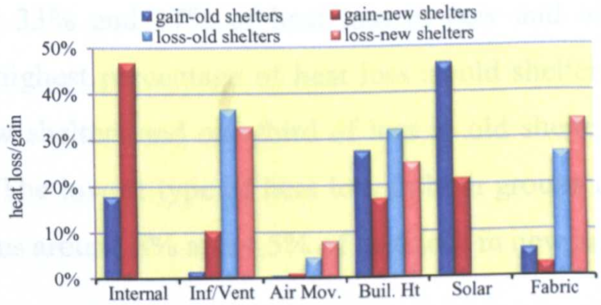
Figure 9.27: Box-plots of PMV distribution for old and new shelters, in summer and winter

9.5.3 Loads Breakdown

Percentages of loads breakdown of total load in all new shelters are computed and compared with those of old shelters. The comparison was conducted for both a summer and a winter days (see figure 9.28).



a. in a winter day (8 Jan)



b. in a summer day (20 July)

Figure 9.28: Percentage of loads breakdown in all old and new shelters

In winter: Findings indicates that the majority of heat in new shelters is the *Internal* gain forming about 60% of total heat gain, while *Internal* gain in old shelters forms about 29% of total heat gain. *Building Heat Transfere* gain represents the highest percentage of total heat gain in old shelters (about 32%), while it represents about 22% of heat gain in new shelters, which comes in the second place after *Internal* gain. Besides, *Solar* gain forms about 25% and 14% of total gain in old and new shelters respectively. The lowest percentage of heat gain in new shelters is *Fabric* gain constituting about 1.4% of heat gain, while it represents around 14% of heat gain of old shelters. The lowest percentage of heat gain in old shelters is *Infiltration/Ventilation* gain constituting about 1.0% of heat gain, and it represents around 2.6 % of heat gain of new shelters. In terms of heat loss in winter, *Fabrics* loss is the highest percentage of heat loss in new shelters which constitutes about 56%, while it represents 16.6% of the total heat loss in old shelters. Moreover, *Infiltration/Ventilation* loss is the highest percentage of heat loss in old shelters and constitutes about 55%, while it represents 30% of total heat loss in new shelters. *Building Heat Transfer* causes about 26% and 11% of total loss in old and new shelters respectively.

In summer: It is revealed that the highest percentage of heat gain in new shelters is *Internal* gain (about 47%), followed by *Solar* gain (about 21%). In contrast, the highest percentage of heat gain in old shelters is *Solar* gain (about 47%), followed by *Internal* gain (about 18%). *Building Heat Transfere* gain represents approximately 17% and 28%, and *Infiltration/Ventilation* gain represents 15.5% and 1.6% of total heat gain in new and old shelters respectively. Besides, Heat flows in through *Fabrics* forming about 3% and 6% of heat gain in new and old shelters respectively. The lowest type of heat gain in both groups of shelters is *Air Movement* which constitutes only 1% and 0.5% of heat gain in new and old shelters respectively. In terms of heat loss in summer, *Fabrics* loss forms about 34% and 27% of heat loss in new and old shelters resplectively, represenrting the highest percentage of heat loss in new shelters. *Infiltration/Ventilation* loss forms about 33% and 37% of heat loss in new and old shelters resplectively, represenrting the highest percentage of heat loss in old shelters. Further, about one-quarter of loss in new shelters and one-third of loss in old shelters are caused by *Building Heat Transfere.* The lowest type of heat loss in both groups of shelters is *Air Movement* which constitutes around 8% and 4.5% of heat loss in new and old shelters respectively.

It is worth to highlight that the simulation analysis of the internal gain in both groups of shelters coincide with the survey results of the reasons of discomfort in summer which represented earlier in section (7.5.2). The survey indicated that the small area of the shelter comes in the first and the second place as the first reason of discomfort in new and old shelters respectively. The simulation indicates that internal gain is the highest percentage of heat gain in new shelters while in the old shelters it comes at the second place. This correlation between the simulation result for the internal gain and the survey result for the shelter area can be explained by another connectting variabel which is the number of occupants. The sufficient amount of space is determined by the number of users in addition to activities as clarified earlier in section (3.5.3). The internal heat gain is determined also by the number of occupants in addition to lights and equipments as clarified earlier in section (9.2).

9.5.4 Fabrics Loss/Gain

Percentages of loss/gain for various components (walls, roofs, walls, and windows) of total fabrics loads in all new shelters are computed and compared with those of old shelters. The comparison was conducted for both a summer and a winter days (see figure 9.29).

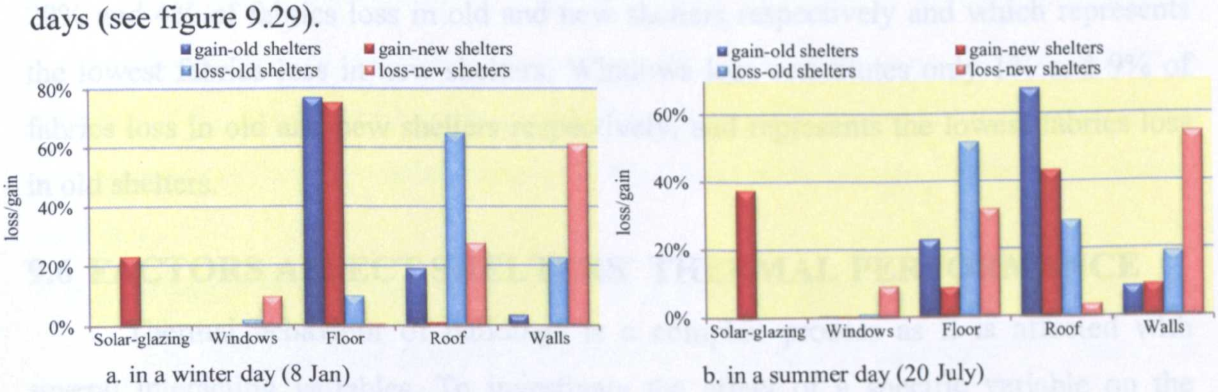


Figure 9.29: Percentage of loads breakdown in all old and new shelters

In winter: The majority of fabrics gain in both old and new shelters flows through floors forming about three-quarter of fabrics gain. Roof gain represents about 19% of fabrics gain in old shelters, while it represents only 1.2% of fabrics gain in new shelters. As there are no glazed windows in old shelter, solar gain through glazing is existent only in new shelters representing about one-quarter of fabrics gain in these shelters. Besides, heat gain through walls represents only 0.03% and 3.5% of fabrics gain in old and new shelters respectively. The lowest amount of fabrics gain in both groups of shelters flows through windows, constituting less than one percent of fabrics gain. In terms of heat loss in winter, walls loss is the highest percentage of fabrics loss in new shelters (about 61%), followed by *roofs* loss (about 28%). In contrast, the highest percentage of fabrics loss in old shelters is *roofs* loss (about 65%), followed by *walls loss* (about 23%). Floors loss is approximately 1% and 10% of fabrics loss in new and old shelters respectively and represents the lowest percentage of fabrics loss in new shelters. However, windows loss is about 10% and 2% of fabrics loss in new and old shelters respectively and represents the lowest percentage of fabrics loss in old shelters.

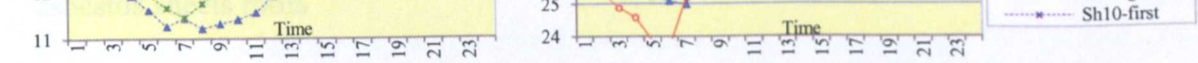
In summer: The highest percentage of fabrics gain in both old and new shelters is roof gain which forms about 68% and 43% of fabrics gain in old and new shelters respectively. In new shelters, solar gain through glazing represents about 38% of fabrics gain. Besides, floor gain represents about 23% and 9%, while walls gain represents around 9% and 10% of fabrics gain in old and new shelters respectively. The lowest percentage of fabrics gain in both groups of shelters conducts by windows which constitutes less than one percent of fabrics gain. In terms of fabrics loss in summer, walls loss is about 55% and 19% of fabrics loss in new and old shelters respectively, and represents the highest percentage of fabrics loss in new shelters. Floors loss is about 32% and 52% of fabrics loss in new and old shelters respectively, and represents the highest percentage of fabrics loss in old shelters. Besides, roof loss constitutes about 28% and 4% of fabrics loss in old and new shelters respectively and which represents the lowest fabrics loss in new shelters. Windows loss constitutes only 1% and 9% of fabrics loss in old and new shelters respectively, and represents the lowest fabrics loss in old shelters.

9.6 FACTORS AFFECT SHELTERS' THERMAL PERFORMANCE

Thermal behaviour of buildings is a complex process as it is affected with several interacting variables. To investigate the effect of a specific variable on the thermal performance of the shelters, other variables should be fixed. However, this could not be completely achieved in the 20 shelters which are analysed in this chapter because the two samples of the old and the new shelters were drawn to include diverse shelters in terms of thermal factors. Therefore, the effects of only two factors (floor level and roof material) were investigated in the studied shelters.

9.6.1 Rooms at Different Floor Levels (New Shelters)

The effect of rooms` levels in two-floor shelters on shelters` thermal performance is examined by comparing the average resultant temperatures of the ground floor rooms with that of the first floor rooms. In order to obtain similarity to some extent in other variables, the comparison was conducted between rooms in the same shelters, and kitchens were excluding as they got higher internal equipment gains. As the old shelters are one-floor, this investigation was conducted on the new shelters that comprise two floors which are Sh5, Sh6, Sh7, Sh8, Sh9, and Sh10. Figure (9.30) provides the average resultant temperatures of the ground floor rooms and the first floor rooms in both a summer and a winter days. It was revealed that the average RT of the ground floor rooms is higher than the average RT of the first floor rooms in winter. The maximum differences in temperature range from 1.9 to 3 °C. In contrast, it was found that the average RT of the ground floor rooms is lower than the average RT of the first floor rooms in summer. The maximum differences in temperature range from 1.5 °C to 3.4 °C. This means that the first floor rooms are colder in winter and hotter in summer.



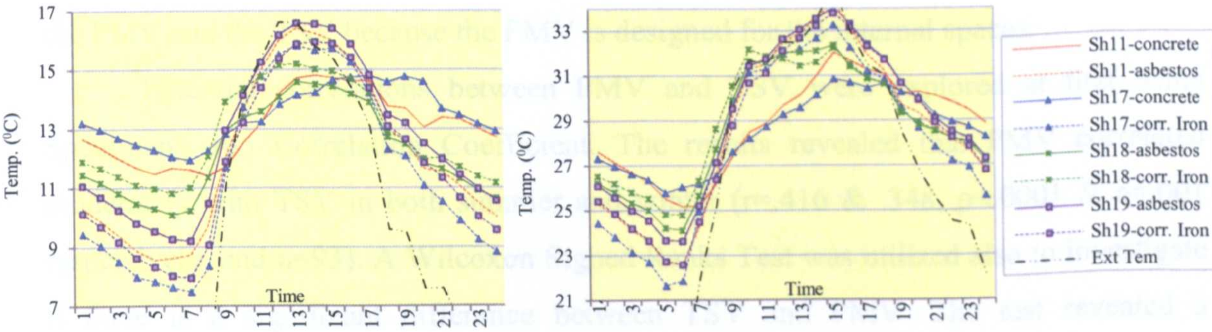
a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.30: RT in ground floor rooms vs. RT in first floor rooms of two-floor new shelters

These findings can be explained by the fact that the area exposed to the external weather of the first floor rooms is greater than that of the ground floor rooms. In other words, the first floor rooms have exposed roofs leading to greater heat loss and greater heat gain.

9.6.2 Rooms With Different Roof Materials (Old Shelters)

The effect of roof materials on thermal behaviour is examined by comparing average resultant temperatures of rooms comprising various roof materials. This investigation was conducted on old shelters as they include different roof materials which are asbestos sheets, corrugated iron sheets, and hollow concrete slaps. In order to obtain similarity to some extent in other variables, the comparison was carried out between rooms in the same shelters, and kitchens were also excluding as they got higher internal equipment gains. Figure (9.31) provides the average resultant temperatures RT in rooms with different roof materials in Sh11, Sh17, Sh18, and Sh19.



a. in a winter day (8 Jan) b. in a summer day (20 July)

Figure 9.31: Resultant temperature (RT) in rooms with different roof materials in old shelters

It was revealed that RT of rooms comprising concrete roof is lower during the daytime than RT of rooms with corrugated iron or asbestos sheets roofs with a maximum difference of 2.8 °C and 1.8 °C, in summer and winter respectively. In contrast, during the night, RT of rooms comprising concrete roof is higher than RT of rooms comprising other roof materials with a maximum difference of 4.2 °C and 4.5 °C, in summer and winter respectively. As overall, averages daily RT in rooms with concrete roof are slightly higher than those in rooms with other roof materials, in both summer and winter. Further, swing in RT of rooms comprising concrete roof is smaller than swing in RT of rooms with corrugated iron or asbestos sheets roofs. On the other hand, RT of rooms with corrugated iron roofs is quite similar to RT of rooms with asbestos sheets roofs

9.7 THERMAL COMFORT– TAS RESULT vs. SURVEY RESULT

Thermal comfort in the main spaces of the SHC shelters is predicted by TAS through estimating the Predicted Mean Vote (PMV), and is also estimated in the field survey by the occupants` thermal sensation vote (TSV). Comparisons between the results from the both methods of predicting thermal comfort were carried out where; the maximum PMV is contrasted with the occupants`` TSV for summer, and the minimum PMV is contrasted with the occupants`` TSV for winter. Shelter no. 19 is excluded from the comparison because it was observed that TSV in this shelter was influenced with a hot thermal environment. As mentioned earlier in chapter 5 (section 5.6) that the survey was conducted in autumn to avoid the effects of the hot or the cold seasons on the respondents` thermal sensation votes. However, the survey team visited this shelter while the resident (who filled the questionnaire) had been baking bread using two ovens which generated high internal heat gain. Thus, in this shelter, TSV for winter was (comfort) while TSV for summer was (hot) and these votes differed obviously from the estimated PMV. In addition, the courtyards are excluded from the comparison between the PMV and the TSV because the PMV is designed for the internal spaces.

Potential correlations between PMV and TSV were explored at first using Spearman's rho Correlation Coefficient. The results revealed that PMV correlated moderately with TSV in both summer and winter ($r=.416$ & $.348$, $\rho<.0001$ & $\rho=.001$ respectively, and $n=93$). A Wilcoxon Signed Ranks Test was utilized also to investigate if there is a significant difference between TSV and PMV. The test revealed a statistically significant difference between TSV and PMV in summer ($\rho<.01$) and in winter ($\rho<.05$) with small effect size ($r= 0.24$ and 0.16 respectively). PMV is higher than TSV in summer and lower in winter (see figure 9.32). This means that PMV overestimates the occupants' responses at high temperature and underestimates them at low temperature. These results agree with various field studies conducted on naturally ventilated residential buildings; in cold environment Becker and Paciuk (2009) and Hong (2009) found that PMV is lower than the actual mean vote by the occupants, while in hot environment the PMV is observed to be higher than the actual mean vote (Ealiwa et al. 2000, Olesen and Parsons 2002, Heidari and Sharples 2002, Feriad and Wong 2004, Han et al. 2007, Ogbonna and Harris 2008, and Indraganti 2010a, 2010b, and 2011). The difference between the survey data (TSV) and the computer modelling data (PMV) could be due to the occupants` behavioural, physiological and psychological adaptations which make the occupants more tolerant to hot and cold environments, particularly that the studied shelters are naturally-ventilated. This also appears to confirm the suggestions by Olesen and Parsons (2002) and Nicol (2004) about the limitations of the PMV in predicting thermal comfort in naturally-ventilated buildings.

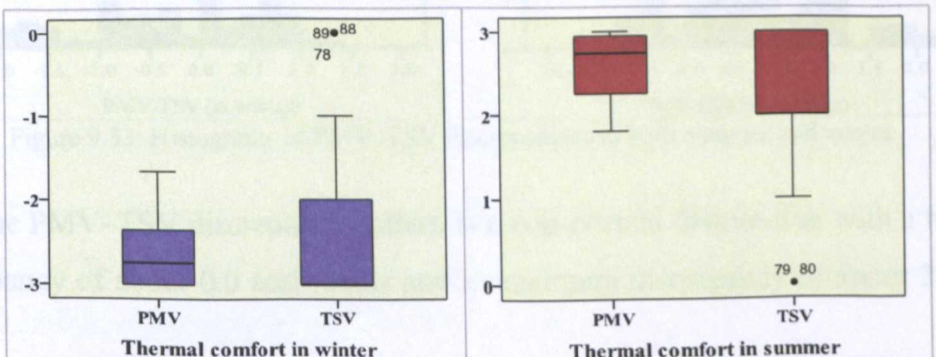


Figure 9.32: Distribution of TSV and PMV in SHC shelters in both summer and winter

Humphreys and Nicol in their research paper (2002b) stated that by subtracting TSV from the corresponding PMV for each survey instance, an unbiased but low precision estimate of the discrepancy between PMV and TSV can be obtained, and they suggested using ±0.25 scale unit as the indication of whether the PMV has significant bias in predicting TSV. Therefore, the mean of PMV–TSV discrepancy would need to be within ±0.25 scale unit to indicate an acceptable bias

It is worth to highlight that the tools and processes used to calculate the PMV and the TSV in this study are different from those used by previous researches and that could allow for a wider margin of acceptable bias for two reasons. First, in the previous researches the PMV is calculated using the parameters (including temperature, humidity, air velocity, pressure, metabolic rate, and clothing value) which are measured in the field at the same time of recording the TSV while the PMV in this study is calculated using computer simulation. In simulating the PMV by TAS, some parameters such as humidity and temperature are estimated by the programme and other parameters such as air velocity, metabolic rate, and clothing value are assumed by the researcher as mentioned earlier in (section 9.3.3). Measuring these values in the field would be more precise than estimating or assuming them. Second, in the previous researches the TSV is recorded by the respondents for the time of conducting the survey, while in this study TSV for both summer and winter is recorded through a survey conducted in autumn. Because of time constraints in this study, the survey was conducted once through the study where autumn was selected to avoid the effects of the extreme hot or cold seasons on the respondents` thermal sensation votes as mentioned earlier.

In this research, discrepancies between PMV and TSV were calculated and their distributions are presented in the histograms in figure 9.33.

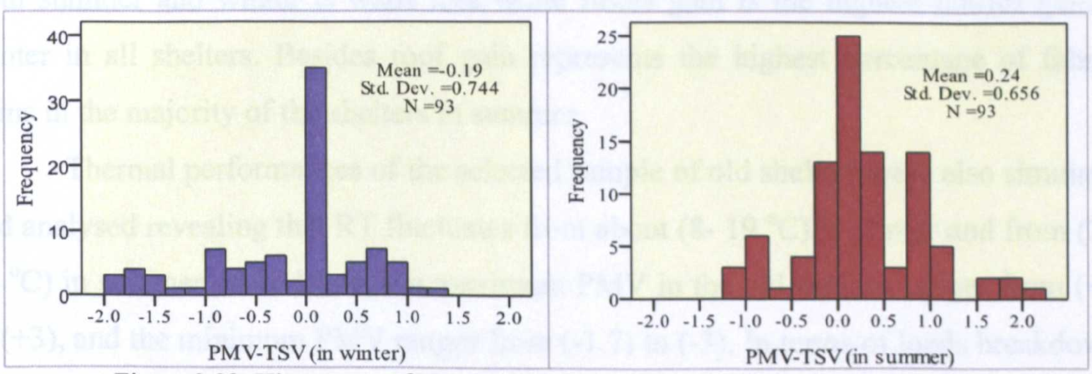


Figure 9.33: Histograms of PMV–TSV discrepancies in both summer and winter

The PMV–TSV discrepancy pattern is a non-normal distribution with a majority of discrepancy of about 0.0 scale units and a maximum discrepancy of about 2.4 scale units. Table 9.1 summarizes the mean values and standard deviations for PMV–TSV differences in old shelter, new shelter and the combined data in both types of shelters.

Table 9.1: PMV–TSV discrepancies

PMV-TSV	old shelters		new shelters		all shelters	
	summer	winter	summer	winter	summer	winter
mean	0.240	-0.241	0.240	-0.146	0.240	-0.191
Std. Deviation	0.453	0.621	0.801	0.843	0.656	0.744
Median	0.000	0.000	0.300	-0.070	0.010	0.000
N	44	44	49	49	93	93

For both summer and winter, the standard deviations of PMV–TSV discrepancies are less than one scale unit and the mean of PMV–TSV discrepancies is less than 0.25 scale units which is considered an acceptable bias according to Humphreys and Nicol suggestions in 2002. This indicates that PMV estimated by TAS simulation is free from serious bias and could be utilized to predict thermal comfort in the SHC shelters.

9.8 SUMMARY

Thermal performances of the selected samples of both old and new shelters were analysed in this chapter using thermal modelling programme (TAS V9.1.4.1). It was revealed that, in the new shelters, resultant temperature (RT) fluctuates from (13-17 °C) in winter and from (25-34 °C) in summer. Further, it was found that the maximum PMV in the new shelters ranges from (+1.8) to (+3), and the minimum PMV ranges from (-1.7) to (-3). In terms of loads breakdown, findings indicated that the highest percentage of heat gain in the majority of the new shelters is the internal gain, while fabrics loss represents the highest percentage of heat loss. Furthermore, the highest fabrics loss in both summer and winter is walls loss while floors gain is the highest fabrics gain in winter in all shelters. Besides roof gain represents the highest percentage of fabrics gains in the majority of the shelters in summer.

Thermal performances of the selected sample of old shelters were also simulated and analysed revealing that RT fluctuates from about (8- 19 °C) in winter and from (22-36 °C) in summer. In addition, the maximum PMV in the old shelters ranges from (+2) to (+3), and the minimum PMV ranges from (-1.7) to (-3). In terms of loads breakdown, findings indicated that the highest percentage of heat loss in the majority of the old shelters in both summer and winter is the *Infiltration/Ventilation* loss. Furthermore, heat loss through roofs in winter is the highest fabrics loss in the majority of the old shelters, while roofs gain in summer is the highest fabrics gain.

A comparison of thermal performances of old shelters and new shelters indicated that swing in RT in the new shelters is less that in the old shelters, in addition, the old shelters are colder in winter and hotter in summer.

Finally, comparison between TSV (questionnaires results) and PMV (TAS results) was conducted. A Wilcoxon Signed Ranks Test revealed a statistically significant difference between TSV and PMV; where PMV is higher than TSV in summer and lower in winter. However, the mean of PMV–TSV discrepancies was less than 0.25 scale units which is an acceptable bias. This indicated that PMV estimated by TAS simulation could be utilized to predict thermal comfort in the studied shelters.

CHAPTER 10

IMPROVING NEW SHC SHELTERS` FABRICS

10.1 INTRODUCTION

This chapter concerns with the enhancement of the indoor thermal environment of the new SHC shelters by improving the shelters` envelopes. This approach for the improvement is attained for two reasons. The first reason is that the fabrics loss/gain has great impact on the thermal comfort and the thermal performance of SHC shelters as it is revealed through the survey as well as through the thermal simulation of the shelters. The survey indicated that the heat loss and gain through walls and roofs are the most influence factors causing discomfort in the majority of shelters in both winter and summer. Further, the thermal simulation showed that the majority of heat loss in winter is the fabrics loss and represents 53% to 76% of the total heat loss. The second reason is that the quality of the shelter envelope can be controlled and monitored by the UNRWA through the shelter reconstruction programme which has been promoted by the agency for SHC families.

In this study, thermal simulation was conducted for different proposed shelters` components including; walls, roofs, floors and windows. The proposed fabrics are applied on one-floor; two-floor and three-floor shelters. The potential improvement of the indoor thermal environment during summer and winter is investigated by altering each element separately. Afterwards, combinations of the proposed components are simulated to reflect the thermal comfort levels attained through all seasons and to reflect the energy reduction achieved. At the end, cost analysis for the proposed fabrics combinations is provided.

10.2 SELECTING A SAMPLE

Due to time constraints, the proposed enhancements of fabrics could not be tested on all the studied new shelters whose thermal performances were analysed in the previous chapter. Therefore, a sample comprising three shelters was drawn in accordance with two aspects; (1) thermal comfort, and (2) number of floors. The least comfort shelters of the one-floor and the two-floor shelters were identified and selected. Table 10.1 provides the percentage of hours in which the PMV ranges from (+1) to (-1) and from (+0.5) to (-0.5). Findings indicated that the lowest percentage of comfort hours was estimated for Sh1 of the one-floor shelters and Sh7 of the two-floor shelters; accordingly Sh1 and Sh7 were chosen.

Table 10.1: Percentage of comfort hours in new shelters

Shelters	$-1 \leq PMV \leq 1$	$-0.5 \leq PMV \leq 0.5$
One-floor shelters:		
Sh1	**62.13%**	**36.49%**
Sh2	62.15%	38.67%
Sh3	62.41%	36.51%
Sh4	65.90%	39.11%
Two-floor shelters:		
Sh5	59.66%	35.73%
Sh6	64.45%	39.67%
Sh7	**59.14%**	**34.71%**
Sh8	63.92%	38.68%
Sh9	65.81%	40.79%
Sh10	63.06%	38.41%

A three-floor shelter (Sh21) was added also to the sample, although the UNRWA has constructed only one-floor or two-floor shelters, because some occupants add floors by themselves in accordance with their future needs. In view of that, more comprehensive proposed improvements, which are appropriate for the shelters at the present as well as appropriate for the future (i.e. with any potential vertical extensions), could be achieved by considering the three-floor shelters. As discussed earlier in chapter 5 of this thesis (section 5.6.3) that; among all the surveyed shelters, three of them were consisted of three floors and Sh21 was the selected one. Thermal performance of Sh21 was simulated and analysed before applying the proposed improvements (the results of its analysis is provided in appendix C)

10.3 THERMAL MODELLING OF VARIOUS WALLS

In order to identify the best thermal comfort level that can be achieved through the all seasons, various types and thickness of walls were proposed and simulated. The resultant temperature in both a summer and a winter days was estimated with the implementation of the various proposed walls and compared with the resultant temperature in the case of the existing wall. Furthermore, the percentages of comfort hours through each season and through the whole year were predicted with the implementation of the proposed walls. Description for the tested walls and the simulation results are provided in the following subsections.

10.3.1 Description For The Proposed Walls

As mentioned earlier in the literature view of this thesis (section 5.6.3), some authors indicate that the effectiveness of capacitive insulation (thermal mass) is acceptable where the diurnal variation of ambient temperatures exceeds 10K. According to the weather condition of the studied shelters` location, the range between monthly mean maximum and minimum temperature for the 12 months is higher than 10K. Therefore, thermal mass is proposed to be applied for the walls in order to examine its competence in achieving better thermal comfort particularly in the studied shelters.

In addition, various resistive insulations were proposed because of their ability to control the heat flow through the walls in both directions. However, using resistive insulation could be appropriate in winter as the heat loss through walls is the highest in all shelters representing 44% to 71% of the total fabric loss, while it could be ineffective in summer as the heat loss through walls is significantly higher than heat gain, as revealed by the thermal analysis of the shelters in the previous chapter. This means that the thermal performance of walls with higher conductance could be more appropriate for summer. Therefore, the effectiveness of the proposed walls was tested and simulated for each season separately and together for the whole year in order to reflect the best thermal comfort level attained.

The world building materials market supplies many types of insulation materials which have different insulating properties; however the materials market of Palestine is relatively limited. Therefore, the building materials, particularly the insulation materials, which are available in the local market, were firstly surveyed in order to incorporate obtainable materials in the proposed fabrics.

In view of the thermal analysis of the shelters and the available materials in the local market, seventeen walls were proposed for the simulation by TAS; where (W2a to W2e) represent walls with various thermal mass, (W3a and W3b) are walls incorporating air cavity, (W4a to W5e) represent walls incorporating thermal insulation materials. The simulation of the various proposed walls is aimed to stand on the different thermal performance that can be provided by the use of each type of wall. Table (10.2) and figures (10.1 & 10.2) provide the proposed walls explaining their layers, thicknesses, and thermal conductance.

Table 10.2: Description for the proposed walls

Walls type	Layers description	Conductance W/m^2.°C	Walls type	Layers description	Conductance W/m^2.°C
Existing wall (W1):			***Walls of various thermal mass (W2a to W2e):***		
W1	Paint 5mm Tyrolean render 15mm external rendering 200mm hollow conc. Block 13mm internal plaster Internal paint	4.183	W2a	Paint 5mm Tyrolean render 15mm external rendering 150mm solid conc. Block 13mm internal plaster Internal paint	10.002
W2b	Paint 5mm Tyrolean render 15mm external rendering 200mm solid conc. Block 13mm internal plaster Internal paint	8.079	W2c	Paint 5mm Tyrolean render 15mm external rendering 380mm solid conc. Block 13mm internal plaster Internal paint	4.773
W2d	Paint 5mm Tyrolean render 15mm external rendering 100mm solid conc. Block 50mm Extruded Polystyrene 100mm solid conc. Block 13mm internal plaster Internal paint	0.417	W2e	Paint 5mm Tyrolean render 15mm external rendering 100mm solid conc. Block 100mm Extruded Polystyrene 100mm solid conc. Block 13mm internal plaster Internal paint	0.214
Walls incorporating air cavity (W3a to W3b):					
W3a	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm air gap 100mm hollow conc. Block 13mm internal plaster Internal paint	2.168	W3b	Paint 5mm Tyrolean render 15mm external rendering 100mm solid conc. Block 50mm air gap 100mm solid conc. Block 13mm internal plaster Internal paint	3.169
Walls with 50mm resistive insulation (W4a to W4e):			***Walls with 100mm resistive insulation (W5a to W5e):***		
W4a	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm mineral wool 100mm hollow conc. Block 13mm internal plaster Internal paint	0.672	W5a	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 100mm mineral wool 100mm hollow conc. Block 13mm internal plaster Internal paint	0.369
W4b	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm glass wool 100mm hollow conc. Block 13mm internal plaster Internal paint	0.658	W5b	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 100mm glass wool 100mm hollow conc. Block 13mm internal plaster Internal paint	0.361
W4c	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm foamed polyurethane 100mm hollow conc. Block 13mm internal plaster Internal paint	0.658	W5c	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 100mm foamed polyurethane 100mm hollow conc. Block 13mm internal plaster Internal paint	0.361
W4d	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm Expanded Polystyrene 100mm hollow conc. Block 13mm internal plaster Internal paint	0.546	W5d	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 100mm Expanded Polystyrene 100mm hollow conc. Block 13mm internal plaster Internal paint	0.295
W4e	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 50mm Extruded Polystyrene 100mm hollow conc. Block 13mm internal plaster Internal paint	0.393	W5e	Paint 5mm Tyrolean render 15mm external rendering 100mm hollow conc. Block 100mm Extruded Polystyrene 100mm hollow conc. Block 13mm internal plaster Internal paint	0.208

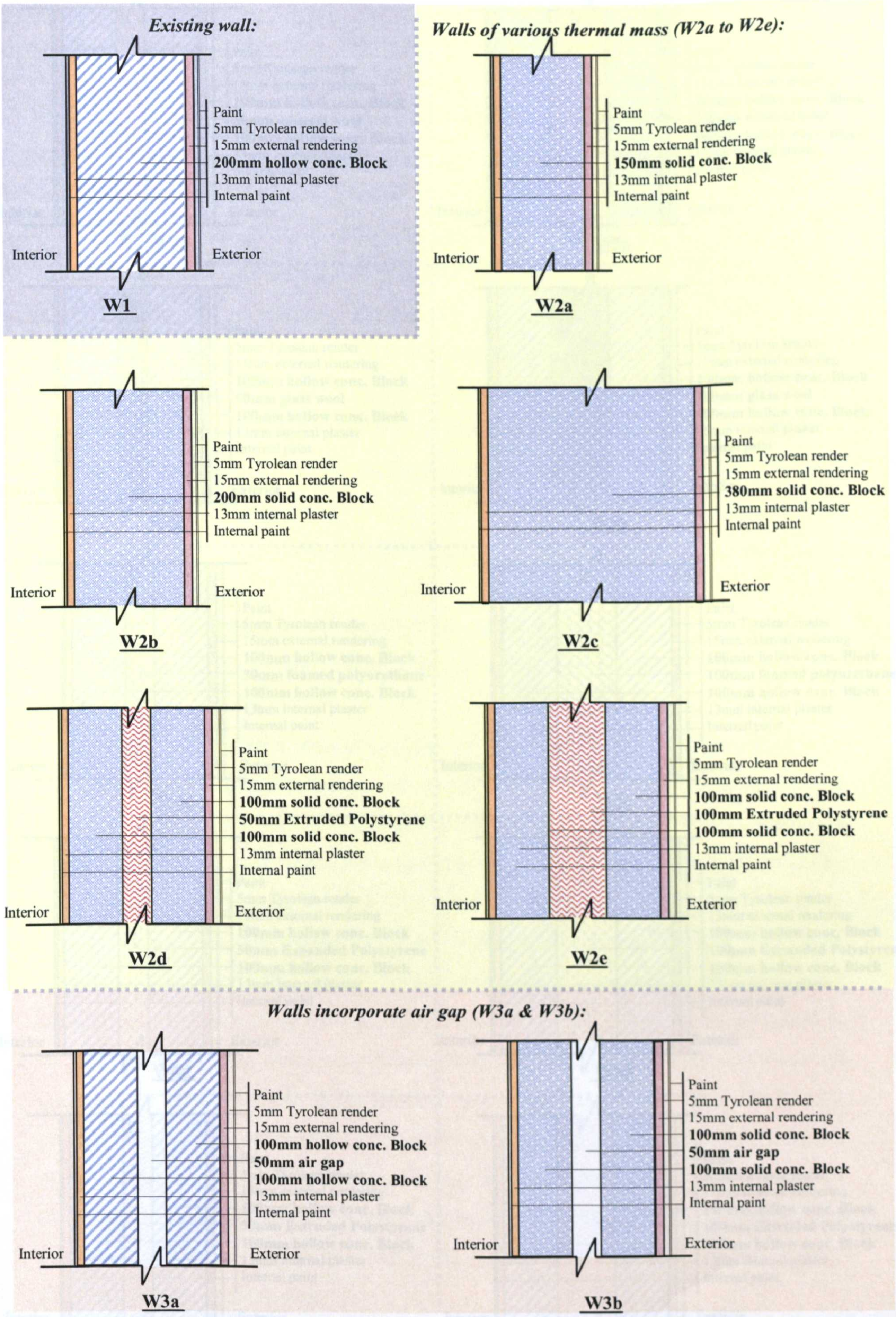


Figure 10.1: Detailed drawings for existing wall (W1), thermal mass walls (W2a to W2e), and walls with air gap (W3a & W3b)

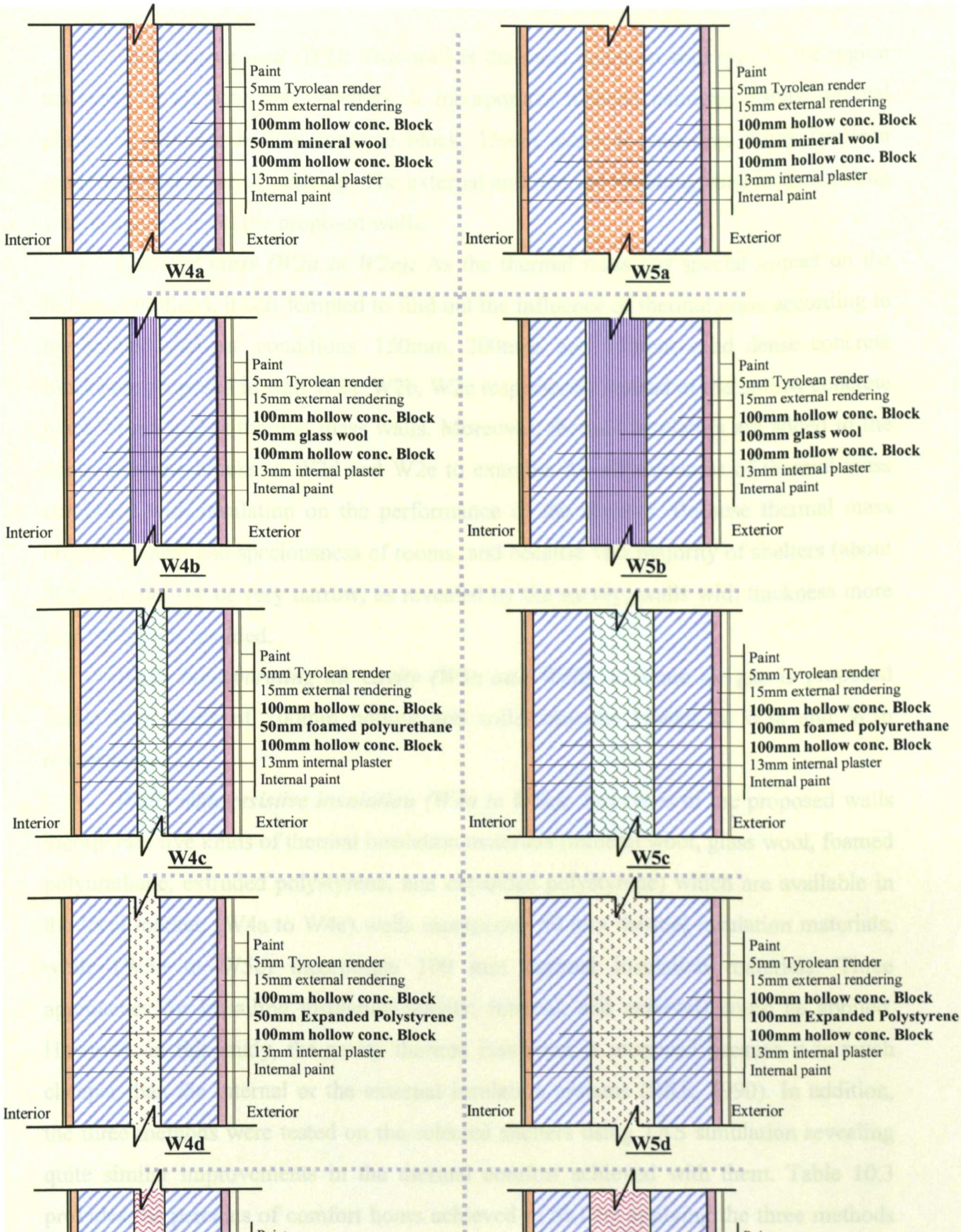


Figure 10.2: Detailed drawings for walls (W4a to W5e) which incorporate resistive insulation

The existing wall (W1): This wall is the most common wall type in the region and used in all new SHC shelters. It incorporates internal painting, 13mm internal plastering, 200mm hollow concrete block, 15mm external rendering, 5mm Tyrolean rendering, and external painting. The external and internal finishing used in the existing wall is applied in all the proposed walls.

Thermal mass (W2a to W2e): As the thermal mass has special impact on the indoor conditions, it was tempted to find out the influence of thermal mass according to the studied shelters' conditions. 150mm, 200mm, and 380mm solid dense concrete blocks are proposed in wall W2a, W2b, W2c respectively instead of the hollow concrete block to get higher thermal mass walls. Moreover, thermal insulation are added to the dense concrete blocks in W2d and W2e to examine the effectiveness of thermal mass combined with insulation on the performance of the shelters. Because thermal mass affects the area and speciousness of rooms, and because vast majority of shelters (about 80%) are narrow or very narrow, as revealed by the survey; walls with thickness more than 380mm is avoided.

Walls incorporating air cavity (W3a and W3b): a 50mm air gap is proposed inside two layers of 100mm hollow and solid concrete blocks in W3a and W3b respectively.

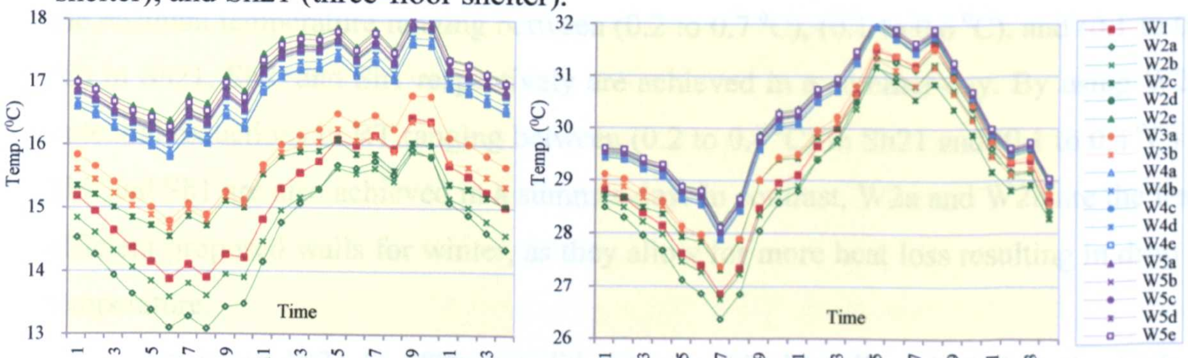
Walls with resistive insulation (W4a to W5e): Ten types of the proposed walls incorporate five kinds of thermal insulation materials (mineral wool, glass wool, foamed polyurethane, extruded polystyrene, and expanded polystyrene) which are available in the local market. (W4a to W4e) walls incorporate 50 mm thermal insulation materials, while (W5a to W5e) incorporate 100 mm thermal insulation materials. Three approaches for installing insulation (cavity, internal, and external) could be applied. However, in this study, the cavity thermal insulation is proposed because it is much cheaper than the internal or the external insulation systems (BRE, 1990). In addition, the three methods were tested on the selected shelters using TAS simulation revealing quite similar improvements in the thermal comfort achieved with them. Table 10.3 provides the percents of comfort hours achieved in Sh1 by applying the three methods of insulation. As indicated by the results, very slight differences in comfort hours are found, where the cavity and the internal wall insulations achieved slightly more comfort in winter and summer respectively, while the external wall insulation achieves slightly more comfort in the entire year.

Table 10.3: Percent of comfort hours using the three methods of insulation

Insulation System	Percent of comfort hours			
	winter	summer	Spring & Autumn	whole year
Cavity wall insulation	**79.8%**	14.4%	82.1%	64.7%
External wall insulation	79.5%	14.7%	**82.6%**	**64.9%**
Internal wall insulation	79.0%	**15.5%**	81.8%	64.6%

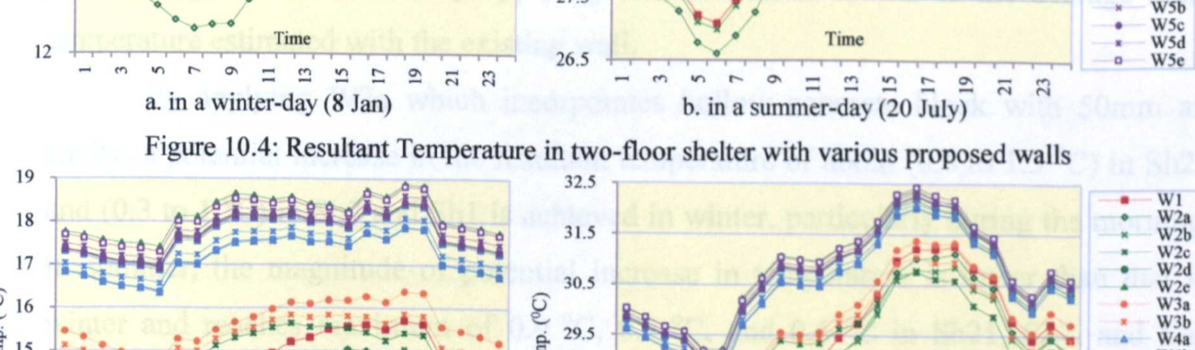
10.3.2 Temperature With Proposed Walls

The resultant temperature (RT) in both a summer and a winter days was estimated with the implementation of the various proposed walls (see figures 10.3, 10.4, and 10.5). The simulation tests were applied on Sh1 (one-floor shelter), Sh7 (two-floor shelter), and Sh21 (three-floor shelter).



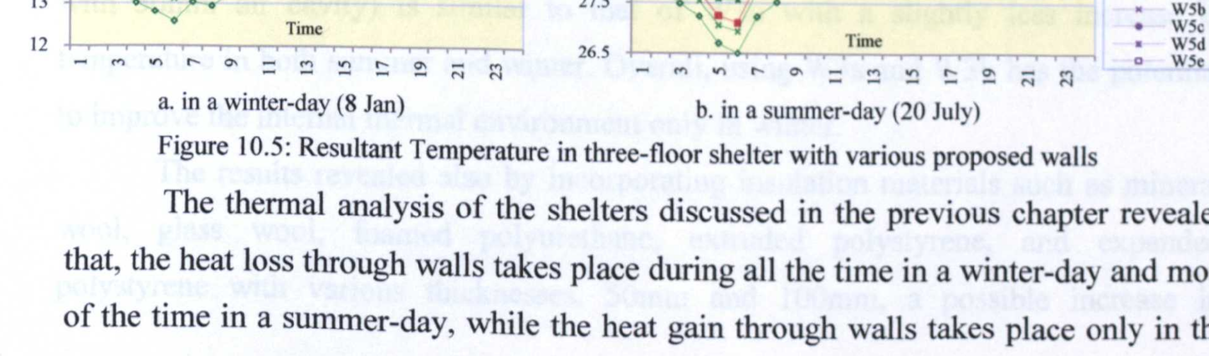
a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.3: Resultant Temperature in one-floor shelter with various proposed walls



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.4: Resultant Temperature in two-floor shelter with various proposed walls



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.5: Resultant Temperature in three-floor shelter with various proposed walls

The thermal analysis of the shelters discussed in the previous chapter revealed that, the heat loss through walls takes place during all the time in a winter-day and most of the time in a summer-day, while the heat gain through walls takes place only in the evening in summer with the total gain is significantly lower than the total loss. This means that walls with lower thermal conductance than that of the existing walls could reduce heat loss/gain resulting in achieving more thermal comfort in winter and less thermal comfort in summer.

As indicated in figures 10.1, 10.2, and 10.3, the lowest RT in a summer-day in the three shelters is estimated when applying W2a (a 150mm solid concrete block wall) which has the highest thermal conductance among all the proposed walls, followed by W2b (a 200mm solid concrete block wall). By using W2a, the potential reductions in the resultant temperature ranging between (0.2 to 0.7 °C), (0.1 to 0.6 °C), and (0.1 to 0.5 °C) in Sh21, Sh7, and Sh1 respectively are achieved in a summer-day. By using W2b, potential reductions in RT ranging between (0.2 to 0.4 °C) in Sh21 and (0.1 to 0.4 °C) in Sh7 and Sh1 are also achieved in a summer-day. In contrast, W2a and W2b are the least efficient proposed walls for winter, as they allow for more heat loss resulting in drop in temperature.

By using W2c (a 380mm solid concrete block wall), which has the highest thermal mass of the proposed walls, a more steady thermal environment is sustained as the internal temperature swings decrease with an average of 0.9 °C and 1 °C in winter and summer respectively. The resultant temperature predicted when applying W2c is almost higher in the morning and lower in the evening than the resultant temperature in the case of W1 (the existing wall), in both summer and winter. However, the average daily temperature estimated by applying W2c is overall similar to the average daily temperature estimated with the existing wall.

By applying W3a which incorporates hollow concrete block with 50mm air cavity, a potential increase in the resultant temperature of about (0.6 to 1.3 °C) in Sh21 and (0.3 to 1 °C) in Sh7 and Sh1 is achieved in winter, particularly during the morning. In summer, the magnitude of potential increase in temperature is lower than that in winter and reaches maximum of 0.9 °C, 0.7 °C, and 0.6 °C in Sh21, Sh7, and Sh1 respectively. The potential improvement obtained by using W3b (solid concrete block with 50mm air cavity) is similar to that of W3a with a slightly less increase in temperature in both summer and winter. Overall, using W3a and W3b has the potential to improve the internal thermal environment only in winter.

The results revealed also by incorporating insulation materials such as mineral wool, glass wool, foamed polyurethane, extruded polystyrene, and expanded polystyrene with various thicknesses, 50mm and 100mm, a possible increase in temperature of about (1.9 to 4.1 °C), (1.1 to 2.8 °C), and (1.1 to 2.7 °C) could be obtained in winter in Sh21, Sh7, and Sh1 respectively. In summer, the magnitude of potential increase in temperature is lower than that in winter and ranges between (0.5 to 2.4 °C), (0.2 to 1.8 °C), and (0.1 to 1.4 °C) in Sh21, Sh7, and Sh1 respectively. Overall, greater increase in temperature is attained with greater thickness and lower thermal conductance of the insulation material. Therefore the highest increase in temperature is achieved by using 100mm extruded polystyrene and the lowest is achieved by using 50mm mineral wool. Consequently, applying insulation materials for walls has the potential to improve thermal environment in winter but could make it worse in summer.

In a comparison between the potential improvements in the three shelters, it is observed that the highest possible increase or reduction in the temperature by applying the proposed walls is achieved in Sh21 (three-floor shelter), followed by Sh7 and Sh1.

10.3.3 Thermal Comfort With Proposed Walls

The percentages of comfort hours, where PMV ranges from (+1) to (-1), in each season of the year were estimated with the implementation of the various proposed walls in Sh1 (one-floor shelter), Sh7 (two-floor shelter), and Sh21 (three-floor shelter) (see figure10.6). The potential increase or reduction of the percentage of comfort hours comparing with the existing wall is also provided in table 10.4.

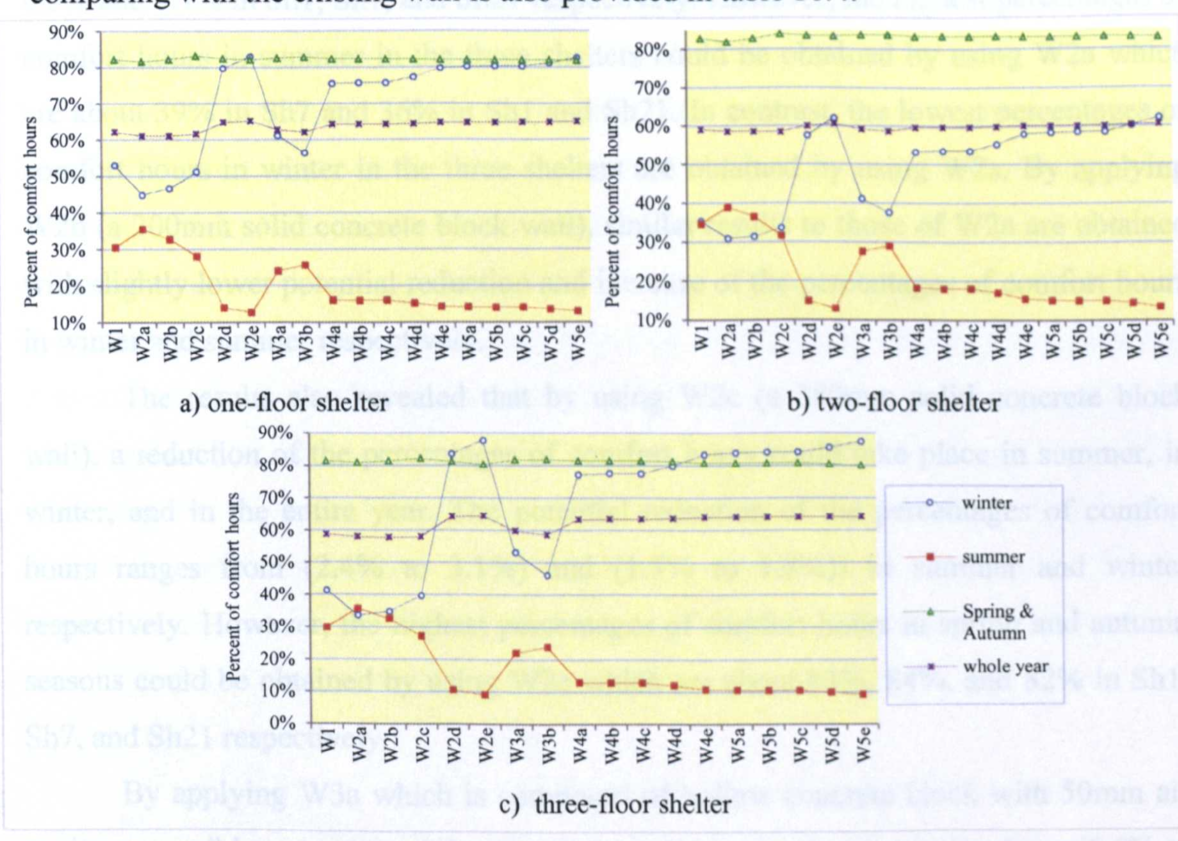


Figure 10.6: Percent of comfort hours in Sh1, Sh7, and Sh21 for various proposed Walls

Table 10.4: Potential increase or reduction of percentage of comfort hours for the proposed walls

Wall type	one-floor shelter (Sh1)				Two-floor shelter (Sh7)				Three-floor shelter (Sh21)			
	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual
W2a	-8.1%	5.0%	-0.6%	-1.0%	-4.5%	4.3%	-0.9%	-0.5%	-7.8%	5.8%	-0.5%	-0.7%
W2b	-6.4%	2.1%	0.0%	-1.0%	-4.0%	1.9%	0.0%	-0.5%	-6.6%	2.8%	-0.1%	-1.0%
W2c	-1.7%	-2.4%	1.0%	-0.5%	-1.8%	-3.1%	1.2%	-0.6%	-1.7%	-2.7%	0.7%	-0.8%
W2d	26.9%	-16.5%	0.2%	2.6%	22.2%	-19.7%	0.7%	0.9%	42.2%	-19.3%	-0.3%	5.4%
W2e	30.2%	-17.8%	-0.1%	3.0%	26.7%	-21.6%	0.6%	1.5%	46.3%	-20.7%	-1.2%	5.7%
W3a	8.3%	-6.5%	0.4%	0.6%	5.7%	-7.0%	0.9%	0.1%	11.7%	-7.8%	0.3%	1.1%
W3b	3.4%	-4.9%	0.7%	0.0%	2.2%	-5.6%	0.9%	-0.4%	4.7%	-5.9%	0.4%	-0.1%
W4a	22.7%	-14.3%	0.1%	2.1%	17.9%	-16.4%	0.5%	0.6%	35.6%	-16.9%	0.0%	4.6%
W4b	22.9%	-14.5%	0.1%	2.1%	18.1%	-16.6%	0.5%	0.6%	36.0%	-17.1%	0.0%	4.6%
W4c	22.9%	-14.4%	0.1%	2.1%	18.2%	-16.5%	0.5%	0.6%	36.0%	-17.0%	0.0%	4.6%
W4d	24.4%	-15.2%	0.0%	2.2%	19.9%	-17.6%	0.5%	0.8%	38.4%	-17.9%	-0.2%	4.9%
W4e	26.9%	-16.2%	-0.1%	2.5%	22.6%	-19.1%	0.3%	1.0%	42.0%	-19.1%	-0.6%	5.3%
W5a	27.4%	-16.3%	-0.2%	2.6%	23.0%	-19.4%	0.3%	1.0%	42.5%	-19.3%	-0.7%	5.3%
W5b	27.5%	-16.4%	-0.2%	2.6%	23.1%	-19.5%	0.3%	1.0%	42.7%	-19.4%	-0.7%	5.3%
W5c	27.5%	-16.4%	-0.2%	2.6%	23.1%	-19.5%	0.3%	1.0%	42.6%	-19.4%	-0.7%	5.3%
W5d	28.4%	-16.9%	-0.2%	2.7%	24.7%	-20.1%	0.2%	1.2%	44.0%	-19.9%	-1.0%	5.4%
W5e	29.8%	-17.5%	-0.4%	2.8%	26.7%	-21.1%	0.1%	1.4%	45.9%	-20.6%	-1.5%	5.4%

The result revealed that by applying W2a (a 150mm solid concrete block wall) a possible reduction of the percentages of comfort hours of about 8.1%, 4.5% and 7.8% could occur in winter, while a possible increase of about 5%, 4.3%, and 5.8% could be achieved in summer in Sh1, Sh7, and Sh21 respectively. For spring and autumn, very slight potential reductions of the percentages of comfort hours of about 0.6%, 0.9%, and 0.5% occur by using W2a in Sh1, Sh7, and Sh21 respectively. Overall, applying W2a could lead to a slight annual reduction of the percentages of comfort hours of about 1%, 0.5% and 0.7% in Sh1, Sh7, and Sh21 respectively. However, the highest percentages of comfort hours in summer in the three shelters could be obtained by using W2a which are about 39% in Sh7 and 36% in Sh1 and Sh21. In contrast, the lowest percentages of comfort hours in winter in the three shelters are obtained by using W2a. By applying W2b (a 200mm solid concrete block wall), similar results to those of W2a are obtained with slightly lower potential reduction and increase of the percentages of comfort hours in winter and summer respectively.

The results also revealed that by using W2c (a 380mm solid concrete block wall), a reduction of the percentages of comfort hours could take place in summer, in winter, and in the entire year. The potential reduction of the percentages of comfort hours ranges from (2.4% to 3.1%) and (1.7% to 1.8%)) in summer and winter respectively. However, the highest percentages of comfort hours in spring and autumn seasons could be obtained by using W2c which are about 83%, 84%, and 82% in Sh1, Sh7, and Sh21 respectively.

By applying W3a which is composed of hollow concrete block with 50mm air cavity, a possible reduction of the percentages of comfort hours ranging from (6.5% to 7.8%) could occur in summer, while a possible increase of about 8.3%, 5.7%, and

11.7% could be achieved in winter in Sh1, Sh7, and Sh21 respectively. For spring and autumn, very slight potential increase of the percentage of comfort hours ranging from 0.3% to 0.9% takes place by using W3a leading to overall slight annual increase in comfort hours. By applying W3b which composed of solid concrete block with 50mm air cavity, similar results to those of W3a are obtained with lower potential reduction and increase of the percentages of comfort hours in summer and winter respectively.

The results revealed also by incorporating insulation materials with various thicknesses, 50mm and 100mm, a possible increase in the percentages of comfort hours ranging about from (23% to 30%), (18% to 27%), and (36% to 46%) could be obtained in winter in Sh1, Sh7, and Sh21 respectively. In contrast, in summer, by using insulation materials a possible reduction in the percentages of comfort hours ranging about from (14% to 18%), (16% to 22%), and (17% to 21%) could take place in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying insulation materials in the proposed walls could lead to a slight annual increase of the percentages of comfort hours ranging about from (2.1% to 3%), (0.6% to 1.5%), and (4.6% to 5.7%) in Sh1, Sh7, and Sh21 respectively. Overall, greater increase in comfort hours is attained with greater thickness and lower thermal conductance of the insulation material. Therefore the highest increase in the percentage of comfort hours is achieved by using 100mm extruded polystyrene and the lowest is achieved by using 50mm mineral wool.

In a comparison between the potential improvements in the thermal comfort in the three shelters, it is observed that the highest possible increase in the percentage of comfort hours by applying the proposed walls is achieved in Sh21, followed by Sh1 and the lowest increase is achieved in Sh7. This could be due to that each shelter initially has its own characteristics which have effect on their thermal performance. This also revealed by the thermal analysis of the shelters in the previous chapter where the percentages of the heat loss through the existing walls in winter are found about 76%, 73%, and 59% of the total fabrics loss in Sh21, Sh7, and Sh1 respectively. Besides, the ratio of the walls' area to the total fabrics' area is one of the factors that could affect the magnitude of the potential improvement by using the proposed wall, where the ratio in Sh1, Sh7, and Sh21 are about 0.42, 0.65, and 0.47 respectively.

10.4 THERMAL MODELLING OF VARIOUS ROOFS

Various types of roofs were proposed and simulated in order to identify the best thermal comfort level that can be achieved through all seasons. The resultant temperature and the percentages of comfort hours were estimated with the implementation of the various proposed roofs and compared with those of the existing roof. Explanation for the tested roofs and the simulation results are provided in the following subsections.

10.4.1 Description For The Proposed Roofs

As revealed by the thermal analysis of the shelters in the previous chapter, heat gain through the roofs in a summer-day (the hottest day) is higher than the roof loss, while the heat loss through the roofs in a winter-day is higher than the roof gains, with the majority of shelters get zero roof gain in a winter-day (the coldest day). Therefore, various types of roofs, with lower thermal conductance than that of the existing roof, were proposed to minimize the heat loss in winter and to minimize the heat gain in summer. Thermal mass was not proposed for the roof because heavy roofs will increase the structure dead load and consequently its cost, the use of additional insulation was proposed instead. Table 10.5 and figures (10.7& 10.8) provide the proposed roofs explaining their layers, thicknesses, and thermal conductance.

The existing roof **(R1)** is the most common roof type in the region and used in all new SHC shelters. It is 270mm reinforced concrete slap with 13mm internal plastering and painting. The slap is composed of 240mm reinforced concrete ribs filled with heavy hollow concrete blocks, followed by 30mm plain concrete. **(R2)** is a reinforced concrete slap, similar to R1, with adding a layer of 60mm foamed concrete. **(R3)** is similar to R2 but light concrete blocks are used to fill the ribs instead of the heavy concrete blocks. **(R4a to R4e)** and **(R5a to R5e)** are roofs incorporate 50mm and 100mm thermal insulation materials respectively. These roofs are composed of 60mm foamed concrete in the external surface, followed by water proofing layer of 5mm bitumen, 30mm foamed concrete, 50mm or 100mm resistive insulation material, then 270mm light concrete slap (where light concrete blocks are used to fill the ribs), and 13mm internal plastering and painting.

Table 10.5: Description for the proposed roofs

Roof type	Layers description	Conductance W/m².°C	Roof type	Layers description	Conductance W/m².°C
R1 Existing	300mm reinforced concrete slap 13mm internal plaster Internal paint	5.041			
R2	60mm foamed concrete 5mm Bitumen 300mm reinforced concrete slap 13mm internal plaster Internal paint	1.371	R3	60mm foamed concrete 5mm Bitumen 300mm light reinforced concrete slap 13mm internal plaster Internal paint	1.174
R4a	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 50mm Mineral wool 300mm light reinforced conc. slap 13mm internal plaster Internal paint	0.431	R5a	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 100mm Mineral wool 300mm light reinforced concrete slap 13mm internal plaster Internal paint	0.282
R4b	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 50mm Glass wool 300mm light reinforced conc. slap 13mm internal plaster Internal paint	0.425	R5b	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 100mm Glass wool 300mm light reinforced concrete slap 13mm internal plaster Internal paint	0.278
R4c	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 50mm Foamed Polyurethane 300mm light reinforced conc. slap 13mm internal plaster Internal paint	0.425	R5c	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 100mm Foamed Polyurethane 300mm light reinforced concrete slap 13mm internal plaster Internal paint	0.278
R4d	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 50mm Expanded Polystyrene 300mm light reinforced conc. slap 13mm internal plaster Internal paint	0.375	R5d	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 100mm Expanded Polystyrene 300mm light reinforced concrete slap 13mm internal plaster Internal paint	0.237
R4e	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 50mm Extruded Polystyrene 300mm light reinforced conc. slap 13mm internal plaster Internal paint	0.296	R5e	60mm foamed concrete 5mm Bitumen 30mm foamed concrete 100mm Extruded Polystyrene 300mm light reinforced concrete slap 13mm internal plaster Internal paint	0.177

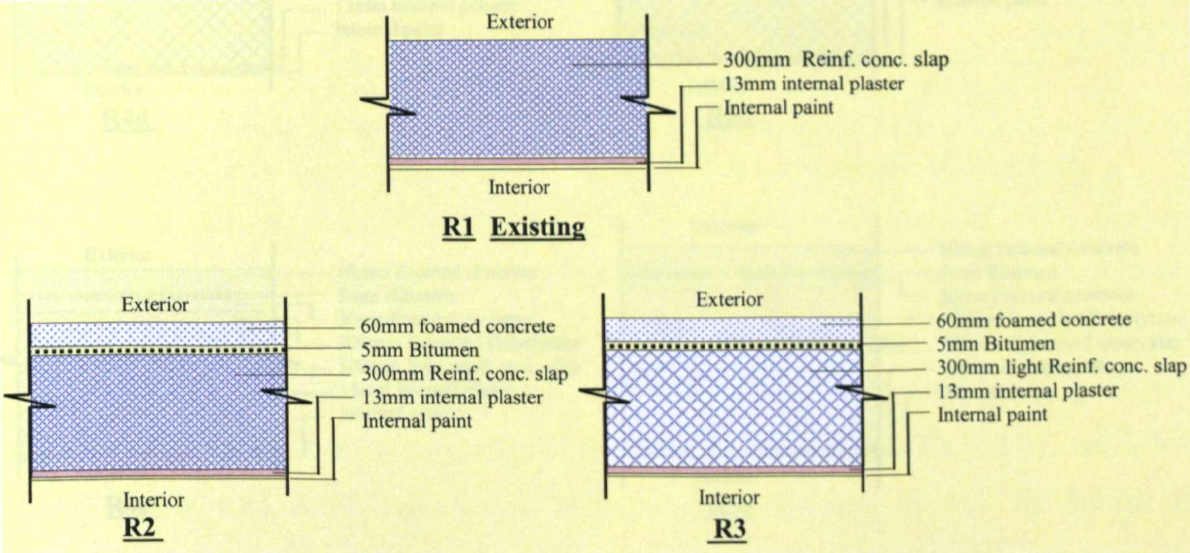


Figure 10.7: Detailed drawings for existing roof (R1) and the proposed roofs (R2 and R3)

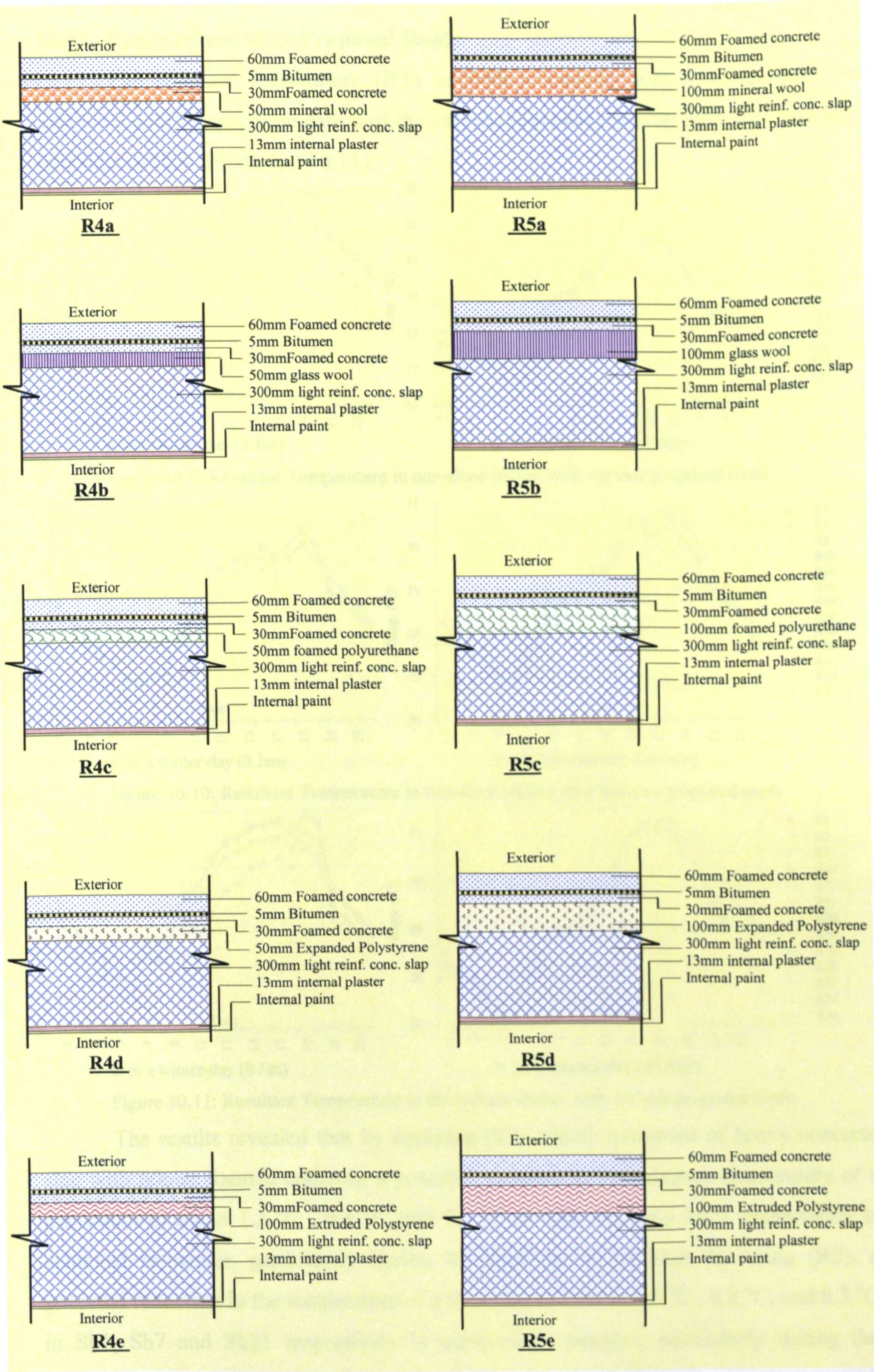
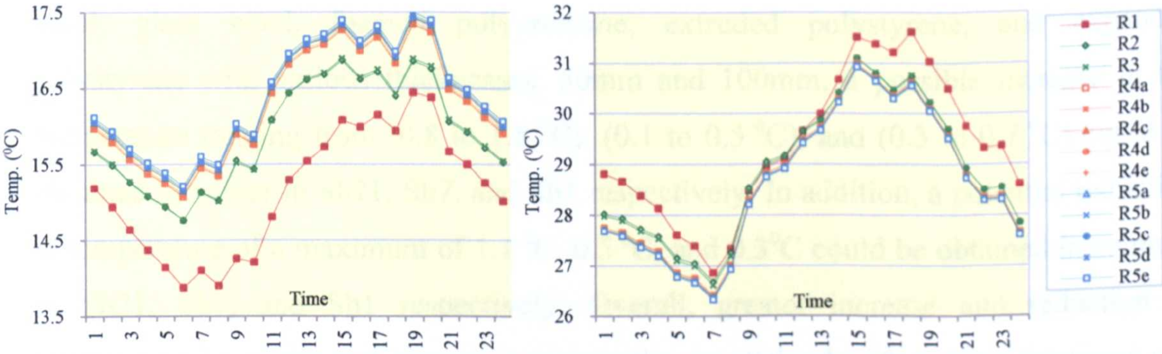


Figure 10.8: Detailed drawings for roofs (R4a to R5e) which incorporate resistive insulation

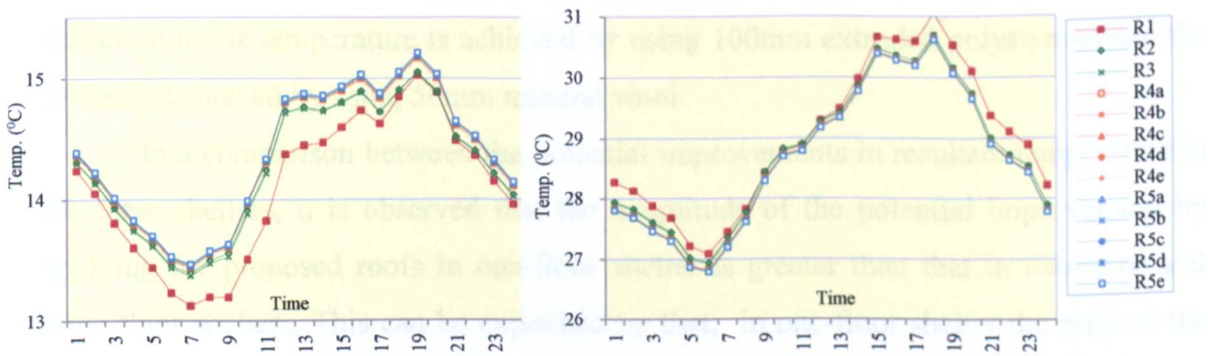
10.4.2 Temperature With Proposed Roofs

The resultant temperature (RT) in both a summer and a winter days was estimated with the implementation of the various proposed roofs on Sh1, Sh7, and Sh21 (see figures 10.9, 10.10, and 10.11).



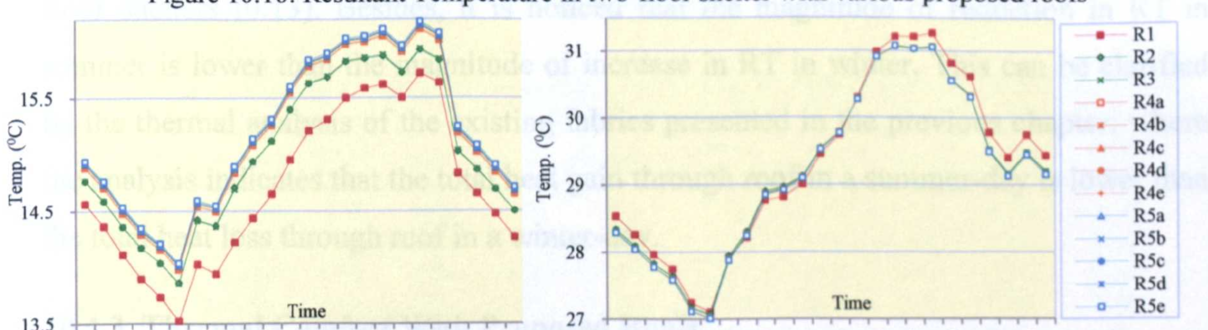
a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.9: Resultant Temperature in one-floor shelter with various proposed roofs



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.10: Resultant Temperature in two-floor shelter with various proposed roofs



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.11: Resultant Temperature in three-floor shelter with various proposed roofs

The results revealed that by applying (R2) which composed of heavy concrete slap with 60mm foamed concrete, a potential increase in the resultant temperature of a maximum of about 1.3 ºC , 0.4 ºC, and 0.5 ºC in Sh1, Sh7 and Sh21 respectively is achieved in winter, particularly during the daytime. In addition, by using (R2), a potential reduction in the temperature of a maximum of about 0.9 ºC , 0.4 ºC, and 0.3 ºC in Sh1, Sh7 and Sh21 respectively is achieved in summer, particularly during the evening and the night. By applying (R3) which composed of light concrete slap with

60mm foamed concrete, similar results to those of (R2) are obtained with very slightly higher potential reduction and increase of the resultant temperature in summer and winter respectively.

The results revealed also by incorporating insulation materials such as mineral wool, glass wool, foamed polyurethane, extruded polystyrene, and expanded polystyrene with various thicknesses, 50mm and 100mm, a possible increase in the temperature ranging from (0.8 to 1.8 °C), (0.1 to 0.5 °C), and (0.3 to 0.7 °C) could be obtained in winter in Sh21, Sh7, and Sh1 respectively. In addition, a potential reduction in temperature of a maximum of 1.1 °C, 0.5 °C, and 0.3°C could be obtained in summer in Sh21, Sh7, and Sh1 respectively. Overall, greater increase and reduction in temperature in winter and summer respectively are attained with greater thickness and lower thermal conductance of the insulation material. Therefore the highest increase and reduction in the temperature is achieved by using 100mm extruded polystyrene and the lowest is achieved by using 50mm mineral wool

In a comparison between the potential improvements in resultant temperature in the three shelters, it is observed that the magnitude of the potential improvement by applying the proposed roofs in one-floor shelter is greater than that in two-floor and three-floor shelters. This can be explained by that; in one-floor shelter the ratio of the roof's area to the total fabrics' area (0.28) is higher than that of two-floor and three-floor shelters (0.13). Besides, it is noticed that the magnitude of reduction in RT in summer is lower than the magnitude of increase in RT in winter. This can be clarified by the thermal analysis of the existing fabrics presented in the previous chapter; where the analysis indicates that the total heat gain through roof in a summer-day is lower than the total heat loss through roof in a winter-day.

10.4.3 Thermal Comfort With Proposed Roofs

The percentages of comfort hours, where the PMV ranges from (+1) to (-1), in each season of the year were estimated with the implementation of the various proposed roofs in Sh1, Sh7, and Sh21 (see figure 10.12). The potential increase or reduction of the percentage of comfort hours comparing with the existing roof is also provided in table 10.6.

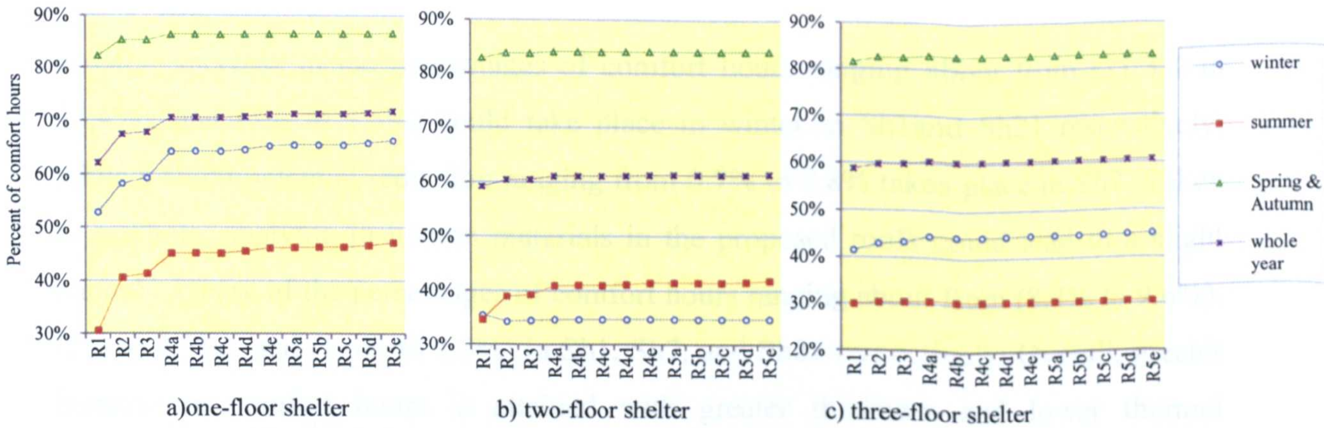


Figure 10.12: Percent of comfort hours for various proposed roofs

The result revealed that by applying (R2) which composed of a heavy concrete slap with 60mm foamed concrete, a possible increase of the percentages of comfort hours of about 10.1%, 4.3% and 0.4% takes place in summer in Sh1, Sh7, and Sh21 respectively. Further, a possible increase of the percentages of comfort hours of about 5.4% and 1.4% takes place in winter in Sh1, and Sh21 respectively, while about 1.1% reduction could occur in Sh7. For spring and autumn, a slight potential increase of the percentages of comfort hours of about 3%, 0.9%, and 1.1% occurs by using (R2) in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying (R2) could lead to a slight annual increase of the percentages of comfort hours of about 5.4%, 1.3% and 1.0% in Sh1, Sh7, and Sh21 respectively. By applying (R3) which composed of a light concrete slap with 60mm foamed concrete, similar results to those of (R2) are obtained with higher potential increase of the annual percentages of comfort hours.

Table 10.6: Potential increase or reduction of percentage of comfort hours for the proposed roofs

Roof type	one-floor shelter (Sh1)				Two-floor shelter (Sh7)				Three-floor shelter (Sh21)			
	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual
R2	5.4%	10.1%	3.0%	5.4%	-1.1%	4.3%	0.9%	1.3%	1.4%	0.4%	1.1%	1.0%
R3	6.5%	10.8%	2.9%	5.8%	-0.9%	4.6%	0.9%	1.4%	1.8%	0.5%	1.0%	1.1%
R4a	11.3%	14.6%	4.0%	8.4%	-0.8%	6.3%	1.2%	2.0%	3.0%	0.7%	1.5%	1.6%
R4b	11.4%	14.7%	4.0%	8.5%	-0.8%	6.4%	1.2%	2.0%	3.0%	0.7%	1.5%	1.6%
R4c	11.4%	14.7%	4.0%	8.5%	-0.8%	6.3%	1.2%	2.0%	3.0%	0.7%	1.5%	1.6%
R4d	11.7%	15.1%	4.0%	8.7%	-0.7%	6.5%	1.2%	2.1%	3.1%	0.7%	1.5%	1.7%
R4e	12.4%	15.7%	4.2%	9.1%	-0.7%	6.8%	1.3%	2.2%	3.2%	0.7%	1.5%	1.7%
R5a	12.6%	15.8%	4.2%	9.1%	-0.7%	6.9%	1.3%	2.2%	3.2%	0.7%	1.6%	1.8%
R5b	12.6%	15.8%	4.2%	9.2%	-0.7%	6.9%	1.3%	2.2%	3.3%	0.7%	1.6%	1.8%
R5c	12.6%	15.8%	4.2%	9.2%	-0.7%	6.9%	1.3%	2.2%	3.3%	0.7%	1.6%	1.8%
R5d	13.0%	16.1%	4.3%	9.4%	-0.7%	7.0%	1.3%	2.2%	3.4%	0.7%	1.6%	1.8%
R5e	13.4%	16.6%	4.3%	9.6%	-0.7%	7.2%	1.3%	2.3%	3.5%	0.7%	1.6%	1.9%

The results revealed also by incorporating insulation materials with various thicknesses, 50mm and 100mm, (R4a to R5e) a possible increase in the percentages of comfort hours of about (14.6% to 16.6%), (6.3% to 4.2%), and 0.7% could be obtained in summer in Sh1, Sh7, and Sh21 respectively. Besides, by using insulation materials a possible increase in the percentages of comfort hours ranging about from (11.3% to 13.4%), and (3% to 3.5%) could take place in winter in Sh1and Sh21 respectively, while a slight potential reduction ranging from 0.7% to 0.8% takes place in Sh7. Taken as a whole, applying insulation materials in the proposed roofs could lead to a slight annual increase of the percentages of comfort hours ranging about from (8.4% to 9.6%), (2% to 2.3%), and (1.6% to 1.9%) in Sh1, Sh7, and Sh21 respectively. Overall, greater increase in comfort hours is attained with greater thickness and lower thermal conductance of the insulation material. Therefore the highest increase in the percentage of comfort hours is achieved by using 100mm extruded polystyrene and the lowest is achieved by using 50mm mineral wool.

In a comparison between the potential improvements in the thermal comfort in the three shelters, it is observed that the magnitude of the potential improvement by applying the proposed roofs in Sh1 is significantly greater than that in Sh7 and Sh21. This can be somewhat explained by that the ratio of the roof's area to the total fabrics' area in Sh1 (about 0.28) is higher than that in Sh7 and Sh21 (about 0.13 in both shelters).

10.5 THERMAL MODELLING OF VARIOUS FLOORS

Three types of ground floors were proposed and simulated in order to identify the best thermal comfort level that can be achieved through all seasons. The resultant temperature and the percentages of comfort hours were estimated with the implementation of the various proposed ground floors and compared with those of the existing floor. Explanation for the proposed ground floors and the simulation results are provided below.

10.5.1 Description For The Proposed Ground Floors

As revealed by the thermal analysis of the shelters in the previous chapter, heat gain through the ground floors in a summer-day is significantly lower than heat loss. Besides, heat gain through the ground floors in a winter-day is significantly higher than heat loss, with the majority of shelters has zero heat loss through the ground floors in a winter-day. Therefore, various types of ground floors with lower thickness and higher thermal conductance than that of the existing ground floor were proposed to maximise the heat loss in summer and the heat gain winter. Figure 10.13 and table 10.7 provide the proposed ground floors explaining their layers, thicknesses, and thermal conductance.

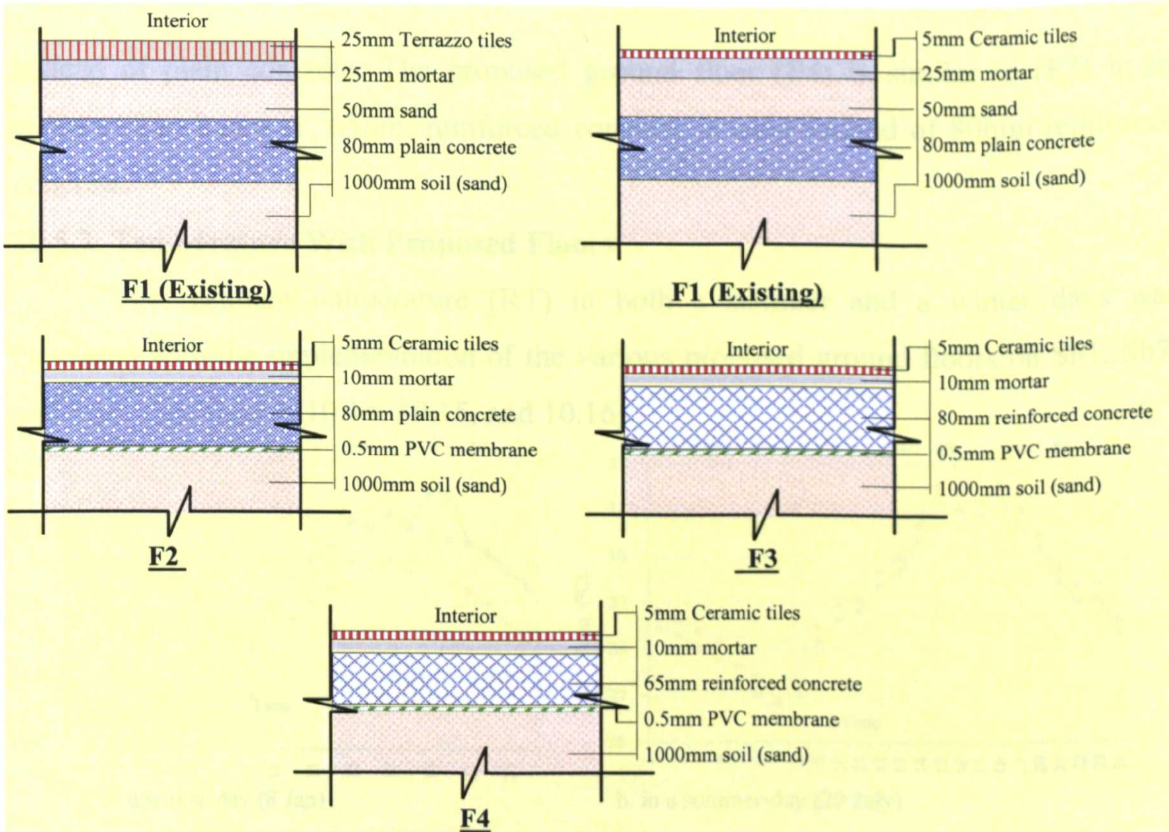


Figure 10.13: Detailed drawings for existing and proposed ground floors

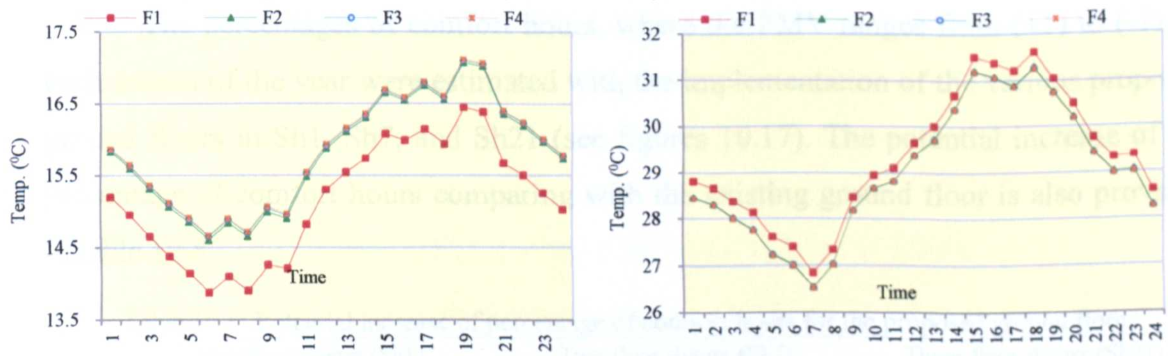
Table 10.7: Description for existing and proposed ground floors

Floor type	Layers description	Conductance (W/m^2.°C)	Floor type	Layers description	Conductance (W/m^2.°C)
F1 Existing	25mm Terrazzo tiles 25mm mortar 50mm sand 80mm plain concrete 1000mm soil (sand)	1.169	F1 Existing	5mm Ceramic tiles 25mm mortar 50mm sand 80mm plain concrete 1000mm soil (sand)	1.198
F2	5mm Ceramic tiles 10mm mortar 80mm plain concrete 0.5mm PVC membrane 1000mm soil (sand)	2.293	F3	5mm Ceramic tiles 10mm mortar 80mm Reinforced concrete 0.5mm PVC membrane 1000mm soil (sand)	2.354
F4	5mm Ceramic tiles 10mm mortar 65mm Reinforced concrete 0.5mm PVC membrane 1000mm soil (sand)	2.388			

The existing ground floor **(F1)** is the most common floor type in the region and is used in all new SHC shelters. It is composed of terrazzo tiles (or ceramic tiles in case of kitchen and bathroom) fixed on 25mm cement mortar laid on 50mm dry sand which is bedded on 80mm plain concrete. The proposed ground floor **(F2)** is composed of ceramic tiles fixed on 10mm cement mortar which is bedded on 80mm plain concrete; and 0.5mm PVC membrane is laid underneath the concrete. The proposed ground floor **(F3)** is similar to **(F2)** in its composition and thickness, but reinforced concrete is used instead of plain concrete. The proposed ground floor (**F4**) is similar to (**F3**) in its composition; however, 65mm reinforced concrete is used instead of 80mm reinforced concrete.

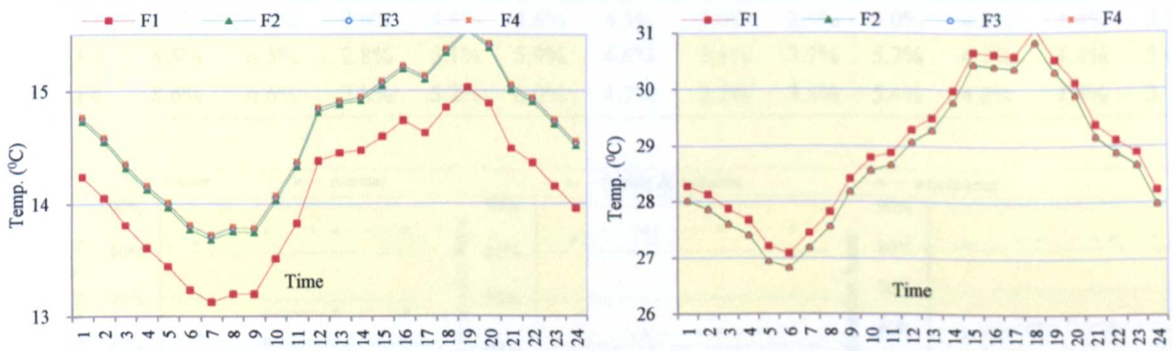
10.5.2 Temperature With Proposed Floors

The resultant temperature (RT) in both a summer and a winter days was estimated with the implementation of the various proposed ground floors on Sh1, Sh7, and Sh21 (see figures 10.14, 10.15, and 10.16).



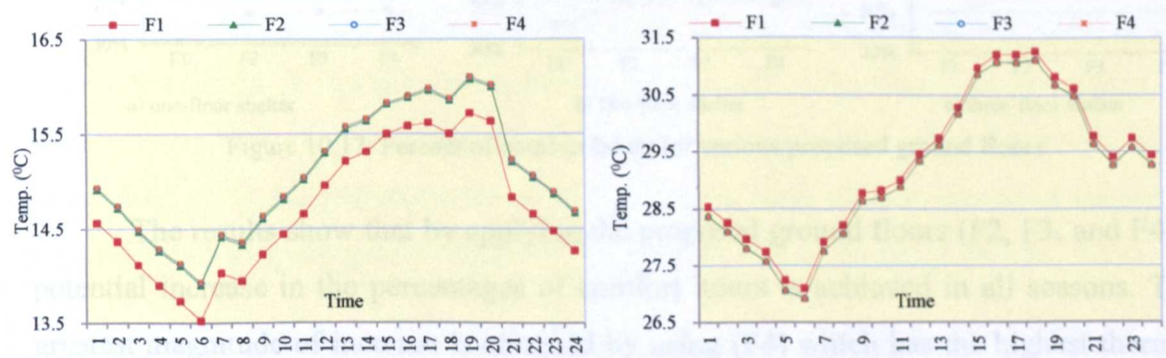
a. in a winter-day (8 Jan)   b. in a summer-day (20 July)

Figure 10.14: Resultant Temperature in one-floor shelter with various proposed ground floors



a. in a winter-day (8 Jan)   b. in a summer-day (20 July)

Figure 10.15: Resultant Temperature in two-floor shelter with various proposed ground floors



a. in a winter-day (8 Jan)   b. in a summer-day (20 July)

Figure 10.16: Resultant Temperature in three-floor shelter with various proposed ground floors

The results revealed that by applying (F2, F3, and F4), similar potential improvements are achieved, with the greatest improvements is achieved by using F4, followed by F3, and the lowest is achieved by using F2. A potential increase in the resultant temperature of a maximum of about 0.8 °C, 0.6 °C, and 0.4 °C in Sh1, Sh7 and Sh21 respectively is achieved in winter. Besides, a potential reduction in the temperature of a maximum of about 0.4 °C, 0.3 °C, and 0.2 °C in Sh1, Sh7 and Sh21 respectively is achieved in summer. It is also observed that the highest possible improvement in the resultant temperature in both summer and winter is achieved in Sh1, followed by Sh7, and the lowest is achieved in Sh21.

10.5.3 Thermal Comfort With Proposed Floors

The percentages of comfort hours, where the PMV ranges from (+1) to (-1), in each season of the year were estimated with the implementation of the various proposed ground floors in Sh1, Sh7, and Sh21 (see figures 10.17). The potential increase of the percentage of comfort hours comparing with the existing ground floor is also provided in table 10.8.

Table 10.8: Potential increase of percentage of comfort hours for the proposed ground floors

Floor type	one-floor shelter (Sh1)				Two-floor shelter (Sh7)				Three-floor shelter (Sh21)			
	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual
F2	8.1%	6.0%	2.6%	4.8%	5.6%	4.5%	2.0%	3.5%	5.0%	4.0%	1.4%	2.9%
F3	8.5%	6.3%	2.8%	5.1%	5.9%	4.6%	2.1%	3.7%	5.2%	4.1%	1.4%	3.0%
F4	8.6%	6.6%	2.8%	5.2%	6.0%	4.7%	2.2%	3.8%	5.4%	4.2%	1.5%	3.1%

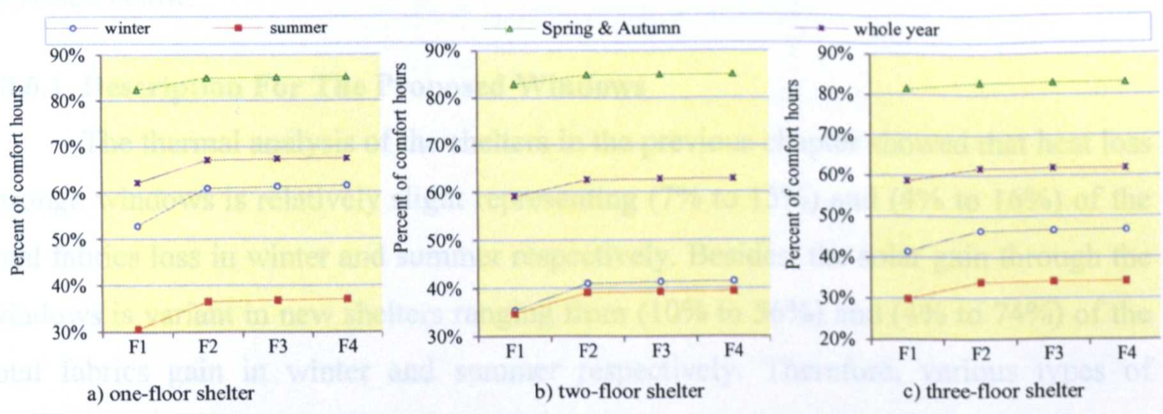


Figure 10.17: Percent of comfort hours for various proposed ground floors

The results show that by applying the proposed ground floors (F2, F3, and F4) a potential increase in the percentages of comfort hours is achieved in all seasons. The greatest magnitude of increase is obtained by using (F4) which has the highest thermal conductance, while the smallest magnitude of increase is obtained by using (F2) which has the lowest thermal conductance.

In summer, possible increases in the percentages of comfort hours of about 6.7%, 4.7%, and 4.2% are obtained in Sh1, Sh7, and Sh21 respectively by using the proposed ground floor (F4). Besides, potential increases in the percentages of comfort hours of about 8.6%, 6%, and 5.4% take place in winter in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying the proposed ground floors (F2, F3, and F4) could lead to annual increases of the percentage of comfort hours ranging about from (4.8% - 5.2%), (3.5% - 3.8%), and (2.9% - 3.1%) in Sh1, Sh7, and Sh21 respectively.

In a comparison between the potential improvements in the thermal comfort in the three shelters, it is observed that the highest magnitude of the potential improvement by applying the proposed ground floors is obtained in Sh1, followed by Sh7, and the lowest is obtained in Sh21. This could be explained by that the ratio of the floor's area to the total fabrics' area in Sh1 (about 0.28) is higher than that in Sh7 (about 0.16) and Sh21 (about 0.15).

10.6 THERMAL MODELLING OF VARIOUS WINDOWS

Five types of windows were proposed and simulated in order to identify the best thermal comfort level that can be achieved through all seasons. The resultant temperature and the percentages of comfort hours were estimated with the implementation of the various proposed windows and compared with those of the existing windows. Explanation for the proposed windows and the simulation results are provided below.

10.6.1 Description For The Proposed Windows

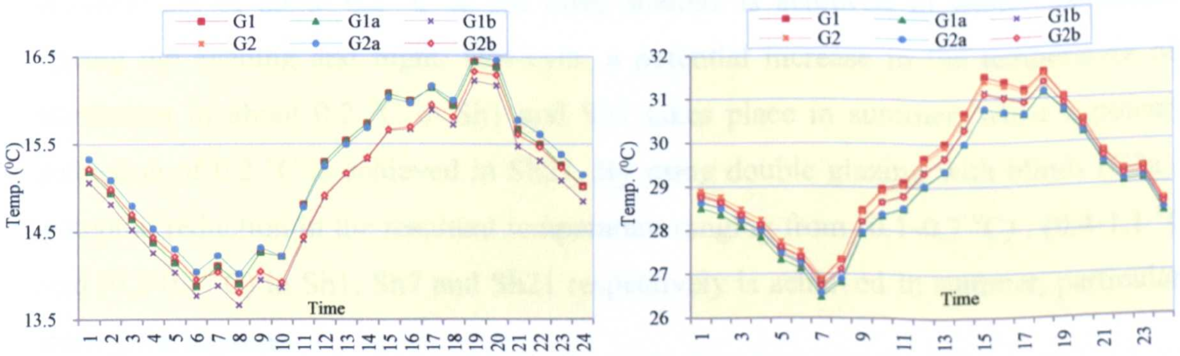
The thermal analysis of the shelters in the previous chapter showed that heat loss through windows is relatively slight representing (7% to 15%) and (4% to 16%) of the total fabrics loss in winter and summer respectively. Besides, the solar gain through the windows is variant in new shelters ranging from (10% to 56%) and (4% to 74%) of the total fabrics gain in winter and summer respectively. Therefore, various types of windows were proposed where some of them were proposed to minimize heat loss in winter such as double glazed windows, while some of them were proposed to minimize solar gain such as glazing with blinds or glazing with reflective layer (see table 10.9).

Table 10.9: Description for the proposed windows

Window	Description
G1-Existing	6mm single glazing
G1a	6mm single glazing with blinds
G1b	6mm single glazing with reflective layer
G2	Double glazing (12mm air)
G2a	Double glazing with blinds
G2b	Double glazing with reflective layer

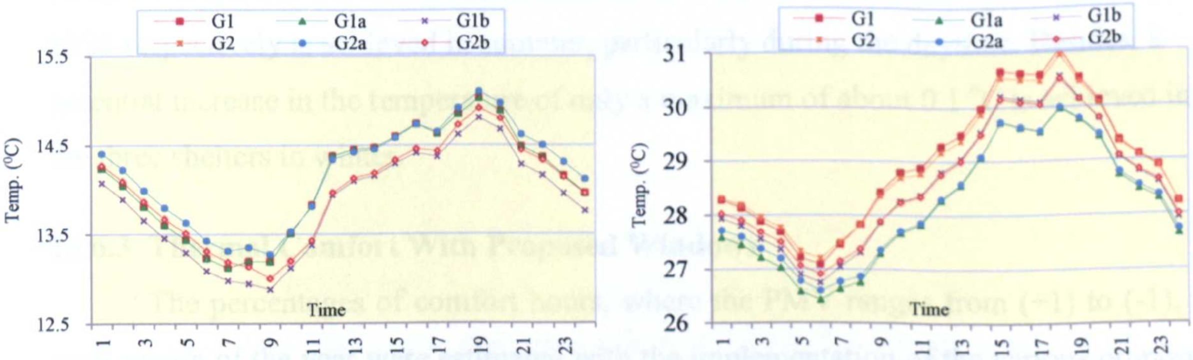
10.6.2 Temperature With Proposed Windows

The resultant temperature (RT) in both a summer and a winter days was estimated with the implementation of the various proposed windows on Sh1, Sh7, and Sh21 (see figures 10.18, 10.19, and 10.20).



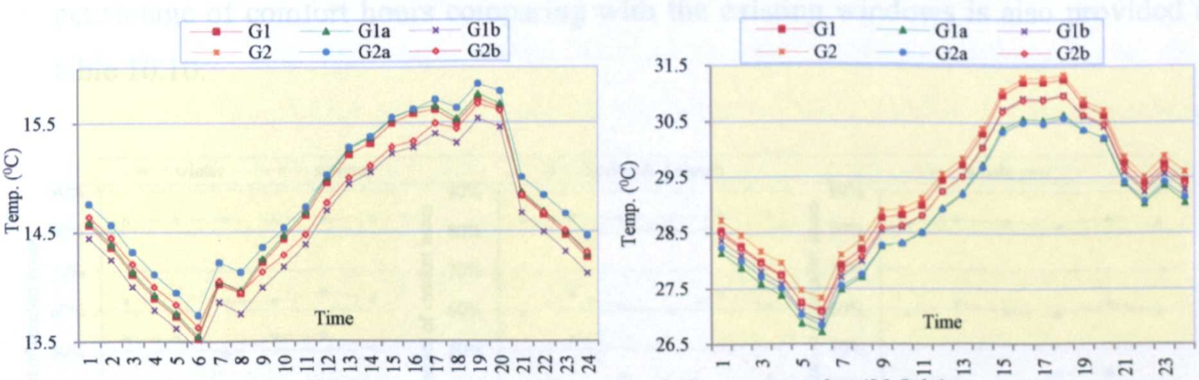
a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.18: Resultant Temperature in one-floor shelter with various proposed windows



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.19: Resultant Temperature in two-floor shelter with various proposed windows



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.20: Resultant Temperature in three-floor shelter with various proposed windows

The results revealed that by implementing single glazing with blinds (G1a), a potential reduction in the resultant temperature ranging from (0.2-0.7 °C) , (0.6-1.1 °C), and (0.4-0.7 °C) in Sh1, Sh7 and Sh21 respectively is achieved in summer, particularly during the daytime. By applying single glazing with reflective layer (G1b), a potential reduction in the resultant temperature of a maximum of about 0.4 °C , 0.5 °C, and 0.3 °C in Sh1, Sh7 and Sh21 respectively is also achieved in summer. However, a potential reduction in the temperature of a maximum of about 0.4 °C in Sh1 and Sh7, and 0.3 °C in Sh21 takes place in winter, as the reflective layer reduces the solar gain

By using double glazing (G2), a potential increase in the resultant temperature of a maximum of about 0.2 °C in the three shelters is achieved in winter, particularly during the evening and night. However, a potential increase in the temperature of a maximum of about 0.2 °C in Sh1 and Sh7 takes place in summer, while a potential reduction of 0.2 °C is achieved in Sh21. By using double glazing with blinds (G2a), a potential reduction in the resultant temperature ranging from (0.1-0.7 °C) , (0.4-1.1 °C), and (0.2-0.7 °C) in Sh1, Sh7 and Sh21 respectively is achieved in summer, particularly during the daytime.

By using double glazing with reflective layer (G2b), a potential reduction in the resultant temperature of a maximum of about 0.4 °C , 0.6 °C, and 0.3 °C in Sh1, Sh7 and Sh21 respectively is achieved in summer, particularly during the daytime. Besides, a potential increase in the temperature of only a maximum of about 0.1 °C is achieved in the three shelters in winter.

10.6.3 Thermal Comfort With Proposed Windows

The percentages of comfort hours, where the PMV ranges from (+1) to (-1), in each season of the year were estimated with the implementation of the various proposed windows in Sh1, Sh7, and Sh21 (see figures 10.21). The potential increase of the percentage of comfort hours comparing with the existing windows is also provided in table 10.10.

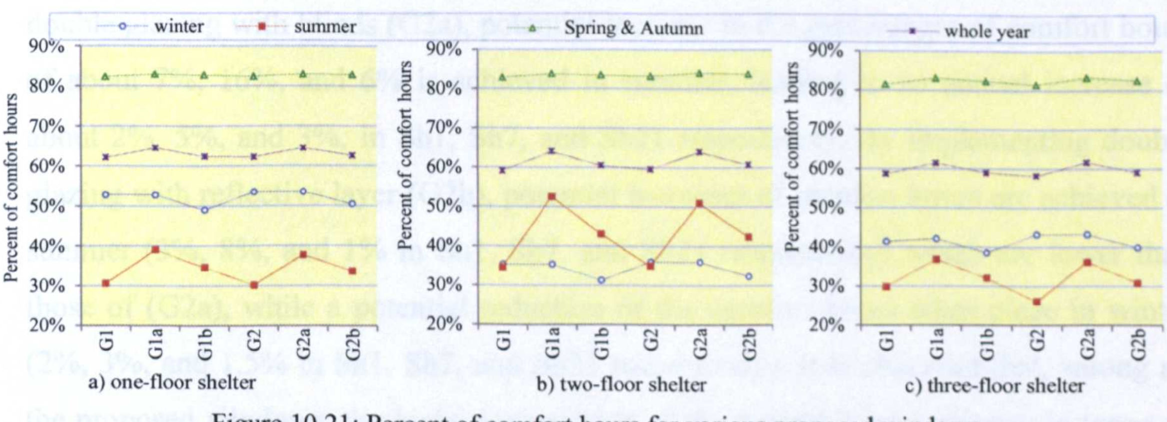


Figure 10.21: Percent of comfort hours for various proposed windows

Table 10.10 : Potential increase or reduction of percentage of comfort hours for the proposed windows

windows type	one-floor shelter (Sh1)				Two-floor shelter (Sh7)				Three-floor shelter (Sh21)			
	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual	winter	summer	spring & autumn	annual
G1a	0.0%	8.5%	0.6%	2.4%	0.0%	17.9%	0.9%	4.9%	0.0%	7.0%	1.9%	2.7%
G1b	-3.8%	4.1%	0.4%	0.3%	-4.1%	8.4%	0.6%	1.4%	-2.8%	2.2%	0.9%	0.3%
G2	0.7%	-0.4%	0.1%	0.1%	0.7%	0.4%	0.4%	0.4%	1.8%	-3.8%	0.0%	-0.5%
G2a	0.7%	7.2%	0.7%	2.3%	0.7%	16.4%	1.2%	4.9%	1.8%	6.3%	1.8%	2.9%
G2b	-2.4%	3.1%	0.5%	0.4%	-3.0%	7.8%	0.9%	1.6%	-1.5%	1.0%	1.0%	0.4%

The results show that by implementing single glazing with blinds (G1a), potential increases in the percentages of comfort hours of about 9%, 18%, and 7% are achieved in summer, and about 0.6%, 0.9%, and 2% are achieved in spring and autumn seasons, in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying (G1a) could lead to annual increases of the percentage of comfort hours of about 2.4%, 5%, and 2.7% in Sh1, Sh7, and Sh21 respectively. It is observed that, among all the proposed windows, the highest magnitude of the potential improvement in terms of thermal comfort, in summer and in the entire year, is attained by using (G1a). By implementing single glazing with reflective layer (G1b), potential increases in the percentages of comfort hours of about 4%, 8.4%, and 2.2% are achieved in summer, while a reduction of about 3.8%, 4.1%, and 2.8% could take place in winter, in Sh1, Sh7, and Sh21 respectively. Hence, slight annual increases in the percentages of comfort hours of about 0.27%, 1.4%, and 0.3% could be achieved in Sh1, Sh7, and Sh21 respectively.

The results also show that by implementing double glazed windows (G2), a potential increase in comfort hours is achieved in winter (1.8% in Sh21 and 0.7% in Sh1 and Sh7), while a reduction of the comfort hours could happen in summer (3.8% and 0.4% in Sh21 and Sh1 respectively), leading to slight annual improvement in Sh1 (0.1%) and Sh7 (0.4%) and slight annual reduction in Sh21 (0.5%). By implementing double glazing with blinds (G2a), potential increase in the percentages of comfort hours of about 7%, 16%, and 6% is achieved in summer, leading to an annual increase of about 2%, 5%, and 3%, in Sh1, Sh7, and Sh21 respectively. By implementing double glazing with reflective layer (G2b), potential increases of comfort hours are achieved in summer (3%, 8%, and 1% in Sh1, Sh7, and Sh21 respectively) which are lower than those of (G2a), while a potential reduction of the comfort hours takes place in winter (2%, 3%, and 1.5% in Sh1, Sh7, and Sh21 respectively). It is observed that, among all the proposed windows, the highest magnitude of the potential improvement in terms of thermal comfort in winter, spring, and autumn is attained by using (G2a).

In a comparison between the potential improvements in the thermal comfort in the three shelters, it is observed that the highest magnitude of the potential improvement by applying the proposed windows is obtained in Sh7, though the ratio of windows` area to the total fabrics` area in this shelter is equal to that of Sh1 (about 0.03) and slightly lower than that of Sh21 (about 0.04). This could be explained by that the windows in Sh7 are more exposed to solar radiation than in Sh1. Besides, the windows in the ground floor of Sh21 are initially with blinds.

10.7 THERMAL MODELLING OF FABRICS COMBINATIONS

Combinations of the various proposed walls, roofs, floors, and windows were selected and simulated to ascertain the overall thermal performance of the shelters and to identify the total improvement which could be achieved. The resultant temperature and the percentage of comfort hours were estimated with the implementation of the various combinations of fabrics and compared with those of the existing fabrics. The potential energy savings attained by applying these combinations of shelters` envelope were also calculated followed by cost analysis. Explanation for the selected combinations and the simulation results are provided below.

10.7.1 Description For The Proposed Combinations of Fabrics

One of the proposed floors, one of the proposed windows, five of the proposed roofs, and six of the proposed walls were selected to form ten combinations of fabrics. The selection was based on; (1) The annual potential improvement in thermal comfort, (2) The potential improvement in thermal comfort in summer, (3) The potential improvement in thermal comfort in winter, (4) and the cost of the materials.

The potential improvement in the thermal comfort attained by using floor (F4) is the highest in all seasons among all the potential improvements obtained by using the other proposed floors (F2, F3, and F4). Besides, the cost of (F4) is lower than that of F3 and slightly higher than that of F2. Therefore, (F4) is selected to be used in the ten combinations of fabrics.

For windows, single glazing with blinds (G1a) is selected to be used in the ten combinations of fabrics for different reasons. First, the highest increase in the percentage of comfort hours in summer and in the entire year in all shelters is achieved by implementing single glazing with blinds (G1a). Second, single glazing is less costly than double glazing. Third, by implementing double glazing, slightly more comfort is attained in winter than that attained by using single glazing but a reduction could take place in summer leading to lower annual improvement. Fourth, blinds can be manually controlled by the occupants, while using glazing with reflective layer would reduce the solar gain in both summer and winter resulting in lower thermal comfort in winter.

Form the proposed roofs, five of them are selected (R3, R4d, R4e, R5d, and R5e) and from the proposed walls six of them are selected (W2a, W3a, W4d, W4e, W5d, and W5e) to form the combinations explained in table (10.11).

Table 10.11: Description for the proposed combinations of fabrics

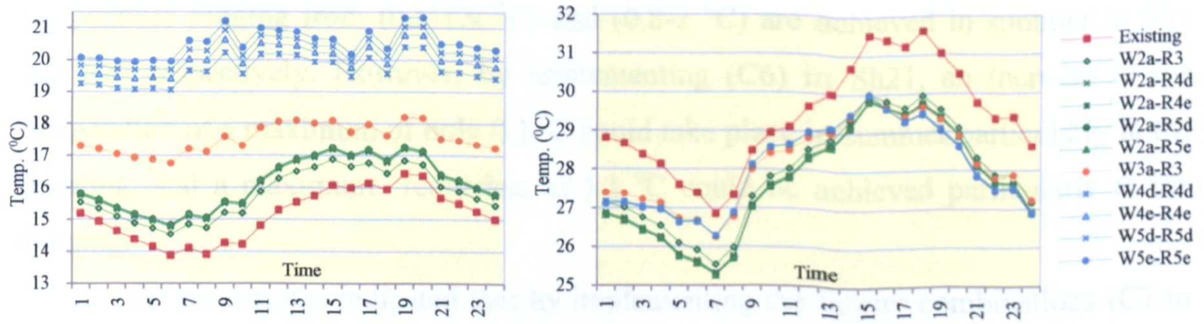
Combination	Elements	Notes
C1	W2a-R3	*Combinations incorporate the most efficient wall, in terms of thermal comfort for summer*
C2	W2a-R4d	
C3	W2a-R4e	
C4	W2a-R5d	
C5	W2a-R5e	
C6	W3a-R3	*A combination with relatively low capital cost & moderate thermal improvement*
C7	W4d-R4d	*The most efficient combinations for the entire year and for winter in particular in terms of thermal comfort*
C8	W4e-R4e	
C9	W5d-R5d	
C10	W5e-R5e	

The wall which composed of 150mm solid concrete block (W2a) is selected as it generates the highest potential improvement for thermal comfort in summer among the other proposed walls. The roof which incorporate foamed concrete (R3) and the wall with air cavity (W3a) are selected to form a combination with relatively low cost as well as moderate annual potential improvement in terms of thermal comfort and energy savings. Besides, the proposed roofs (R4d, R4e, R5d, and R5e) and the walls (W4d, W4e, W5d, and W5e) which incorporate extruded polystyrene and expanded polystyrene with various thickness, 50mm and 100mm, are selected to form combinations with high potential improvements for the entire year as overall and for winter in particular. The proposed roofs and walls which incorporate the other insulation materials (mineral wool, glass wool, and foamed polyurethane) are excluded because the cost of these materials in the local market is higher than that of the polystyrene and their thermal conductivity is lower.

It is worth to mention that the selection of polystyrene in this study depends purely on its thermal conductivity and its cost. However, if other properties such as reaction to fire or sound absorption are needed to be more considered, the other proposed thermal insulation materials could be used in the proposed combinations of fabrics. For instance, if the focus on fire protection properties, mineral wool and glass wool could be selected as they are non-combustible and the other materials (extruded and expanded polystyrene and foamed polyurethane) should be excluded as they are combustible.

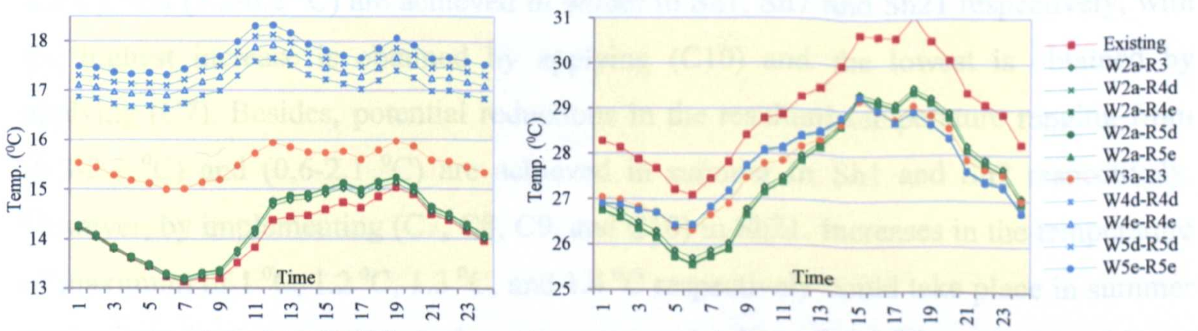
10.7.2 Temperature With Proposed Combinations of Fabrics

The resultant temperature (RT) in both a summer and a winter days was estimated with the implementation of the ten proposed combinations on Sh1, Sh7, and Sh21 (see figures 10.22, 10.23, and 10.24).



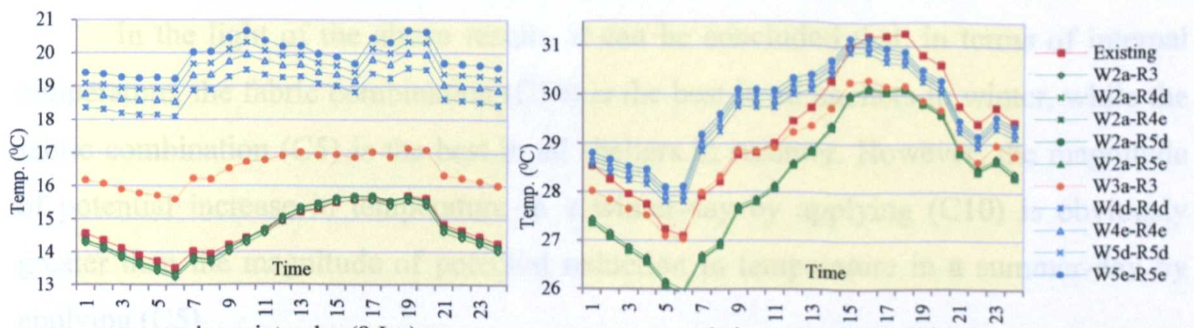
a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.22: Resultant Temperature in one-floor shelter with various combinations of fabrics



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.23: Resultant Temperature in two-floor shelter with various combinations of fabrics



a. in a winter-day (8 Jan) b. in a summer-day (20 July)

Figure 10.24: Resultant Temperature in three-floor shelter with various combinations of fabrics

The results revealed that by implementing the fabrics combinations (C1 to C5) potential reductions in the resultant temperature ranging from (1.1-2 ^{o}C) , (1.2-1.9^{o}C), and (0.9-1.3 ^{o}C) in Sh1, Sh7 and Sh21 respectively are achieved in summer, with the highest reduction is obtained by applying (C5) and the lowest is obtained by applying (C1). Besides, potential increases in the resultant temperature ranging from (0.3-1.4 ^{o}C) in Sh1, and a maximum of 0.4 ^{o}C in Sh7, are achieved in winter. However, by implementing (C1 to C5) in Sh21, a reduction in the temperature of a maximum of 0.3 °C could take place in winter particularly during the night, and a maximum increase of only 0.2 °C could be achieved particularly during the daytime.

By implementing the combination (C6) potential increases in the resultant temperature ranging from (1.7-3.3 °C), (0.9-2°C), and (1.3-2.3 °C) are achieved in winter in Sh1, Sh7 and Sh21 respectively. Besides, potential reductions in the resultant temperature ranging from (0.5-1.9 °C) and (0.8-2 °C) are achieved in summer in Sh1 and Sh7 respectively. However, by implementing (C6) in Sh21, an increase in the temperature of a maximum of only 0.1 °C could take place in summer particularly in the morning, and a maximum reduction of 1.1 °C could be achieved particularly in the evening.

The results also indicated that by implementing the fabrics combinations (C7 to C10) potential increases in the resultant temperature ranging from (3.5-7 °C), (2.4-4.5°C), and (3.2-6.2 °C) are achieved in winter in Sh1, Sh7 and Sh21 respectively, with the highest increase is obtained by applying (C10) and the lowest is obtained by applying (C7). Besides, potential reductions in the resultant temperature ranging from (0.3-2.2 °C) and (0.6-2.1 °C) are achieved in summer in Sh1 and Sh7 respectively. However, by implementing (C7, C8, C9, and C10) in Sh21, increases in the temperature of maximum of 1 °C, 1.2 °C, 1.3 °C, and 1.4 °C respectively could take place in summer particularly in the morning, and a maximum reduction of 0.6 °C could be achieved particularly in the evening until the mid of the night.

In the light of the above results, it can be concluded that, in terms of internal temperature, the fabric combination (C10) is the best in all shelters in winter, while the fabric combination (C5) is the best in all shelters in summer. However, the magnitude of potential increase in temperature in a winter-day by applying (C10) is obviously greater than the magnitude of potential reduction in temperature in a summer-day by applying (C5)

10.7.3 Thermal Comfort With Proposed Combinations of Fabrics

The percentages of comfort hours, where the PMV ranges from (+1) to (-1), in each season of the year were estimated with the implementation of the various combinations of fabrics in Sh1, Sh7, and Sh21 (see figures 10.25). The potential increase of the percentage of comfort hours comparing with the existing windows is also provided in table 10.12.

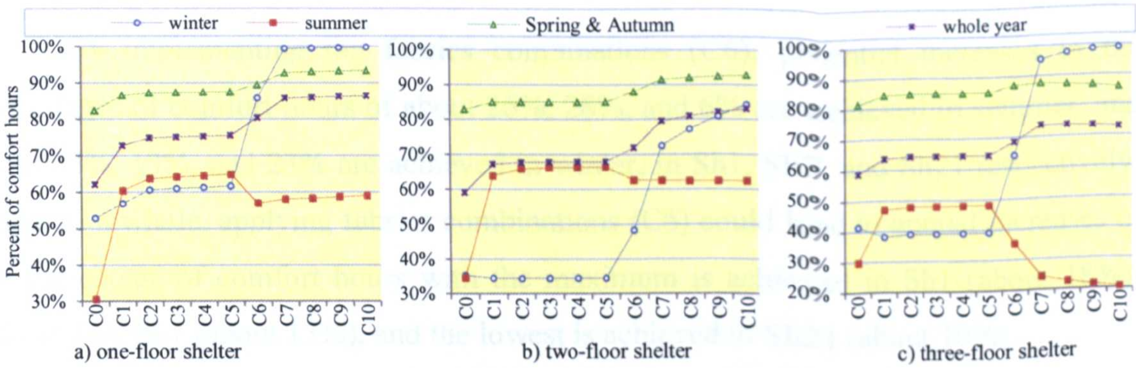


Figure 10.25: Percent of comfort hours for various combinations of fabrics

Table 10.12: Percentage of increase in comfort hours for various combinations of Fabrics comparing with existing combination (C0). Note: sign (-) means a percentage of reduction.

Combinations		one-floor shelter (Sh1)			Two-floor shelter (Sh7)			Three-floor shelter (Sh21)		
		winter	summer	annual	winter	summer	annual	winter	summer	annual
Combinations incorporate the most efficient wall , in terms of thermal comfort for summer										
C1	W2a+R3	4.02%	29.92%	10.58%	-0.84%	29.16%	8.11%	-3.09%	17.10%	5.00%
C2	W2a+R4d	7.75%	33.15%	12.67%	-0.87%	31.22%	8.65%	-2.39%	17.96%	5.57%
C3	W2a+R4e	8.17%	33.61%	12.92%	-0.86%	31.58%	8.74%	-2.31%	18.05%	5.64%
C4	W2a+R5d	8.39%	33.93%	13.09%	-0.85%	31.68%	8.78%	-2.25%	18.17%	5.70%
C5	W2a+R5e	8.78%	34.28%	13.31%	-0.81%	31.79%	8.82%	-2.15%	18.28%	5.78%
A combination with relatively low capital cost & moderate thermal improvement										
C6	W3a+R3	32.85%	26.42%	18.29%	12.95%	27.92%	12.77%	22.81%	5.55%	9.89%
The most efficient combinations for the entire year and for winter in particular in terms of thermal comfort										
C7	W4d+R4d	46.46%	27.56%	23.59%	37.10%	27.83%	20.46%	53.89%	-5.49%	15.05%
C8	W4e+R4e	46.64%	27.75%	23.84%	41.85%	27.76%	21.91%	56.04%	-7.19%	14.93%
C9	W5d+R5d	46.79%	28.16%	24.06%	45.63%	27.69%	23.01%	57.03%	-8.36%	14.61%
C10	W5e+R5e	46.93%	28.46%	24.24%	48.86%	27.72%	23.97%	57.53%	-9.42%	14.08%

The results show that by implementing the fabrics combinations (C1 to C5), the potential increases in the percentage of comfort hours ranging from about (30% to 34%), (29% to 32%), and (17% to 18%) are achieved in summer, in Sh1, Sh7, and Sh21 respectively, with the highest is obtained by applying (C5) and the lowest is obtained by applying (C1). Besides, in winter, a relatively small potential increase ranging from (4% to 9%) is achieved in Sh1, while a reduction of a maximum of 0.87% and 3% could takes place in Sh7 and Sh21 respectively. Taken as a whole, applying the fabrics combinations (C1 to C5) could lead to annual increases in the percentage of comfort hours ranging from about (11% to 13%), (8% to 9%), and (5% to 6%) in Sh1, Sh7, and Sh21 respectively.

By implementing the fabrics combinations (C6), potential increases in the percentages of comfort hours of about 26%, 28%, and 6% are achieved in summer, and about 33%, 13%, and 23% are achieved in winter, in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying fabrics combinations (C6) could lead to annual increases in the percentage of comfort hours with the maximum is achieved in Sh1 (about 18%), followed by Sh7 (about 13%), and the lowest is achieved in Sh21 (about 10%).

The results also revealed that by implementing the fabrics combinations (C7 to C10), relatively great potential increases in the percentages of comfort hours ranging from about (46% to 47%), (37% to 49%), and (54% to 58%) are achieved in winter, in Sh1, Sh7, and Sh21 respectively, with the highest is obtained by applying (C10) and the lowest is obtained by applying (C7). Besides, in summer, a potential increase in the percentage of comfort hours of approximately 28% is achieved in Sh1 and Sh7, while a reduction ranging from 5% to 9% could takes place in Sh21. Taken as a whole, applying fabrics combinations (C7 to 10) could lead to relatively great annual increases in the percentage of comfort hours ranging from about (23.6% to 24.2%), (20.5% to 24%), and (14% to 15%) in Sh1, Sh7, and Sh21 respectively. It is observed that the highest potential annual increase in Sh1 and Sh7 is obtained by applying (C10) and the lowest is obtained by applying (C7). In contrast, the highest potential annual increase in Sh21 is obtained by applying (C7) and the lowest is obtained by applying (C10). This means that; in terms of annual thermal comfort, the combinations (C7and C8) which comprise 50mm insulation materials are recommended to be implemented in Sh21 (three-floor shelter) than the combinations (C7and C8) which comprise 100mm insulation materials.

Overall, in all shelters, the highest increase in the percentage of comfort hours in winter and in the entire year could be achieved by implementing the fabrics combinations (C7 to C10), followed by (C6), and the lowest is achieved by implementing the fabrics combinations (C1 to C5). In contrast, the highest increase in the percentage of comfort hours in summer could be achieved by implementing the fabrics combinations (C1 to C5).

10.7.4 Energy Savings With Proposed Combinations of Fabrics

The energy savings of the proposed fabrics combinations is measured approximately where the shelters are assumed with air conditioning in order to estimate the annual heating and cooling loads. The lower and upper temperatures are set 20 °C and 26 °C respectively. Figure 10.26 provides the annual heating and cooling, and the total loads with the implementation of the various fabrics combinations in Sh1, Sh7, and Sh21, and table 10.13 provides the percentage of loads savings comparing with the existing fabrics.

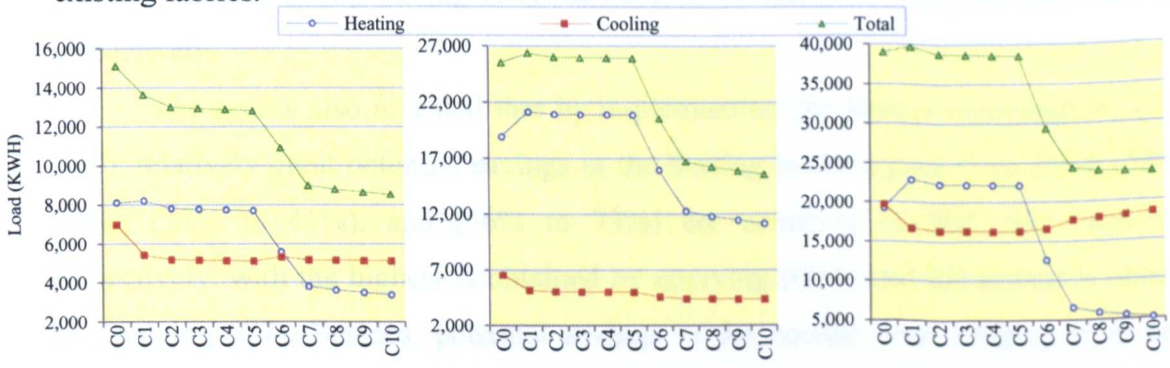


Figure 10.26: Annual heating and cooling load for various combinations of fabrics

Table 10.13: Percentage of savings in annual load for various combinations of fabrics comparing with existing combination (C0)

Combinations		one-floor shelter (Sh1)			Two-floor shelter (Sh7)			Three-floor shelter (Sh21)		
		Heating	Cooling	Total	Heating	Cooling	Total	Heating	Cooling	Total
C1	W2a-R3	-1.3%	22.3%	9.6%	-11.8%	21.2%	-3.3%	-18.9%	15.0%	-1.7%
C2	W2a-R4d	3.6%	25.5%	13.7%	-10.7%	23.0%	-2.0%	-15.9%	16.6%	0.5%
C3	W2a-R4e	4.1%	26.0%	14.2%	-10.5%	23.3%	-1.8%	-15.6%	16.8%	0.8%
C4	W2a-R5d	4.5%	26.3%	14.6%	-10.4%	23.4%	-1.7%	-15.3%	16.9%	1.0%
C5	W2a-R5e	4.9%	26.6%	15.0%	-10.3%	23.6%	-1.6%	-15.1%	17.1%	1.2%
C6	W3a-R3	31.0%	23.7%	27.6%	15.8%	30.1%	19.5%	34.2%	15.5%	24.7%
C7	W4d-R4d	53.1%	25.9%	40.5%	35.2%	32.5%	34.5%	65.8%	10.1%	37.7%
C8	W4e-R4e	55.3%	26.1%	41.8%	37.7%	32.8%	36.4%	69.3%	8.6%	38.6%
C9	W5d-R5d	55.3%	26.1%	42.7%	37.7%	32.8%	37.8%	69.3%	8.6%	39.0%
C10	W5e-R5e	58.1%	26.6%	43.5%	41.0%	33.2%	39.0%	73.2%	6.1%	39.3%

The results show that by implementing the fabrics combinations (C1 to C5), the potential savings in the cooling loads ranging from about (22% to 27%), (21% to 24%), and (15% to 17%) are achieved in Sh1, Sh7, and Sh21 respectively, with the highest is saved by applying (C5) and the lowest is saved by applying (C1). However, there is a relatively small possible saving in the heating loads in Sh1 (excluding in the case of C1) ranging from 3.6% to 4.9%, while a potential increase in the heating load could take place in Sh7 and Sh21 ranging from about (10% to 12%) and (15% to 19%) respectively. Taken as a whole, applying the fabrics combinations (C1 to C5) could lead to annual savings in Sh1 (10% to 15%) and Sh21 (only 0.5% to 1.2%) excluding by applying (C1) in Sh21 where an increase of annual loads (about 1.7%) could occur. In contrast, implementing the fabrics combinations (C1 to C5) in Sh7 could lead to an increase of annual loads ranging from 1.6% to 3.3%.

By implementing the fabrics combination (C6), potential savings in the heating loads (31%, 16%, and 34%) and the cooling loads (24%, 30%, and 16%) could take place, leading to annual saving of about 28%, 20%, and 25% , in Sh1, Sh7, and Sh21 respectively.

The results also revealed that by implementing the fabrics combinations (C7 to C10), relatively great potential savings in the heating load ranging from about (53% to 58%), (35% to 41%), and (66% to 73%) are achieved in Sh1, Sh7, and Sh21 respectively, with the highest is obtained by applying (C10) and the lowest is obtained by applying (C7). Besides, potential savings in the cooling load ranging from about (26% to 27%), (32.5% to 33.2%), and only (6% to 10%) are achieved in Sh1, Sh7, and Sh21 respectively. Taken as a whole, applying the fabrics combinations (C7 to 10) could lead to relatively great annual loads savings ranging from about (41% to 44%), (35% to 39%), and (38% to 39%) in Sh1, Sh7, and Sh21 respectively. It is observed that the highest potential annual energy saving in Sh1 and Sh7 is obtained by applying (C10) and the lowest is obtained by applying (C7). In contrast, the highest potential annual energy saving in Sh21 is obtained by applying (C7) and the lowest is obtained by applying (C10).

Overall, in all shelters, the highest savings in the annual loads could be achieved by implementing the fabrics combinations (C7 to C10), followed by (C6), and the lowest is achieved by implementing the fabrics combinations (C1 to C5). In terms of annual energy savings, the fabrics combinations (C1 to C5) are not recommended to be implemented in Sh7 (two-floor shelter) as they could cause increase in the annual loads. In addition, (C1) is not recommended to be implemented in Sh21 (three-floor shelter) for the same reason.

10.7.5 Cost Analysis For Proposed Combinations of Fabrics

Designing an energy conscious and comfortable building is often faced with a dilemma that; a proposed design saves the money through heating/cooling load reduction but the building costs could be greater. Some of the energy conservation alternatives are very highly cost effective due to their low purchasing and installing costs in contrast with their savings, while others may be expensive to purchase and to install with little savings. Therefore, it is essential to demonstrate the cost-effectiveness of the proposed solutions in order to get a strategic framework for taking a final decision. The simple payback method for cost analysis is applied in this study to measure the cost effectiveness of the proposed combinations of fabrics. The simple payback analysis determines how quickly the initial investment can be recovered by dividing the incremental capital cost of the proposed fabrics by the annual energy savings. Table 10.14 provides the payback analysis of the propose combinations of fabrics.

As indicated in table 10.14, the payback periods could not be calculated for the combinations (C1 to C5) in Sh7, and the combination (C1) in Sh21 as there is no energy savings in these cases. The cost analysis revealed that the shortest payback periods for Sh1 (4 years) is by implementing the fabrics combination (C1), followed by the payback period of (C6) (about 4.5 years), and the longest is calculated for the fabrics combination (C5) (about 31.5 years). The payback periods of the fabrics combination (C2 to C5) in Sh21 are relatively so long ranging from about 117 to 157 years.

Table 10.14: Cost analysis (payback period) for the proposed combinations of Fabrics

Combinations		one-floor shelter			Two-floor shelter			Three-floor shelter		
		Incremental capital cost ($)	Annual energy savings ($)	Payback period (years)	Incremental capital cost ($)	Annual energy savings ($)	Payback period (years)	Incremental capital cost t ($)	Annual energy savings ($)	Payback period (years)
C1	W2a-R3	769.2	190.0	4.0	88.2	-111.0	-	-58.2	-88.6	-
C2	W2a-R4d	4613.4	270.9	17.0	2367.9	-66.2	-	4054.2	26.2	154.8
C3	W2a-R4e	5163.8	280.5	18.4	2694.3	-61.0	-	4643.0	39.6	117.2
C4	W2a-R5d	8165.2	287.9	28.4	4474.2	-56.9	-	7853.8	50.0	157.0
C5	W2a-R5e	9300.4	295.4	31.5	5147.4	-52.8	-	9068.2	60.6	149.7
C6	W3a-R3	2435.4	544.5	4.5	3378.1	649.2	5.2	6133.8	1257.8	4.9
C7	W4d-R4d	12444.6	797.6	15.6	17830.4	1147.6	15.5	33156.7	1914.6	17.3
C8	W4e-R4e	12174.7	823.4	14.8	16537.2	1211.4	13.7	30697.1	1963.9	15.6
C9	W5d-R5d	20508.0	841.3	24.4	28844.8	1256.1	23.0	53722.4	1982.5	27.1
C10	W5e-R5e	23296.6	858.0	27.2	32782.6	1298.0	25.3	61081.2	1996.7	30.6

The analysis also revealed that the shortest payback periods for Sh7 (5.2 years) and Sh21 (4.9 years) are achieved by implementing the fabrics combination (C6). Further, by implementing the fabrics combination (C7 to C10) in Sh7 and Sh21, the predicted payback periods range from about (14 to 25 years) and (16 to 31 years) respectively, with the longest estimated for (C10) and the shortest estimated for (C8).

In the light of the annual potential increase in the percentage of comfort hours, the annual potential energy savings, and the payback periods for the various proposed combinations of fabrics, the following can be concluded.

Fabrics combination (C1): In Sh1 (one floor shelter), it has the lowest potential saving in loads, the lowest potential improvement in comfort hours, and the shortest estimated payback period, so (C1) could be one of the recommended alternative for one-floor shelter (Sh1). However, the implementation of (C1) in Sh7 (two-floor shelter) and Sh21 (three-floor shelter) could cause increases in energy consumption, so it is not recommended to be applied in two-floor shelter (Sh7) and three-floor shelter (Sh21).

Fabrics combinations (C2 to C5): In Sh1 and Sh21, comparing with the fabrics combination (C7) and (C8), they have less energy savings and less comfort improvement and longer payback period particularly in Sh21. Besides, the fabrics combinations (C2 to C5) in Sh7 could cause increase in the energy consumption. For these reasons, (C2 to C5) are not recommended to be applied in all shelters.

Fabrics combination (C6): It has relatively moderate energy saving and moderate comfort improvement, and relatively short payback period, so (C6) could be one of the recommended alternative for all shelters.

Fabrics combinations (C7 to C10): They have the highest potential energy savings and the greatest comfort improvement among all the combinations in all shelters. In Sh1 and Sh7, the potential energy savings and potential improvement in comfort hours are slightly higher for (C9) and (C10), but the payback periods are considerably longer. Therefore, the fabrics combinations (C7) and (C8) are more recommended to be used in Sh1 and Sh7 than the fabrics combinations (C9) and (C10). Further, in Sh21, (C7) and (C8) have shorter payback periods and higher improvements in thermal comfort than those of (C9) and (C10). Hence, the fabrics combinations (C9) and (C10) are not recommended to be implemented in the three-floor shelter (Sh21)

It is important to mention that the percentages of comfort hours achieved in summer by implementing the recommended fabrics combinations (C7 to C10) are about (58% to 59%), (62% to 63%) and (21% to 24%), in Sh1, Sh7, and Sh21 respectively, which are quite low comparing with those achieved in winter particularly in the three-floor shelter which are (92.7% to 93.3%), (73% to 84%) and (95% to 99%) in Sh1, Sh7, and Sh21 respectively. Therefore, other strategies to enhance the indoor thermal environment in summer, along with the improvement of the shelters` fabrics, should be examined. The effect of revised night ventilation on the thermal comfort in summer, as one of the enhancement strategies, was examined.

10.7.6 The Effect Of Revised Ventilation Strategy

As the outside temperature falls down during the night in summer, a night ventilation of 30 air change rate was proposed to be applied in the studied shelters. The percentages of the comfort hours in summer were estimated with applying the night ventilation from 7pm to 7am, along with the implementation of the most recommended fabrics combinations in Sh1, Sh7, and Sh21 (see figures 10.27). The potential increase in the percentage of comfort hours comparing with the conditions without night ventilation was also computed.

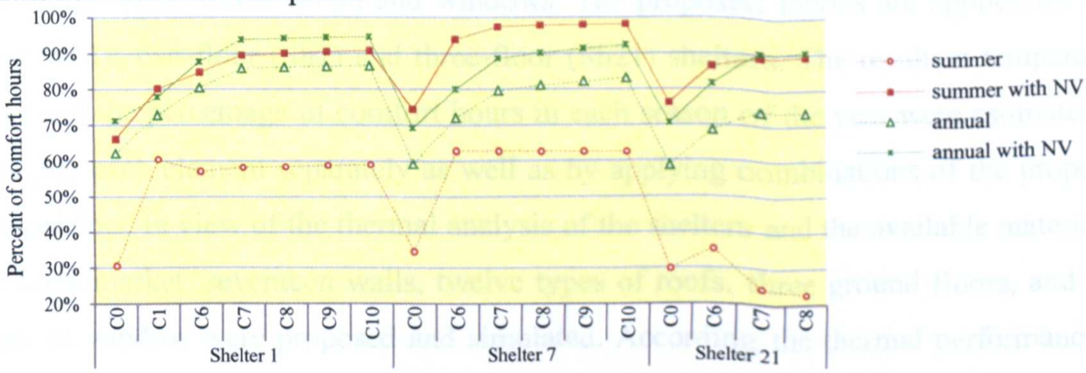


Figure 10.27: Percent of comfort hours with applying night ventilation of 30 air change rate along with some recommended fabrics combinations

The results revealed that by applying night ventilation in summer with the existing combination of fabrics (C0), significant potential increases in the percentages of comfort hours of about 36%, 40%, and 46% are achieved in Sh1, Sh7, and Sh21 respectively. Further, by applying night ventilation along with the most recommended fabrics combinations, significant increases in the percentages of comfort hours ranging from (20% to 32%), (31% to 36%), and (51% to 67%) could be achieved in Sh1, Sh7, and Sh21 respectively. By this, the percentages of comfort hours in summer in Sh1, Sh7, and Sh21 grow to range from (80% to 91%), (94% to 98%), and (86% to 89%) respectively which are significantly higher than the conditions without night ventilation. Taken as overall improvement, applying night ventilation of about 30 air change rate in summer, an annual increase in the percentage of comfort hours ranging from (5% to 8), (8% to 9), and (13% to 17) could be obtained in Sh1, Sh7, and Sh21 respectively.

10.8 SUMMARY

The potential improvement for the indoor thermal environment was inspected through conducting thermal simulation for various proposed shelters` components including; walls, roofs, floors and windows. The proposed fabrics are applied on one-floor (Sh1); two-floor (Sh7) and three-floor (Sh21) shelters. The resultant temperature (RT) and the percentage of comfort hours in each season of the year were estimated by applying each element separately as well as by applying combinations of the proposed components. In view of the thermal analysis of the shelters and the available material in the local market, seventeen walls, twelve types of roofs, three ground floors, and five types of window were proposed and simulated. According the thermal performance of the proposed fabrics and their cost, ten combinations (C1 to C10) of six types of walls, five types of roofs, one floor, and one type of window were selected and simulated to ascertain the overall thermal performance of the shelters and to identify the total improvement which could be achieved. The potential energy savings of the proposed fabrics combinations was then measured and the cost analysis was conducted. In the light of the potential annual increase in the percentage of comfort hours, the potential annual energy savings, and the payback periods for the various proposed combinations of fabrics, number of combinations are recommended for each shelter.

By implementing the recommended combinations of fabrics, the maximum annual potential increases of comfort hours are 24%, 22%, and 15% in Sh1, Sh7, and Sh21 respectively. The maximum potential increases in percentages of comfort hours in winter are 47%, 49% and 56%, and in summer are 29%, 28% and 18%, in Sh1, Sh7, and Sh12 respectively which are obviously lower than those in winter particularly in three-floor shelter. Therefore, other strategies to enhance the indoor thermal environment in these shelters in summer such as night ventilation, along with the improvement of the shelters` fabrics, are recommended. The night ventilation strategy to enhance the indoor thermal environment in summer was proposed and examined. The results showed that by applying the night ventilation, potential increase in the percentage of comfort hours in summer of maximum of 32%, 36%, and 67% could be achieved in Sh1, Sh7, and Sh21 respectively.

CHAPTER 11

CONCLUSIONS & RECOMMENDATIONS

11.1 INTRODUCTION

The major aim of this thesis is to evaluate the indoor environment of SHC shelters including thermal, visual, acoustic environments, and other environmental aspects, with focus on thermal conditions, and to propose alternate envelops seeking for potential enhancement in thermal comfort level. Shelters in refugee camps is influenced by a wide range of complicated factors, including dense urban environment, economic limitations, absence of regulations, environmental issues, and political consideration, which make any proposed modifications for these shelters more difficult. The objective of the reconstruction programme for Special Hardship Cases (SHC) families promoted by the UNRWA is to ensure that dwellings meet the minimum requirements of the space, the health conditions, and the needs of the family. SHC shelters which reconstructed by the UNRWA (the new shelters) and those which wait for reconstruction (the old shelters), are evaluated and compared in this research. Studying the two groups of shelters, old and new, was to help assessing the value of the improvement that has already taken place by the UNRWA and to bring greater comprehension of the indoor conditions that still needs more enhancements. After analysing the studied shelters, various fabrics are proposed for the new shelters looking for potential improvement in the indoor thermal environment.

A combination of methods was practised to achieve the research aims and objectives including two main methods, the questionnaires and the computer model, along with other methods such as observations and interviews. The questionnaire in this study is used as a main tool to examine the indoor environment conditions; with focus on thermal comfort. The computer model is utilized to analyse the thermal performance of the existing SHC shelters, and to identify the potential enhancement in thermal comfort and energy savings of the proposed alternate materials for shelters` envelope.

About 204 SHC families are surveyed with an average response rate of 74 percent and data gathered are analysed using statistical analysis software (SPSS). Afterwards, using a selected Thermal Analysis Software (TAS), twenty one shelters (10 old shelters and 11 new shelters) are simulated and analysed and three of them are chosen for the modelling the proposed modifications. A number of conclusions and recommendations are drawn based on the research results. The main conclusions are briefly presented in the following three sections, followed by recommendations for further research.

11.2 CONCLUSION BASED ON FIELD SURVEY

Using face-to-face questionnaires, a purposive convenience sample of 155 SHC families from Jabalia refugee camp was successfully interviewed. The questionnaires were ultimately designed to evaluate the indoor environment of SHC shelters with focus on the thermal environment. The main findings from the survey are presented below.

11.2.1 Thermal Environment

The survey indicates that the indoor thermal environment during summer and winter is not comfortable in both the old and the new shelters, but it is worse in the old shelters. The median of TSV for old shelters (+2.75) is higher than the median of TSV for new SHC shelters (+2.2), while in winter the median of TSV for old shelters (-2.87) is lower than the median of TSV for new SHC shelters (-2.6). The difference in TSV between the old and the new shelters is significant from a statistical point of view.

The survey revealed that the large heat gain through roofs and walls, the poor ventilation, and the small area of shelters are the main reasons of discomfort in summer, where the roof gains have statistically greater influence in the old shelters, while the small area has statistically greater influence in the new shelters. The major factors which cause discomfort in the old shelters during winter are the great heat loss through roofs and walls and the large infiltration. In the new shelters, the most influence factors causing discomfort in the majority of shelters are "large wall heat loss", followed by "the shelter is shaded by surrounding buildings", "very little sunshine comes in through windows", and "large roof heat loss". The roof loss and the infiltration reasons have greater influence in the old shelters from a statistical point of view.

For cooling, the vast majority of occupants have been utilizing the natural ventilation and around 81 percent of them have been using electric fans too. Almost one-half of electric fans` users use the electric fans 24 hours a day in summer. For heating during winter, various means are used in SHC shelters including; electric fires, firewood, charcoal and kerosene fires, with an average ranges from 4 to 10 hours a day. However, over one-half of SHC shelters` occupants do not use any heating means which can be related to their financial conditions.

Various factors that could influence thermal comfort in SHC shelters were inspected. The indoor air in winter is demonstrated as "humid and too humid" in all the old shelters and in the majority of the new shelters. Besides, the indoor solar radiation is generally poor in SHC shelters particularly in winter. The analysis indicated statistically significant moderate negative correlations between TSV_{summer} and air circulation, and between TSV_{winter} and air humidity. Through examining the effect of materials on thermal comfort, the results showed that shelters with sand block walls is colder in winter and hotter in summer than shelters with concrete block walls. In investigating the effect of shelter height on thermal comfort, the statistical test indicated that the one-floor shelters are colder in winter than the two-floor shelters.

11.2.2 Visual Environment

The quality of visual environment in SHC shelter were evaluated by inspecting the daylight amount, the visual comfort, the occupants satisfaction, and the visual amenity including view out and visual privacy. The survey indicated that the amount of daylight in old and new shelters is generally low particularly in winter, where it is lower in new shelters than in old shelters. Besides, the quality of daylight is overall not sufficient enough to achieve the visual comfort for occupants, and it is generally worse in new shelters than in old shelters. Subsequently, there is no satisfaction with visual comfort in the majority of shelters during winter and in around 40 percent of the shelters during summer. The survey revealed that; the electric lights are turned on all the daytime in winter in majority of shelters , while in summer, lights are turned on in about one-fifth and one-half of the new and the old shelters respectively.

In terms of view out, the overall findings indicate that the view outside SHC shelters is generally simple and limited, and restricted largely by the surrounding buildings. Besides, the window size and the sill height restrict the outside view, especially in the old shelters. In examining the visual privacy in the SHC shelters, it was found that the occupants of the new shelters who are satisfied with visual privacy are quite more than those who are not satisfied. In contrast, the dissatisfaction in the old shelters is more than the satisfaction.

11.2.3 Acoustic Environment

The quality of the acoustic environment was investigated and the occupants' satisfaction with the noise levels was explored too, along with surveying the noise sources and the speech privacy. The survey revealed several external sources of noise where the highest recorded sources in the vast majority of SHC shelters is "children playing in neighbouring areas". In terms of noise level, slightly more than one-half of shelters are demonstrated to be "neutral", while an average of one-third of the shelters are rated under "noisy" category. Further, the speech privacy which was showed to be important for the occupants was insufficient for the desires of the majority of occupants.

11.2.4 Other Indoor Environmental Aspects and General Evaluation

Other indoor environmental features were evaluated in SHC shelters including; adequacy of space, indoor air quality, security, and windows with their using. The survey indicated that the amount of area in the majority of SHC shelters is overall not adequate (i.e. narrow or very narrow) with the highest percentage is recorded for "very narrow" category. Therefore, the majority of occupants are not satisfied with the adequacy of space. Further, the amount of area is less sufficient in the new shelters. In terms of indoor air quality, the indoor air was described as "dusty", "stuffy", and "stale smelling" in about 30 to 40 percent of the old shelters. Occupants of old shelters who are dissatisfied with air quality are more than those who are satisfied. Furthermore, the security level in the new shelters is overall better than in the old shelters. The most important reasons to open windows were to increase cross ventilation and natural light, while the major reasons to close them were to increase visual privacy and to avoid hazards. Besides, three-quarter of the new shelters and 60 percent of the old shelters have SWHSs which provide adequate hot water in an average of about 5 months through the year.

General evaluation for the indoor conditions of the SHC shelters revealed that the most preferable modifications to the occupants were "more area", followed by "more comfortable temperature", "more visual privacy", "better ventilation", and " better natural light ". In the overall comparison between the old and the new shelters, the occupants of the new shelters demonstrated that; their new shelters are better or similar to their old shelters in terms of all the indoor environment features excluding the adequacy of space.

11.3 CONCLUSION BASED ON THERMAL ANALYSIS OF SHELTERS

The thermal analysis of the shelters represents the second phase of evaluation the shelters, which was carried out using thermal modelling programme (TAS V9.1.4.1). In the new shelters, the resultant temperature (RT) fluctuates from (13-17 °C) in winter and from (25-34 °C) in summer. Further, it was found that the maximum PMV in the new shelters ranges from (+1.8) to (+3), and the minimum PMV ranges from (-1.7) to (-3). In terms of loads breakdown, findings indicated that the highest percentage of heat gain in the majority of the new shelters is the internal gain, while fabrics loss represents the highest percentage of heat loss. Furthermore, the highest fabrics loss in both summer and winter is the walls loss while the floors gain is the highest fabrics gain in winter in all shelters. Besides the roof gain represents the highest percentage of fabrics gains in the majority of the shelters in summer.

Thermal performances of the selected sample of old shelters were also simulated and analysed revealing that RT fluctuates from about (8- 19 °C) in winter and from (22-36 °C) in summer. In addition, the maximum PMV in the old shelters ranges from (+2) to (+3), and the minimum PMV ranges from (-1.7) to (-3). In terms of loads breakdown, findings indicated that the highest percentage of heat loss in the majority of the old shelters in both summer and winter is the *Infiltration/Ventilation* loss. The heat loss through roofs in winter is the highest fabrics loss in the majority of the old shelters, while the roofs gain in summer is the highest fabrics gain.

A comparison of the thermal performances of the old shelters and the new shelters indicated that the swing in RT in the new shelters is less that in the old shelters. In addition, the old shelters are colder in winter and hotter in summer than the new shelters. A comparison between the TSV (the questionnaires results) and the PMV (the TAS results) revealed a significant difference between TSV and PMV from a statistical point of view; where the PMV is higher in summer and lower in winter than TSV. However, the mean of PMV–TSV discrepancies was less than 0.25 scale units which is an acceptable bias. This indicated that the PMV estimated by TAS simulation could be utilized to predict thermal comfort in the studied shelters.

11.4 CONCLUSION BASED ON THERMAL MODELLING OF PROPOSED FABRICS

In view of the thermal analysis of the shelters and the available material in the local market, seventeen walls, twelve types of roofs, three ground floors, and five types of window were proposed for the simulation by TAS. Afterwards, ten combinations (C1 to C10) of six types of walls, five types of roofs, one floor, and one type of windows (single glazed windows with blinds) were selected and simulated to ascertain the overall thermal performance of the shelters and to identify the total improvement which could be achieved. These combinations are explained in details in section (10.7) of the previous chapter. The combinations (C1 to C5) incorporate wall (W2a) which has the best performance in summer in terms of thermal comfort. The combination (C6) represents fabrics with relatively low cost and moderate potential improvement. The combinations (C7 to C10) represent fabrics with the greatest potential improvement for the whole year as overall and for winter in particular.

The results show that by implementing the fabrics combinations (C1 to C5), a potential increase in the percentage of comfort hours of a maximum of 34%, 32%, and 18% is achieved in summer, in Sh1, Sh7, and Sh21 respectively. However, in winter, slight increases in the percentage of comfort hours in Sh1 and a slight reduction in Sh7 and Sh21 could take place leading to relatively small annual increases of the percentage of comfort hours of maximum of 13%, 9%, and 6% in Sh1, Sh7, and Sh21 respectively. By implementing the fabrics combinations (C6), the potential increases in percentages of comfort hours of about 26%, 28%, and 6% are achieved in summer, and about 33%, 13%, and 23% are achieved in winter, leading to annual increases of about 18% , 13%, and 10%, in Sh1, Sh7, and Sh21 respectively. The results also revealed that by implementing the fabrics combinations (C7 to C10), relatively great potential increases in percentages of comfort hours ranging from about (46% to 47%), (37% to 49%), and (54% to 58%) are achieved in winter, in Sh1, Sh7, and Sh21 respectively. Besides, in summer, potential increase in percentage of comfort hours of approximately 28% is achieved in Sh1 and Sh7, while reduction ranging from 5% to 9% could takes place in Sh21. Taken as a whole, applying fabrics combinations (C7 to C10) could lead to relatively great annual increase of the percentage of comfort hours of maximum of 24.2%, 24%, and 15% in Sh1, Sh7, and Sh21 respectively

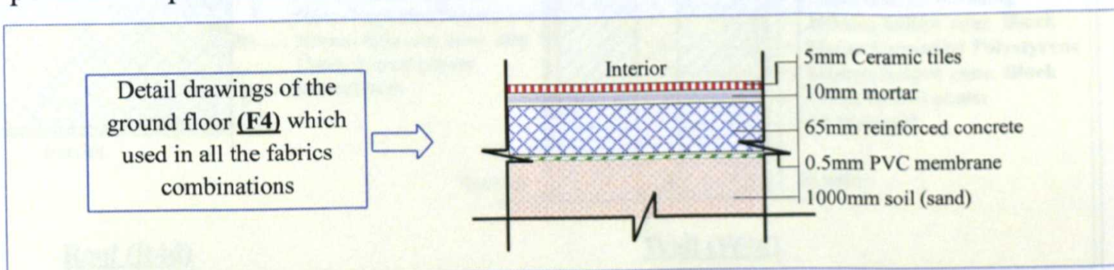
Despite the increase in the initial cost of these proposed fabrics, the reduced running cost in terms of energy means that the capital cost could be retrieved in some period of time. This is in addition to the positive environmental return. In the light of the thermal comfort, the potential energy savings, and the payback periods for the implementation of the proposed ten combinations, the following can be concluded:

- ***Fabrics combination (C1):*** In Sh1 (one floor shelter), it has the lowest potential saving in loads, the lowest potential improvement in comfort hours, and the shortest estimated payback period, so (C1) could be one of the recommended alternative for one-floor shelter (Sh1). However, the implementation of (C1) in Sh7 (two-floor shelter) and Sh21 (three-floor shelter) could cause increases in energy consumption, so it is not recommended to be applied in two-floor shelter (Sh7) and three-floor shelter (Sh21).
- ***Fabrics combinations (C2 to C5):*** In Sh1 and Sh21, comparing with the fabrics combination (C7) and (C8), they have less energy savings and less comfort improvement and longer payback period particularly in Sh21. Besides, the fabrics

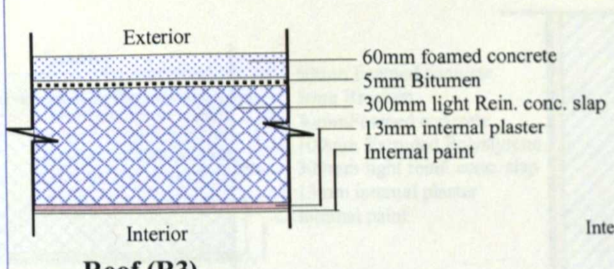
combinations (C2 to C5) in Sh7 could cause increase in the energy consumption. For these reasons, (C2 to C5) are not recommended to be applied in all shelters.

- ***Fabrics combination (C6):*** It has relatively moderate energy saving and moderate comfort improvement, and relatively short payback period, so (C6) could be one of the recommended alternative for all shelters.
- ***Fabrics combinations (C7 to C10):*** They have the highest potential energy savings and the greatest comfort improvement among all the combinations in all shelters. In Sh1 and Sh7, the potential energy savings and potential improvement in comfort hours are slightly higher for (C9) and (C10), but the payback periods are considerably longer. Therefore, the fabrics combinations (C7) and (C8) are more recommended to be used in Sh1 and Sh7 than the fabrics combinations (C9) and (C10). Further, in Sh21, (C7) and (C8) have shorter payback periods and higher improvements in thermal comfort than those of (C9) and (C10). Hence, the fabrics combinations (C9) and (C10) are not recommended to be implemented in the three-floor shelter (Sh21).

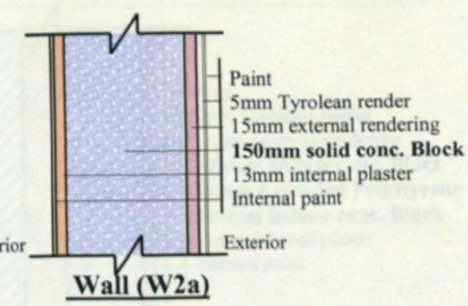
Figure (11.1) provides detail drawings of these combinations and summarizes their potential improvements.



Combination (C1)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	4%	30%	10.6%	9.6%	4



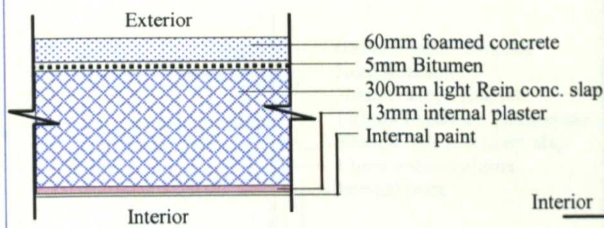
Roof (R3)



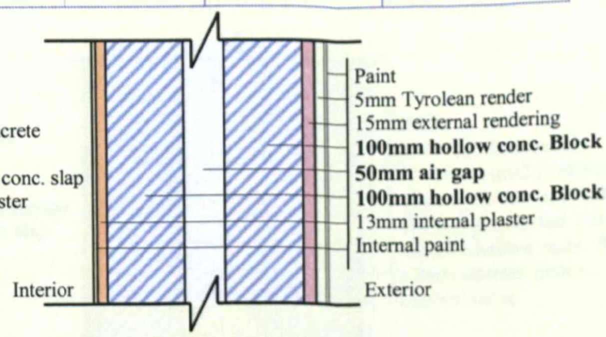
Wall (W2a)

Figure 11.1: Detail drawings and potential improvement of the recommended fabrics combinations C1 and C6 to C10. Continued

Combination (C6)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	32.9%	26.4%	18.3%	27.6%	4.5
Sh7 (two-floor shelter)	13%	27.9%	12.8%	19.5%	5.2
Sh21 (three-floor shelter)	22.8%	5.6%	9.9%	24.7%	4.9

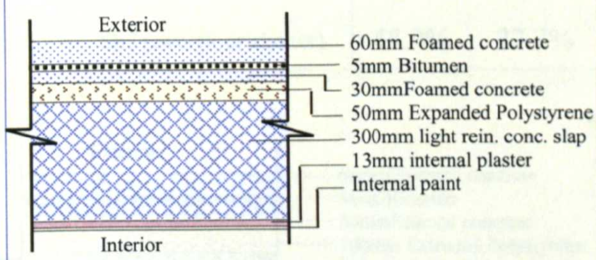


Roof (R3)

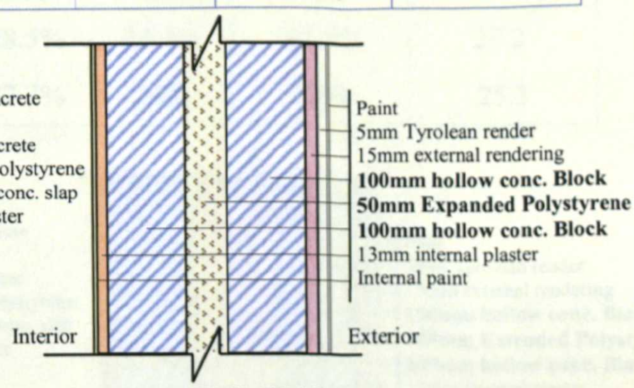


Wall (W3a)

Combination (C7)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	46.5%	27.6%	23.6%	40.5%	15.6
Sh7 (two-floor shelter)	37.1%	27.8%	20.5%	34.5%	15.5
Sh21 (three-floor shelter)	53.9%	-5.5%	15.1%	37.7%	17.3

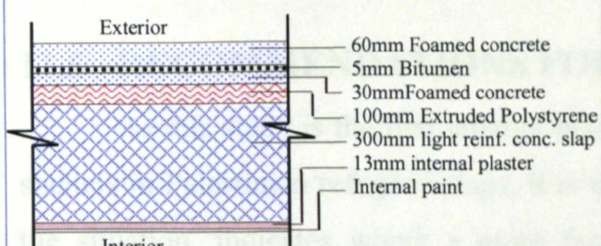


Roof (R4d)

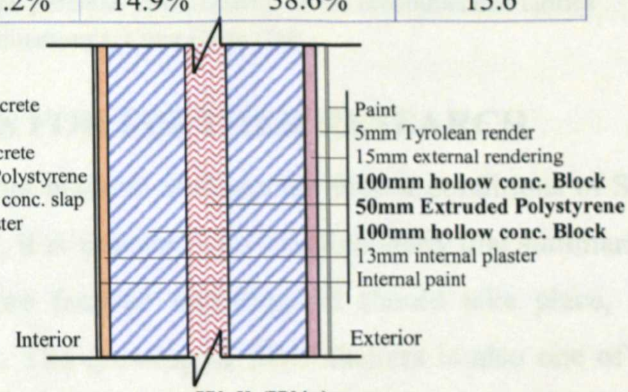


Wall (W4d)

Combination (C8)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	46.6%	27.8%	23.8%	41.8%	14.8
Sh7 (two-floor shelter)	41.9%	27.8%	21.9%	36.4%	13.7
Sh21 (three-floor shelter)	56%	-7.2%	14.9%	38.6%	15.6



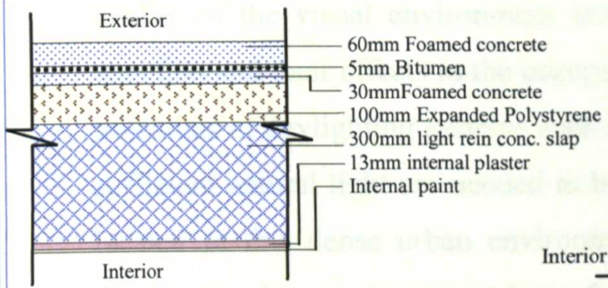
Roof (R4e)



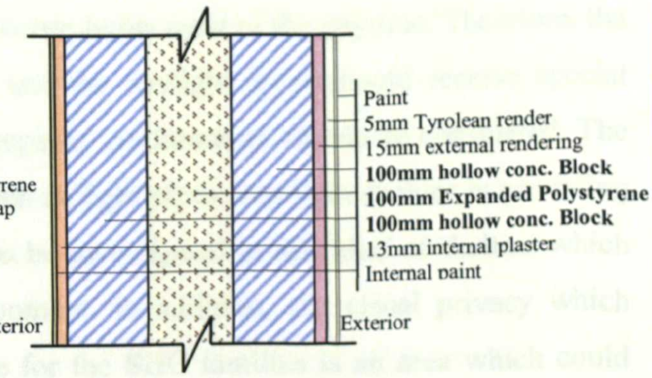
Wall (W4e)

Figure 11.1: Detail drawings and potential improvement of the recommended fabrics combinations C1 and C6 to C10. Continued

Combination (C9)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	46.8%	28.2%	24.1%	42.7%	24.4
Sh7 (two-floor shelter)	45.6%	27.7%	23%	37.8%	23

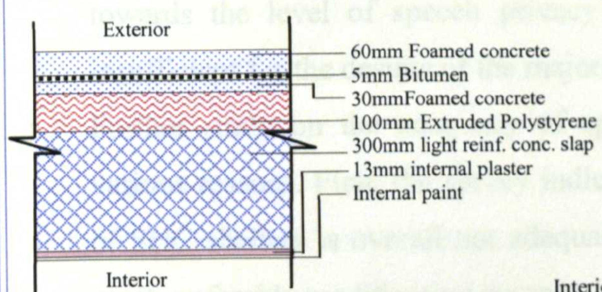


Roof (R5d)

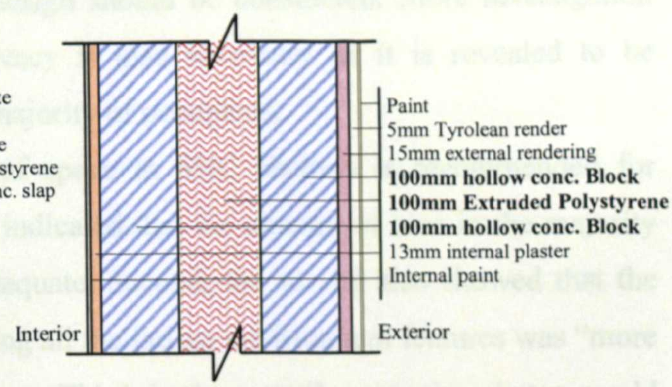


Wall (W5d)

Combination (C10)	percent of increase in comfort hours			annual energy savings %	Payback period years
	winter	summer	entire year		
Sh1 (one-floor shelter)	46.9%	28.5%	24.2%	43.5%	27.2
Sh7 (two-floor shelter)	48.9%	27.7%	24%	39%	25.3



Roof (R5e)



Wall (W5e)

Figure 11.1: Detail drawings and potential improvement of the recommended fabrics combinations C1 and C6 to C10.

11.5 RECOMMENDATIONS FOR FURTHER RESEARCH

As this study is the first attempt made to evaluate the indoor conditions of SHC shelters in Palestinian refugee camps, it is intended as a baseline study that summarizes the situation, indicates where a more focused investigation should take place, and provides a context for micro-studies. The growing of SHC shelters is also one of the reasons showing the need for various serious studies in this field. Areas which deserves further in-depth investigation and recommendations for future research are provides below.

- Visual environment in the SHC shelters is an area which deserves more detailed study as it was revealed that the amount of daylight in these shelters is low and the majority of occupants have to use electric lights most of the daytime. Therefore, the quality of the visual environment and the daylight level should receive special attention and their effects in the occupants' performance should be considered. The potentials of daylighting systems such as light pipes, and light shelves in providing sufficient natural light are needed to be investigated in this kind of shelters which located in this dense urban environment. In addition, the visual privacy which demonstrated as an important issue for the SHC families is an area which could require more investigation specially that one-third and more than one-half of the new and the old shelters` occupants respectively are dissatisfied with the visual privacy.
- A detailed study to measure the quality of indoor acoustic environment in SHC shelters including noise sources and noise level is needed and means to control the external noise through building design should be considered. More investigation towards the level of speech privacy is also necessary as it is revealed to be insufficient for the desires of the majority of occupants.
- Further study on the adequacy of space in SHC shelters is recommended for various reasons. First, the survey indicated that the amount of area in the majority of SHC shelters is overall not adequate. Second, the survey also showed that the most preferable modification among all the indoor environment features was "more area" particularly in the new shelters. Third, in the overall comparison between old and new shelters, it was revealed that responses recorded for "new shelter is better" are higher than those recorded for "old shelter is better" in terms of all indoor environment features excluding the adequacy of space where the responses for "old shelter is better" is higher. Fourth, the adequacy of space could be considered as a significant aspect of the functional requirements of building design which depends not only on the identifiable activities but also on people`s culture.
- Solar water heating system, as a clean and energy saving system implemented in the shelters in refugee camps, could be an interesting subject for investigation. The efficiency of the system and the possible methods for its integration in shelters`

envelope in such kind of dense urban environment (i.e. refugee camps) are recommended to be explored.

- The potential of integrating courtyards, as significant features affecting the indoor environment including thermal, visual, and acoustic environment, in the new SHC shelters is recommended for study particularly that a number of old shelters (about 43 percent) still comprise courtyards. Reasons for roofing the courtyards in some old shelters and reasons for not integrated them by the UNRWA in the new shelters should be further investigated. The potential impact of different configurations of courtyards in shelters in refugee camp with its compact built environment is also recommended for study.

Other recommended studies, observed from focusing on the thermal environment, are provided below.

- As this study is carried out on refugee camps in hot humid climate, it is recommended to extend this study to refugee camps in other climates; in the West Bank, Jordan, Lebanon and Syria, to make a more comprehensive contribution.
- A further study should focus on the strategies and the techniques that maximize the access of the solar radiation into the shelters in refugee camps particularly in winter.
- An in-depth analysis of the ventilation in the shelters in refugee camps using CFD programmes is certainly recommended. Night ventilation strategies should receive special attention because a great potential improvement in thermal comfort could be achieved by increasing the ventilation rate in the studied shelters during the night as clarified in section (10.7.6) of this thesis.
- Evaluation of the adaptation of passive cooling systems such as wind catcher and solar chimney is an interesting subject to be applied on shelters in refugee camps. The study should investigate the best way of adapting these cooling systems in the refugee shelters and the possible energy conservation and the thermal comfort measures that could be achieved by integrating these systems.
- Lastly, a detailed study is required about the practicality of applying the recommended fabrics in the SHC shelters, considering the incremental cost of the proposed materials. It is required from the concerned official bodies in the UNRWA office to take an action to legalize the issue through appropriate design norms and policies for reconstruction SHC shelters that put the thermal comfort and the energy-efficiency of shelters in action.

11.6 SUMMARY

It is seen that this study has been fulfilled within the frame of the main aims and objectives stated earlier in chapter one. The findings and the recommendations should be considered as suggestive rather than conclusive. It is believed that this study has introduced innovative ideas and contributions to knowledge. In general, it provides some useful tools and techniques for evaluating and enhancing the environmental performance of residential buildings located in a compact urban environment.

REFERENCES

REFERENCES

AbdulHadi, R., 1994, *"Construction And Housing In The West Bank And Gaza Strip"*, United Nations Conference on Trade and Development (UNCTAD), ECDC, SEU4.

AGBM- Australian Government, Bureau of Meteorology, About the WBGT and Apparent Temperature Indices, available at: http://www.bom.gov.au/info/thermal_stress/ [Accessed Jan. 2010]

Al-khatib, I, Arafat, R., and Musmar, M., 2005, "*Housing Environment and Women's Health in a Palestinian Refugee Camp*", International Journal of Environmental Health Research, Vol.15, Issue 3, Pages 181-191

ARIJ, 1997," *The Status of the Environment in the West Bank"*, the Applied Research Institute-Jerusalem, ARIJ Online Publications, available at: http://www.arij.org/index.php?option=com_content&task=section&id=6&Itemid=26&lang=en, [Accessed Feb. 2010]

ARIJ, 2001," *Part tow - Overview of the Palestinian Environment"*, the Applied Research Institute-Jerusalem, ARIJ Online Publications, available at: http://www.arij.org/index.php?option=com_content&task=section&id=6&Itemid=26&lang=en, [Accessed Feb. 2010]

ARIJ, 2007," *Status of the Environment in the Occupied Palestinian Territory*", the Applied Research Institute-Jerusalem, Bethlehem

Alder, K., et al., 1984, "*Energy Balance and Thermal Comfort in Passive Solar Housing*", First E.E.C. Conference on Solar Heating , Amsterdam.

ASHRAE, 2009, "*ASHRAE Handbook: Fundamentals*", Inch-Pound Edition, Atlanta GA, American Society of Heating Refrigerating and Air Conditioning Engineering, Inc.

Athienitis, A. K., & Santamouris, M., 2002, *"Thermal Analysis and Design of Passive Solar Buildings"*, London, James & James

Auliciems A. & Szokolay S., 2007, "*PLEA Note 3: Thermal comfort*" , Brisbane , PLEA : Passive and Low Energy Architecture International in association with Department of Architecture, The University of Queensland.

Autodesk, 2008, "*Thermal: Analysis Methods*" , available at: http://squ1.org/wiki/Thermal_Analysis_Methods [Accessed Feb. 2010]

Awbi, H. B., 2003, "*Ventilation of Buildings*". 2nd ed. London, Spon press.

Baker, N., & Steemers, K., 2005, "*Energy and Environment in Architecture- A Technical Design Guide*", London, E & FN SPON

Bartholomew D, et al., 1997, "*An Application Manual for Building Energy and Environmental Modelling*", Building Simulation 97, Prague, Vol2, pp387-393

Beins, B., 2009, "*Research Methods- a Tool for Life*", 2nd, Boston, Pearson

Bowers, D., 2007, "*Questionnaire and Form Design*", In: Malhorta, N. K., ed, 2007, "Marketing Research and Applied Orientation", 5th ed, New Jersey: Pearson. Ch. 10.

Brace, I., 2004, "*Questionnaire Design- How to Plan, Structure and Write Survey Material for Effective Market Research*", London, Kogan Page

BRE, 1990, GBG5, "*Choosing Between Cavity, Internal and External Wall Insulation*", Garston: Building Research Establishment.

Britten, J. R., 1977, "*What is a Satisfactory House? A Report of Some Householders Views*" BRE Current Paper 77/26, UK.

Bryman, A., 2005, "*Research Methods and Organization Studies*", London and New York, Routledge

Brynen, R. and Rifai, R., 2007, "*Introduction: Refugee Repatriation, Development, and the Challenges of Palestinian State-Building*". In: Brynen, R. and Rifai, R., ed. 2007, "Palestinian Refugees: Challenges of Repatriation and Development", Ottawa: I. B. Tauris, Ch.1.

Campanelli, P., 2008, "*Testing Survey Questions*", In: Leeuw, D., Hox, J., Dillman, D., ed. 2008, "International Handbook of Survey Methodology", New York: LEA. Ch. 10.

Carmody, J., et al., 2004, "*Window Systems for High-Performance Buildings*", New York, Norton

Charles, K., Reardon, J.T., Magee, R.J., 2005, "*Indoor Air Quality and Thermal Comfort in Open-Plan Offices*", NRC-Institute For Research In Reconstruction, Construction Technology Update No. 64. Available at: http://irc.nrc-cnrc.gc.ca/pubs/ctus/64_e.html

Chianga C., Laib C., 2002, "*A study on the comprehensive indicator of indoor environment assessment for occupants' health in Taiwan*", Building and Environment, vol.37, P 387–392

Chen Q. et al., 1998, "*Detailed experimental data of room airflow with displacement ventilation*", Proceedings of Sixth International Conference on Air Distribution in Rooms, ROOMVENT '98, Stockholm, Sweden, vol.1, P 133–40.

CIBSE, 1999, "*CIBSE Guide A: Environmental Design*", Chartered Institute of Building Services Engineers, London, Yale Press Ltd.

CIBSE, 2006, "*CIBSE Guide A: Environmental Design*", Chartered Institute of Building Services Engineers, London, Yale Press Ltd.

Clarke, A., 2001, "*Energy Simulation in Building Design*", Oxford, Butterworth-Heinemann.

CLEAR, Comfortable Low Energy Architecture, "*thermal comfort*", available at: http://www.learn.londonmet.ac.uk/packages/clear/index.html [Accessed Feb. 2010]

Czemy, R. et al., (ed), 2000, *"Heat and moisture transfer in building"* papers in conferences, International Council for Building Research Studies and Documentation.

Daghigh, R., Sopian, K., Moshtagh. J., 2009, *"Thermal Comfort in Naturally Ventilated Office Under Varied Opening Arrangements: Objective and Subjective Approach"*, European Journal of Scientific Research, Vol.26, Issue 2, Pages 260-276

Davies, G., 2004, *"Building Heat Transfer"*, West Sussex, John Wiley & Sons

De Dear R. J., Brager G. S. 2002, *"Thermal Comfort in Naturally Ventilated Buildings: Revisions to ASHRAE Standard 55"*, Building and Environment, Vol.34, Pages 549–561

Ealiwa, A., Taki, H., Howarth, T., and Seden, R., 2000, *"An Investigation into Thermal Comfort in the Summer Season of Ghadames, Libya"*, Building and Environment, Vol. 36, Pages 231-237.

Eicker, U., 2003, *"Solar Technologies for Buildings"*, England, Wiley.

Elkahlout, G., 2001, *"Post-Oslo Reconstruction of Palestine from Rhetoric to Reality"*, PhD theses, the University of York, UK

EN ISO 7730, 2005, *"Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria"*, 3rd Ed, Brussels, European Committee for Standardization

Fanger, P.O., 1982 *"Thermal Comfort: Analysis and Applications in Environmental Engineering"* Robert E. Krieger Publishing Company, Malabar, Florida, USA.

Fanger, P.O. and Toftum, J., 2002, *"Extension of the PMV Model to Non-Air Conditioned Buildings in Warm Climates"*, Energy and Buildings, Vol.34, Issue 6, Pages 533-536.

Farah, R., 2000, *"Report on the Psychological Effects of Overcrowding in Refugee Camps in the West Bank and Gaza Strip"*, Ottawa: International Development Research Centre (IDRC), Available at: http://www.idrc.ca/en/ev-122506-201-1-DO_TOPIC.html. [Accessed October 2010]

Feriad H., Wong N. H., 2004, *"Thermal Comfort for Naturally Ventilated Houses in Indonesia"*, Energy and Buildings, Vol.36, Pages 614– 626

Fitch, J. M., 1999, *"American building: the environmental forces that shape it"*, Houghton Mifflin Company, New York, Oxford: Oxford University Press.

Foros, A., 2006, *"An Investigation into the Thermal Behaviour of External Insulation Systems with Drained Cavities"*, PhD Theses, the University of Nottingham, UK

Frazer, L., and Lawley, M., 2000, *"Questionnaire Design and Administration"*, Qld: John Wiley & Sons Australia.

Fry, M. & Drew, J. 1982, *"Tropical Architecture in the Dry and Humid Zones"*, 2nd, New York, Krieger

Gillham, B., 2008, "*Developing a Questionnaire*", 2nd ed, London: Continuum.

Givoni, B., 1998, "Climate *considerations in building and urban design*", New York, Van Nostrand Reinhold

Goulding, J. R., Lewis, J. O., and Steemers, T. C, 1992 *"Energy in Architecture- The European Passive Solar Handbook*", London, Batsford

Greenland, J., 1998, "*Foundations of Architectural Science: Heat, Light, Sound*", 3rd Ed., Sydney, University of Technology Sydney, Faculty of Design, Architecture and Building.
Griffiths, I.D, 1991,"*Thermal Comfort in Buildings with Passive Solar Features, Field Studies*", Commission of the European Communities

Hafeetha, M., 2009, *"Planning for Solar Energy as an Energy Option for Palestine"*, Master theses, An-Najah National University, Nablus, Palestine.

Haigh, R, 2008, "*Interview: a Negotiated Partnership*" In: Knight, A., and Ruddock, L., eds, 2008, "Advanced Research Methods in The Built Environment", West Sussex: Blackwell. Ch.10

Han J, et al., 2007, "*Field Study on Occupants' Thermal Comfort and Residential Thermal Environment in a Hot-Humid Climate of China*", Building and Environment, Vol.42, Pages 4043–4050

Harriman, L., & Lstiburek, J., 2009, "*The ASHRAE guide for buildings in hot and humid climates*", Expanded 2nd ed, Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Heidari, S., Sharples, S., 2002, "*A Comparative Analysis of Short-Term and Long-Term Thermal Comfort Surveys in Iran*", Energy and Buildings, Vol. 34, Pages 607–614

Heijs, W., 1994, a paper published: "*The Dependent Variable in Thermal Comfort Research: Some Psychological Considerations*" Thermal Comfort: Past, Present and Future, Proceeding of a Conference Held at BRE, Garston, UK

Hejoj, I., and Badran, A., 2006, "*A Socio-Economic Analysis of Special Hardship Case Families in the Five Fields of UNRWA Operations*", Amman: UNRWA.

Hensen, J. L. M. and Radosevic, M, 2004. "*Some Quality Assurance Issues and Experiences in Teaching Building Performance Simulation*", IBPSA News, International Building Performance Simulation Association, vol.14, no.2, Page 22-33

Hoof, J.V., 2008, "*Forty years of Fanger's model of thermal comfort: comfort for all?*", Indoor Air: International Journal of Indoor Environment and Health, Vol.18, Issue 3, Pages 182–201

Hoof, J., et al. 2010, "*The indoor environment and the integrated design of homes for older people with dementia*", Building and Environment, Issue 5, vol.45, Pages 1244–1261

Hoxley, M., 2008, "*Questionnaire Design and Factor Analysis*" In: Knight, A., and Ruddock, L., eds, 2008, "Advanced Research Methods in The Built Environment", West Sussex: Blackwell. Ch.11

Hui, S., 2001, "*Low energy building design in high density urban cities*", Renewable Energy, Vol. 24, Issues 3-4, Pages 627–640

Humphreys, M.A. and Nicol, J.F., 2002a," *Adaptive Thermal Comfort and Sustainable Thermal Standards for Buildings*", Energy and Buildings, Vol.34, Pages 563– 572

Humphreys, M.A. and Nicol, J.F., 2002b," *The Validity of ISO-PMV for Predicting Comfort Votes in Every-Day Thermal Environments*", Energy and Buildings, Vol.34, Issue 6, Pages 667– 684

Hwang, R.L., Lin, T. P., Kuo, N. J., 2006 "*Field experiments on thermal comfort in campus classrooms in Taiwan*", Energy and Buildings, Vol.38, Issue1, Pages53-62

Hyde, R., 2000, "*Climate Responsive Design-A study of buildings in moderate and hot humid climates*", London, FN Spon

Hyde, R., (Ed), 2008, "*Bioclimatic housing Innovative designs for Warm climates*", London, Sterling

IEA (International Energy Agency), 2000, "*Daylight in buildings- a source book on daylighting systems and components*", a report of IEA SHC Task 21/ ECBCS Annex 29

Indraganti M., 2010a, "*Behavioural Adaptation and the Use of Environmental Controls in Summer for Thermal Comfort in Apartments in India*", Energy and buildings, Vol.42, Pages 1019–1025

Indraganti M., 2010b, "*Thermal Comfort in Naturally Ventilated Apartments in Summer: Findings from a Field Study in Hyderabad, India*", Applied Energy, Vol.87, Pages 866–883

Indraganti M., 2011, "*Thermal Comfort in Apartments in India: Adaptive Use of Environmental Controls and Hindrances*", Renewable Energy, Vol.36, Pages 1182–1189

IPMVPC (International Performance Measurement & Verification Protocol Committee), 2001, "*Concepts and Practices for Improved Indoor Environmental Quality*", Volume II, Available electronically at http://www.doe.gov/bridge

Kim H., Stumpf A., Kim W., 2011, "*Analysis of an Energy Efficient Building Design through Data Mining Approach*", Automation in Construction, vol. 20, Page 37–43

Knight, A., Ruddock, L. (Ed), 2008, "*Advanced Research Methods in the Built Environment*", West Sussex, Blackwell.

Koch-Nielsen, H., 2002, "*Stay cool: a design guide for the built environment in hot climates*", London, James & James.

Koenigsberger, O. H., et al., 1973, "*Manual of Tropical Housing and Building*", London, Longman.

Konya A., 1980, *"Design Primer for Hot Climate"*, London, the Architectural Press

Kreider, J. F., 2001, "*Handbook of Heating, Ventilation, and Air Conditioning*", Boca Raton, CRC Press.

Markus, T. A. & Morris, 1980, "*Buildings, Climate and Energy*", Pitman Publishing Limited, London.

Marsh A., 2003, "*Ecotect and EnergyPlus*", Building Energy Simulation User News, Vol 24, No.6

Marsh A., 2011, *Ecotect Manual: Building Analysis Program*, Square One Research Ltd. Autodesk

Mayer, E., 1993, "*Objective Criteria for Thermal Comfort*", Building and Environment, Vol.28, Issue 4, Pages 399-403

McBurney, D., and White, T., 2007, "*Research Methods*", 7th ed, Belmont: Thomson Wadsworth.

McMullan R., 2002, *"Environmental Science in Building"*, 5th ed Basingstoke: Palgrave.

Ministry of Local Government, 2004, "*The Palestinian Code of Energy Efficient Buildings*", Ramallah: Ministry of Local Government.

Moore, F., 1993, "*Environmental control systems: heating cooling lighting*", New York, McGraw-Hill, Inc.

Natural Frequency, 1994, "*Comfort: Air Movement*", [online] available at: http://wiki.naturalfrequency.com/wiki/Air_Movement [Accessed Feb. 2011]

Nicol , F., 2004, "*Adaptive Thermal Comfort Standards In The Hot–Humid Tropics*", Energy and Buildings, Vol.36, Pages 628-637.

NRC, 1981," *Indoor pollutants*", Committee on Indoor Pollutants, National Research Council, National Academy of Sciences, National Academy Press

Olesen, B. W., & Brager, G. S, 2004, "*A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004*", UC Berkeley: Center for the Built Environment. Retrieved from: http:// escholarship.org/uc/item/2m34683k

Ogbonna A.C., Harris D.J., 2008, "*Thermal Comfort in Sub-Saharan Africa: Field Study Report in Jos-Nigeria*", Applied Energy, Vol.85, Pages 1–11

Ogunsote, O. O. & Prucnal-Ogunsote, B., 2002," *Comfort Limits for the Effective Temperature Index in the Tropics: A Nigerian Case Study*". Architectural Science Review, 45:2, 125-132, Sydney, Australia

Olgyay, V., 1992, "*Design With Climate- Bioclimatic Approach to Architectural Regionalism*", New York, Van Nostrand Reinhold.

Olesen, W., Parsons, K., 2002, "*Introduction to Thermal Comfort Standards and to the Proposed New Version of EN ISO 7730*", Energy and Buildings, Vol.34, Pages 537–548.

Oppenheim, A., 1992 "*Questionnaire Design, Interviewing and Attitude Measurement*", 2nd ed, London: Continuum.

Ottaviani, J., 2007, "*Descriptive Research Design: Survey and Observation*", In: Malhorta, N. K., ed, 2007, "Marketing Research and Applied Orientation", 5th ed, New Jersey: Pearson. Ch. 6.

Palestineremembered.com, "*Conflict For Beginners*", available at http://www.palestineremembered.com/index.html [Accessed Feb. 2010]

Parsons, C., 2002, "*The Effects of Gender, Acclimation State, the Opportunity to Adjust Clothing and Physical Disability on Requirements for Thermal Comfort*", Energy and Buildings, Vol.34, Pages 593– 599

PCBS, 2008a, "*Energy consumption in the Palestinian Territory, Annual Report*", Palestinian National Authority, the Palestinian Central Bureau of Statistics, Ramallah – Palestine

PCBS, 2008b, "*Statistical Abstract of Palestine-No9*", Palestinian National Authority, the Palestinian Central Bureau of Statistics, Ramallah – Palestine

PCBS, 2009, "*Special Report on the 61th Anniversary of the Nakba*", the Palestinian Central Bureau of Statistics, Ramallah – Palestine

PCBS, 2009b, "*Population, Housing and Establishment Census 2007*", Palestinian Central Bureau of Statistics, Ramallah- Palestine

PCBS, 2010, The Palestinian Central Bureau of Statistics, available at http://www.pcbs.gov.ps/DesktopDefault.aspx?tabID=1&lang=en, [Accessed Feb. 2010]

PEA- Palestinian Energy Authority, "*Solar Insulation in Palestine*", available at: http://pea-pal.tripod.com/organization.htm, [Accessed Feb. 2010]

PEC, the Palestinian Energy and Environment Research Centre, available at: http://www.perc.ps/index.htm, [Accessed Feb. 2010]

PECDAR, Palestinian Economic Council for Development and Reconstruction, "*Housing in Palestine*", available at: http://www.pecdar.ps/etemplate.php?id=264&searchkey=construction material [Accessed Feb. 2010]

PMC, Palestine Media Centre, available at: http://www.palestine-pmc.com/maps.asp [Accessed Feb. 2010]

Roaf, S., Fuentes, M., & Thomas, S., 2007, "*Ecohouse: A Design Guide*", Oxford, Elsevier

Santamouris, M. (Ed), 2001," *Energy and Climate in the Urban Built Environment",* London, James & James

Santamouris, M. & Asimakopoulos, D., (Ed), 1996, *"passive cooling of buildings",* London, James & James

Schiff, B., 1995, *"Refugees unto the Third Generation: UN Aid to Palestinians"*, New York, Syracuse University Press.

Scoy, G. V., 2007, "*Measurement and Scaling: Fundamentals and Comparative Scaling*", In: Malhorta, N. K., ed, 2007, "Marketing Research and Applied Orientation", 5th ed, New Jersey: Pearson. Ch. 8.

SIG Insulations, 2010, *"Interstitial Condensation Analysis",* available at: http://www.siginsulations.co.uk/condensation.htm [Accessed Feb. 2010]

Singh M., Mahapatra S., Atreya S.K., 2011, "*Adaptive Thermal Comfort Model for Different Climatic Zones of North-East India*", Applied Energy, Vol.88, Issue 7, Pages 2420–2428

Steenstra, H., 2000, "*Interaction and the Standardized Survey Interview- the Living Questionnaire*", Cambridge, Cambridge university press

Steinemann, A., 2004, *"Human exposure, health hazards, and environmental regulations"* Environmental Impact Assessment Review, Vol.24, Issue 7-8, Pages 695–710

Szokolay, S. V., 1980, "*Environmental science handbook for architects and builders*", Lancaster, the Construction Press Ltd

Szokolay, S. V., 2008, "*Introduction to architectural science: the basis of sustainable design*", 2nd Ed, Oxford: Elsevier Ltd.

Underwood, P., Yik, H., 2004, "*Modelling Methods for Energy in Buildings*", Oxford, Blackwell Science

UNRWA, 1999, "*Report of the Commissioner-General of the United Nations Relief and Works Agency for Palestine Refugees in the Near East (Addendum)-Financial situation of UNRWA in 1998 and 1999 and budget estimates for 2000-2001",* New York: United Nations

UNRWA, 2003, "*Report of the Commissioner-General of the United Nations Relief and Works Agency for Palestine Refugees in the Near East,1- July 2002-30 June 2003",* New York: United Nations

UNRWA, 2007, "*UNRWA in 2006*", Gaza: UNRWA Public information office

UNRWA, 2009a, "*Relief and Social Services-Social Safety Net Programme*", Amman: Department of relief and social services

UNRWA, 2009b, "*Relief and Social Services Programme*", Amman: Department of relief and social services

UNRWA, 2009c, *"Socio-Economic Developments in the Occupied Palestinian Territories, First-Half 2008"*, Gaza: UNRWA

UNRWA, 2010a, *"Palestine Refugees"*, [online] available at: http://www.unrwa.org, [Accessed February 2010]

UNRWA, 2010b, *"UNRWA in Figures"*, Gaza: UNRWA Public information office

UNRWA, 2010c, *"Report of the Commissioner-General of the United Nations Relief and Works Agency for Palestine Refugees in the Near East, 1 January-31 December 2009"*, New York: United Nations

Wang Z., 2006, *"A Field Study of the Thermal Comfort in Residential Buildings in Harbin"*, Building and Environment, Vol.41, Pages 1034– 1039

WBDG, Whole Building Design Guide, 2010, *"Security for Building Occupants and Assets"*, National Institute of Building Sciences, Available at: http://www.wbdg.org/design/provide_security.php, [Accessed Feb. 2010]

WCIP-World Countries Information Portal, *"Palestine"*, Available at: http://www.countryseek.com/geos/palestine.html [Accessed Feb. 2010]

WFHP, Windows for High Performance Commercial Buildings, Available at: http://www.commercialwindows.umn.edu/issues_energy1.php [Accessed Feb. 2010]

Wikimedia , Palestine Topography, Available at: http://commons.wikimedia.org/wiki/Main_Page [Accessed Feb. 2010]

Wilkins, A.J., Nimmo-Smith, I., Slater, A.I, & Bedocs, L., 1988, *"Fluorescent Lighting, Headaches and Eyestrain"* Proceedings of the CIBSE National Lighting Conference, Cambridge (UK), pp. 188-196

Wong, N. H., Khoo, S., 2003, *"Thermal Comfort in Classrooms in the Tropics"*, Energy and Buildings, Vol.35, Issue 4, Pages 337-351

WHO, 1990, *"Indoor environment: health aspects of air quality, thermal environment, light and noise"*. World Health Organization WHO & United Nations Environment Programme UNEP

Yao R., Li B., Liu J., 2009, *"A theoretical Adaptive Model of Thermal Comfort – Adaptive Predicted Mean Vote (aPMV)"*, Building and Environment, Vol.44, Pages 2089–2096

Zalesky, C., 2007, *"Measurement and Scaling: Noncomparative Scaling Techniques"*, In: Malhorta, N. K., ed, 2007, "Marketing Research and Applied Orientation", 5th ed, New Jersey: Pearson. Ch. 9.

Zeidan, A., 1999, *"Environmental Conditions in Palestinian Camps in Lebanon- Case Study"*, [online], Palestinian Refugee ResearchNet PRRN, Available at: http://prrn.mcgill.ca/research/papers/zeidan.htm. [Accessed Feb. 2010]

APPENDIX A

RECONSTRUCTION SCORING SYSTEM

- **A-1: Shelter Rehabilitation Scoring Sheet**
- **A-2: Socio-Economic & Technical Evaluation Form**

Appendix A-1: Shelter Rehabilitation Scoring Sheet

SHELTER REHABILITATION SCORING SYSTEM

	SAFETY AND HYGIENE	Maximum Score	Attained Score
1.	**Shelter condition**		
	1.1 Rooms		
	1.1.1 Structurally unsafe	300	
	1.1.2 Unhygienic	100	
	1.2 Sanitary Facilities		
	1.2.1 Non-existing	200	
	1.2.2 Structurally unsafe	150	
	1.2.3 Unhygienic	100	
	1.3 Kitchen		
	1.3.1 Non-existing	200	
	1.3.2 Structurally unsafe	150	
	1.3.3 Unhygienic	100	
2.	**Type of Shelter**		
	2.1 Straw & mud	100	
	2.2 Barracks (zinc sheet)	80	
	2.3 Wooden shelter	60	
	2.4 Cement bricks shelter with Eternit sheet roofing	40	
	2.5 Concrete house	20	
3.	**Number of Rooms occupied Relative to family size**		
	3.1 Eight persons & over occupying		
	3.1.1 One room	100	
	3.1.2 Two rooms	75	
	3.1.3 Three rooms	50	
	3.1.4 Four rooms	25	
	3.2 Five to Seven persons occupying		
	3.2.1 One room	80	
	3.2.2 Two rooms	60	
	3.2.3 Three rooms	40	
	3.2.4 Four rooms	20	

Appendix A-2: Socio-Economic & Technical Evaluation Form

Engineering and Construction Services Department

SOCIO-ECONOMIC and TECHNICAL EVALUATION FORM

CDD

23-Jan-08

1: GENERAL INFORMATION (To be filled by the Social Worker)

Head of Family	**Ibram Ahmd Hilal**			Date of Survey
IDN	**988910436**	RCN		**23-Jul-07**
Camp	**Kh/Younis**	Shelter No	**- 88**	Field
Camp Status	**Official**	Block	**18**	**Gaza**

2: SOCIO-ECONOMIC EVALUATION

2.1 SOCIAL EVALUATION

		Family Size	**5**	1	3, 2, 1, 0
Registered as SHC ?	**No** Yes/No	SHC No	SHC Cat:	0	4 , 0
Residency in Camp (year)	**12**	Residency in Shelter (year):	**12**	5	5, 3, 1, 0.5

No. of families living in the shelter **4**

	SN	RCN	HOF	F.S	Relation	Remarks
Shareing in shelter						

No scores

No. of family members suffering from disability **0**

	SN	Name of Disabled	Date of Birth	Disability
Disability				

0 4, 3, 2, 1, 0

No. of family members with chronic disease **0**

	SN	Name of Patient	Date of Birth	Type of disease
Chronic Problems				

Social Problems Last Year (Y/N)	Harassment/Violence	Dispute with Neighbor	Separation / Gender	Other	Yes/No
	No	**No**	**No**	**No**	0 0.5 x 4 = 2

2.2 ECONOMIC EVALUATION

Ocupation:	**engineer**	Job Address	**kh/younis**
Educational Degree:	**University or high**	*Elementary, Preparatory, Secondary , Diploma , University*	
Property Ownership	**Own**	*Owned , Rented , shared*	
Other Properties	**No**	*Owned by the family*	

Income (US$)	HoF	Wife	Work/Children	Relatives	Other , Identify	
	250	**0**	**0**	**0**	**0**	3 5, 3, 1, NE

Self Help	Self help Contribution	**No**	*(Yes , Partly , No)*	0 2, 1, 0
	Details of Contribution		*(Financial, Material, Labor, Management)*	

9 / 25

Name of Social Worker **Maha** Signature ________

Engineering and Construction Services Department

SOCIO-ECONOMIC and TECHNICAL EVALUATION FORM

CDD

23-Jan-08

3: TECHNICAL EVALUATION (To be filled by the Engineer)

Head of Family	Ibram Ahmd Hilal		Date of Survey
IDN	988910436	RCN 28304009	23-Jul-07

Structural System: **4-Permenant Structure**

1 Temporary Structure | 2 Temp. Roof over Per Wall | 3 Partially Permenant | 4 Permenant Structure — 4, 0, 0, 0 / 0

Please fill in the propriate boxes the status of each element as :
CS : Collapsing/Severe , VW : Very Weak , W: Weak , S: Stable

In case1 , Weakness = 16,12,9,6 — In case 3 , Weakness = % x RF+(1-%) x

4	WALLS	ROOFS	SLABS	Walls	Roofs	Slabs
				16 / 0	12 / 0	
PERCENT (%)		0		Percent of Temporary Area/Total		
TYPE	Cement		Concrete	Concrete, Cement, Asbestos, Zink, Wood, Mud, Scrap		
WEAKNESS	Stable		Stable	10,12,9,6 / 0	8,6,4,0 / 2	6,4,2,0 / 0
CRACKS	Stable		Stable	3,2,1,0 / 0		2,1,.5,0 / 0
SPALLING	Stable		Stable	3,2,1,0 / 0		2,1,.5,0 / 0
DEFLECTION			Stable		4,2,1,0 / 0	2,1,.5,0 / 0
STABILITY OF SHELTER		Stable			0	8,6,4,0

Number of Floors: **5** — 0 / 40

WC Used	**Internal Full WC**	No WC , External/ partial services , Internal/ partial services , External/ full services , Internal/ full services	0	5, 4, 3, 2, 0
Drainage Sys.	**Percolation pit**	No System, Pecolation pit , Percolation pit + Septec tank, Sewer line		

Fill in boxes : G : Good, A : Acceptable , W: Weak, VW : Very weak

Facilities	Area (M2)	Ventilation	Day Light
Room 1:	19.19	Good	Good
Room 2:	19.19	Good	Good
Room 3:	24.34	Good	Good
Room 4:	17.67	Good	Good
Kitchen	10.70	Good	Good
Bath / WC	9.00	Good	Good
Hall / Corr	75.87	Good	Good
External Area	0.00		

Area of Rooms (M2)	80.4		
Total Area (M2)	176.0		
Overcrowding =(Rooms Area /Fam size)	16	0	10, 6, 4, 0
Total Ventillation	Good	0	5, 3, 1, 0
Total Day light	Good	0	5, 3, 1, 0
		2	2, 0

Dampness Indications (Y/N)	Damp Patches	Shelter Flood	Roof Leakage	Through walls	Other	Yes / No
	No	No	No	No	No	0 .+2+2+2+1=8

Hazards require immediate repair	Severe Flood	Electrical wires	No WC / kitchen	Pipes damag/blockag	Other	Put * on Problem
						OK

2 / 75

Name of Engineer: Zaid — Signature ________ — **11** / 100

APPENDIX B

QUESTIONNAIRES

- **B-1: Questionnaire for new shelters (English version)**
- **B-2: Questionnaire for old shelters (English version)**
- **B-3: Questionnaire for new shelters (Arabic version)**
- **B-4: Questionnaire for old shelters (Arabic version)**

The University of Nottingham

QUESTIONNAIRE

Indoor Environment of Refugees` Shelters

To the occupants of shelters in Jabalia camp

This survey is part of a PhD study carried out at the University of Nottingham, aims to gauge the opinion of the Palestinian refugees about the indoor environment conditions at their shelters and to evaluate how well their shelters perform. The data, which will be collected from this questionnaire, will be precisely analysed using advanced methods, followed by a highly technical simulation for shelters thermal performance using sophisticated computer software.

For your attention, this research is the first of its kind to be conducted on the Palestinian shelters in refugee camps in order to assess areas that need enhancement in terms of thermal comfort, visual comfort, acoustic environment and other indoor environmental aspects, since they have significant social, economical, psychological and health effects on the occupants. Subsequently, appropriate technological solutions will be imparted to help the designer to better accomplish comfort and high performance shelters.

So please give your frank and honest opinion, bearing in mind that there are no right or wrong answers; it is only your opinions that are important. Responding should take about 30-40 minutes of your time. Responses will be kept anonymous and confidential.

Thank you very much for your time and cooperation.

Researcher
SANAA Y. H. SALEH
BSc in Architectural Engineering
MSc in Architecture and Renewable Energy
PhD Research Student
Department of Architecture and Built Environment
The University Of Nottingham






Shelter No.:........................ NEW SHELTERS Date:.....................

This questionnaire is composed of six sections as following:

1- Background Information
2- Thermal Environment
3- Visual Environment
4- Acoustic Environment
5- Other Environmental Factors
6- General

Instructions: Please tick [✓] the answer which is the most appropriate

************ BACKGROUND INFORMATION **************

1- What is your gender?
[ ] Male [ ] Female

2- How old are you? (please write the age inside the box)
............Years

3- How long have you been living in this shelter? (please write the number inside the box)
...........Years

4- How many ration cards do you have? (please write the number inside the box)
.........Ration cards

5- How many persons are living in this shelter? (please write the number inside the box)
.... 15 years old and less .... More than 15 years old

6- How many floors is your shelter? (please write the number inside the box)
...........Floors

7- What is the area of each floor? (please write the number inside the box)
.......Ground floor ....First floor ....Second floor ....Third floor

8- How many rooms in each floor?(Note: Rooms include bedrooms, guest room and living room)
.......In ground floor ....In first floor ....In second floor ....In third floor

9- In which year did the UNRWA reconstruct this shelter? (please write the answer inside the box)
....

10- Is there any extension or changing since the UNRWA reconstructed your shelter?
[ ] Yes [ ] No

11- IF there are extensions, how many floors and rooms did you add? (please write the number inside the box)
.... Floors .... Rooms

12- IF there are changes, what are they? (please write the answer)
....

13- What are the wall materials of your shelter? (Check all that apply)
[ ] Concrete block [ ] Sand block [ ] Other, please specify..........

14- What are the roof materials of your shelter? (Check all that apply)
[ ] Corrugated iron [ ] Asbestos [ ] Concrete roof tiles [ ] Concrete slap [ ] Wood boards
[ ] Other, please specify......................

15- What are the floor materials of your shelter? (Check all that apply)
[ ] Terrazzo tiles [ ] Ceramic tiles [ ] Concrete Slap [ ] Other, please specify..........

16- What do you use for floor covering in summer? (Check all that apply)
[ ] Carpets [ ] Rugs [ ] Mats [ ] Nothing [ ] Other, please specify..........

17- What do you use for floor covering in winter? (Check all that apply)
[ ] Carpets [ ] Rugs [ ] Mats [ ] Nothing [ ] Other, please specify..........

18- What are the types of the windows in your shelter? (Check all that apply)
[ ] Wooden [ ] Glazed Louvered [ ] Plastic Louvered [ ]Glazed with wooden shutters
[ ] Glazed [ ] Aluminium louvered [ ] Steel Windows [ ]Other, please specify...............

Shelter No.:.................... NEW SHELTERS Date:..................

************ THERMAL ENVIRONMENT ************

19- Please assign a rating for thermal comfort at your shelter **in summer** while there is no cooling appliances work. Tick ✓ what is applied to you.(please write the floor number in which each space is located and the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Floor No.	Hot	Warm	Slightly Warm	Comfort	Slightly Cool	Cool	Cold
Kitchen									
Room1	....								
Room2	....								
Room3	....								
Room4	....								
Room5	....								

20- Using the list below, indicate the reasons that make your shelter hot in summer and mark them in order of their influences, where 1 = the most influential reason. (please indicate just what do you think is applied to you)

[ ] I do not know
[ ] Great heat gain through walls
[ ] Great heat gain through roof
[ ] The area of my shelter is small.
[ ] Too much sunshine comes in through windows
[ ] Ventilation through windows is poor
[ ] The roof and external walls are exposed to solar radiation most of the time
[ ] Other reasons, please specify...

21- How is the air humidity in your shelter in summer?

[ ] Too Humid [ ] Humid [ ] Adequate [ ] Dry [ ] Too Dry

22- How is the air circulation in your shelter in summer?

[ ] Still [ ] Good circulation [ ] Too much circulation

23- How often does the sunshine enter your shelter in summer?

[ ] Always [ ] Often [ ] Seldom [ ] Never

24- How do you rate the intensity of solar radiation in your shelter in summer?

[ ] Too Much [ ] Adequate [ ] Poor [ ] No solar radiation

25- How often do you open windows in summer?

[ ] Always [ ] Often [ ] Seldom [ ] Never

26- Indicate in the table below when you open windows in summer. (Check all that apply)

6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-02 am	2-4 am	4-6 am

27- Using the list below, indicate the reasons that you open windows in summer and mark them in order of their importance for you, where1= the most important reason.(please indicate just what is applied to you)

[ ] To let sunshine in
[ ] To increase cross ventilation
[ ] To let fresh air enter
[ ] To break monotony
[ ] To increase room spaciousness
[ ] To maintain visual contact to the outside
[ ] To increase the level of light
[ ] Let you know what the weather is
[ ] Let you see what is going on outside
[ ] Other, Please specify ....

28- How often do you use the windows for cross ventilation in summer? (cross ventilation means the circulation of fresh air through the openings (apertures) such as from open window to another window or to open door)

[ ] Always [ ] Often [ ] Seldom [ ] Never

29- Using the list below, indicate the reasons that you close windows in summer and mark them in order of their importance for you, where1= the most important reason. (Please indicate just what is applied to you)

[ ] To reduce outside noise
[ ] To reduce unpleasant smells
[ ] To reduce the heat from the sun
[ ] To avoid hazards (e.g. insects and mice)
[ ] To reduce hot air
[ ] To reduce dust
[ ] To reduce glare
[ ] To increase security
[ ] To decrease the level of visual stimulus from the outside
[ ] To increase visual privacy (Visual privacy means that no one outside can see you while you are at your shelter)
[ ] To increase speech privacy (Speech privacy means that no one outside can overhear you while you are taking at your shelter)
[ ] Other, Please specify...................................

Shelter No.:........................ NEW SHELTERS Date:....................

30- How often do you close the windows to reduce the penetrated solar radiation in summer?

[ ] Always [ ] Often [ ] Seldom [ ] Never

31- How about the size of your shelter windows, is it:

[ ] Big [ ] About Right [ ] Small

32- Indicate when you use the means in the table below for cooling purpose in summer. (please tick just what is applied to you)

	6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-2 am	2-4 am	4-6 am	Never used
Fan													
Natural ventilation													
Air conditioning													

33- Please assign a rating for thermal comfort at your shelter **in winter** while there is no heating appliances work. Tick ✓ what is applied to you (please write the floor number in which each space is located and the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Floor No.	Hot	Warm	Slightly Warm	Comfort	Slightly Cool	Cool	Cold
kitchen									
Room1	....								
Room2	....								
Room3	....								
Room4	....								
Room5	....								

34- Using the list below, indicate the reasons that make your shelter cold in winter and mark them in order of their influences, where 1 = the most influential reason. (please indicate just what do you think is applied to you)

[ ] I do not know
[ ] Great heat loss through walls
[ ] Great heat loss through roof
[ ] Other reasons, please specify ....
[ ] Great infiltration through windows and doors
[ ] Very little sunshine comes in through windows
[ ] My shelter is shaded by the surrounding shelters

35- How is the air humidity in your shelter in winter?

[ ] Too humid [ ] Humid [ ] Adequate [ ] Dry [ ] Too Dry

36- How is the air circulation in your shelter in winter?

[ ] Still [ ] Moderate circulation [ ] Too much circulation

37- How often does the sunshine enter your shelter in winter?

[ ] Always [ ] Often [ ] Seldom [ ] Never

38- How do you rate the intensity of solar radiation in your shelter in winter?

[ ] Excellent [ ] Good [ ] Moderate [ ] Poor [ ] No solar radiation

39- Using the list below, indicate which you use for heating purpose in winter

	6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-2 am	2-4 am	4-6 am	Never used
Charcoal													
Wood													
Kerosene fire													
Gas fire													
Electric fire													
Air conditioning													

40- In terms of thermal comfort, in which season (winter or summer) do you think your shelter is better

[ ] In summer [ ] In winter [ ] The same

Shelter No.:........................ NEW SHELTERS Date:......................

************* VISUAL ENVIRONMENT **************

41- How do you rate the natural light condition in your shelter **in summer** while there is no artificial light turned on? (please write the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Very Dim	Dim	Slightly Dim	Neutral	Slightly Bright	Bright	Very Bright
kitchen								
Corridors								
Room1	....							
Room2	....							
Room3	....							
Room4	....							
Room5	....							

42- How often does the amount of natural light in your shelter in summer allow you to see clearly?
[ ] Always [ ] Often [ ] Seldom [ ] Never

43- How often does the daylight in summer cause glare strong enough to bother you?
[ ] Always [ ] Often [ ] Seldom [ ] Never

44- How satisfied are you with the visual comfort of the daylight in summer? (Visual comfort occurs when the amount of light is sufficient and without any glare, reflections or contrast)
[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

45- Does the quality of natural light in your shelter in summer have a negative effect on your performance?
[ ] No effect at all [ ] Slight effect [ ] Moderate effect [ ] Large effect [ ] Very much effect

46- How often do you use only the light from the windows in summer?
[ ] Always [ ] Often [ ] Seldom [ ] Never

47- How do you rate the natural light condition in your shelter **in winter** while there is no artificial light turned on? (please write the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Very Dim	Dim	Slightly Dim	Neutral	Slightly Bright	Bright	Very Bright
Kitchen								
Corridors								
Room1	....							
Room2	....							
Room3	....							
Room4	....							
Room5	....							

48- How often does the amount of natural light in your shelter in winter allow you to see clearly?
[ ] Always [ ] Often [ ] Seldom [ ] Never

49- How often does the daylight in winter cause glare strong enough to bother you?
[ ] Always [ ] Often [ ] Seldom [ ] Never

50- How satisfied are you with the visual comfort of the daylight in winter? (Visual comfort occurs when the amount of light is sufficient and without any glare, reflections or contrast)
[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

51- Does the quality of natural light in your shelter in winter have a negative effect on your performance?
[ ] No effect at all [ ] Slight effect [ ]Moderate effect [ ] Large effect [ ]Very much effect

52- How often do you use only the light from the windows in winter?
[ ] Always [ ] Often [ ] Seldom [ ] Never

53- Indicate in the table below when the artificial lights turned on in your shelter. (Please indicate just what is applied to you)

	5-6 am	6-7 am	7-8 am	8-9 am	9-10 am	10-11 am	11-12 am	12-1 pm	1-2 pm	2-3 pm	3-4 pm	4-5 pm	5-6 pm	6-7 pm	7-8 pm
In summer															
In winter															

54- Do you have control over the natural light in your shelter?
[ ] Yes [ ] No

4444444444444444444444444444 ---

55- When you are looking out of the window, do you experience that your view is restricted by any of the following elements?

	Very much restriction	Large restriction	Moderate restriction	Slight restriction	No restriction at all
By the window size					
By the height of window sill					
By the surrounding buildings					

56- Which of the following best describe the view out of the windows of your shelter? (Check all that apply)

[ ] Pleasant [ ] Boring [ ] Spacious [ ] Limited [ ] Simple

57- How much is the view outside important for you?

[ ] Not at all [ ] Slightly [ ] Moderately [ ] Largely [ ] Very much

58- How satisfied are you with the visual privacy in your shelter? (Visual privacy means that no one outside can see you while you are at your shelter)

[ ] Very Satisfied [ ] Satisfied [ ] Moderate [ ] Dissatisfied [ ] Very Dissatisfied

************** ACOUSTIC ENVIRONMENT *************

59- What is the source of noise in your shelter? (Check all that apply)

[ ] Outdoor mechanical noise (such as joinery workshops, metal workshops, factories)
[ ] Outdoor traffic noise
[ ] Internal noise
[ ] People passing in the street
[ ] Children playing in neighbouring areas
[ ] People talking in neighbouring areas
[ ] Other, please specify............

60- Does the distraction from noise bother you?

[ ] Not at all [ ] Slightly [ ] Moderately [ ] Largely [ ] Very much

61- How do you rate the noise level in your shelter?

[ ] Too much noise [ ] Noisy [ ] Neutral [ ] Calm [ ] Very calm

62- How satisfied are you with the noise level in your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

63- How much is the speech privacy important for you? (Speech privacy means that no one outside can overhear you while you are taking at your shelter)

[ ] not important [ ] slightly important [ ] moderately important [ ] largely important [ ] very much important

64- How often do you overhear your neighbours' private conservation?

[ ] Always [ ] Often [ ] Seldom [ ] Never

********** OTHER ENVIRONMENTAL FACTORS *********

65- How do you rate the amount of space/ area of your shelter?

	Very narrow	Narrow	Adequate	Spacious	Very Spacious
Rooms					
Corridors					
Kitchen					
Bath					

66- How satisfied are you with the amount of space/ area of your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

67- Which of the following is applied to the air in your shelter? (Check all that apply)

[ ] Stuffy air [ ] Unpleasant smells [ ] Too little ventilation [ ] Dusty air [ ] Fresh air [ ] Stale smelling air

68- How satisfied are you with the air quality in your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

69- How do you rate the security level of your shelter?

[ ] Very high [ ] High [ ] Moderate [ ] Low [ ] Very low

70- Do you have solar heating water system implemented in your shelter?

[ ] Yes [ ] No

If No, What is the reason? (Check all that apply)

[ ] I do not desire [ ] I cannot afford its cost [ ] Other reasons, please specify.......................

71- If YES, how many panels? (Please write the number inside the box)

..................Panels

5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

Shelter No.:......................... NEW SHELTERS Date:......................

72- In which months dose the system provide you with the adequate amount of hot water. (Check all that apply)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

73- Do you use other means for heating the water?

[ ] Yes [ ] No

If Yes, what do you use?...

*************** **GENERAL** **************

74- Suppose you could make changes to your overall shelter environment. Using the list below, indicate the changes you would make in order of preference, where 1 = the most preferred. (please indicate just what you would make)

[ ] Less noise [ ] Better natural light [ ] More speech privacy [ ] More view out
[ ] More area [ ] Better ventilation [ ] More visual privacy [ ] More comfortable temperatures
[ ] Fresh air [ ] More security [ ] Other (please specify)...................

75- In terms of the features listed below, indicate which is better; your new shelter ,your old shelter (i.e. before it was reconstructed by the UNRWA) or the same?

The better	Tempe -rature	Visual privacy	Natural light	Noise	Area	Speech privacy	Ventilation	Security	Air quality	view out	Other (please specify) ....
New shelter											
Old shelter											
The same											

76- Please add any additional comments about your shelter environment and about any features, you like or dislike in your shelter.

....
....
....
....
....

77- Do you agree for further survey to be taken place on your shelter in the future?

[ ] Yes [ ] No

Thank you for answering this questionnaire and we declare that the whole information which will be collected are only for research purpose and will be kept completely confidential.

Researcher
SANAA Y. H. SALEH
BSc in Architectural Engineering
MSc in Architecture and Renewable Energy
PhD Research Student
Department of Architecture and Built Environment
The University Of Nottingham

6666666666666666666666666666 6

The University of Nottingham

QUESTIONNAIRE

Indoor Environment of Refugees` Shelters

To the occupants of shelters in Jabalia camp

This survey is part of a PhD study carried out at the University of Nottingham, aims to gauge the opinion of the Palestinian refugees about the indoor environment conditions at their shelters and to evaluate how well their shelters perform. The data, which will be collected from this questionnaire, will be precisely analysed using advanced methods, followed by a highly technical simulation for shelters thermal performance using sophisticated computer software.

For your attention, this research is the first of its kind to be conducted on the Palestinian shelters in refugee camps in order to assess areas that need enhancement in terms of thermal comfort, visual comfort, acoustic environment and other indoor environmental aspects, since they have significant social, economical, psychological and health effects on the occupants. Subsequently, appropriate technological solutions will be imparted to help the designer to better accomplish comfort and high performance shelters.

So please give your frank and honest opinion, bearing in mind that there are no right or wrong answers; it is only your opinions that are important. Responding should take about 30-40 minutes of your time. Responses will be kept anonymous and confidential.

Thank you very much for your time and cooperation.

Researcher
SANAA Y. H. SALEH
BSc in Architectural Engineering
MSc in Architecture and Renewable Energy
PhD Research Student
Department of Architecture and Built Environment
The University Of Nottingham






Shelter No.:...................... OLD SHELTERS Date:....................

This questionnaire is composed of six sections as following:

1- Background Information
2- Thermal Environment
3- Visual Environment
4- Acoustic Environment
5- Other Environmental Factors
6- General

Instructions: Please tick [✓] the answer which is the most appropriate

*********** BACKGROUND INFORMATION *************

1- What is your gender?
[ ] Male [ ] Female

2- How old are you? (please write the age inside the box)
.............Years

3- How long have you been living in this shelter? (please write the number inside the box)
...........Years

4- How many ration cards do you have? (please write the number inside the box)
.........Ration cards

5- How many persons are living in this shelter? (please write the number inside the box)
.... 15 years old and less .... More than 15 years old

6- How many floors is your shelter? (please write the number inside the box)
...........Floors

7- What is the area of each floor? (please write the number inside the box)
.......Ground floor ....First floor ....Second floor ....Third floor

8- How many rooms in each floor? (Note: Rooms include bedrooms, guest room and living room)
.......In ground floor ....In first floor ....In second floor ....In third floor

9- What are the wall materials of your shelter? (Check all that apply)
[ ] Concrete block [ ] Sand block [ ] Other, please specify..........

10- What are the roof materials of your shelter? (Check all that apply)
[ ] Corrugated iron [ ] Asbestos [ ] Concrete roof tiles [ ] Concrete slap [ ] Wood boards
[ ] Other, please specify....................

11- What are the floor materials of your shelter? (Check all that apply)
[ ] Terrazzo tiles [ ] Ceramic tiles [ ] Concrete Slap [ ] Other, please specify..........

12- What do you use for floor covering in summer? (Check all that apply)
[ ] Carpets [ ] Rugs [ ] Mats [ ] Nothing [ ] Other, please specify..........

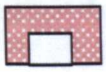
13- What do you use for floor covering in winter? (Check all that apply)
[ ] Carpets [ ] Rugs [ ] Mats [ ] Nothing [ ] Other, please specify..........

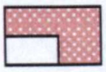
14- What are the types of the windows in your shelter? (Check all that apply)
[ ] Wooden [ ] Glazed Louvered [ ] Plastic Louvered [ ] Glazed with wooden shutters
[ ] Glazed [ ] Aluminium louvered [ ] Steel Windows [ ]Other, please specify................

15- Is there currently uncovered courtyard in your shelter?
[ ] Yes [ ] No

16- IF YES; indicate the location of courtyard in your shelter? (the white area indicates the uncovered courtyard)


[ ]
The court is surrounded by rooms on all sides


[ ]
The court is surrounded by rooms on three sides


[ ]
The court is surrounded by rooms on two side


[ ]
The court is surrounded by rooms on one side

17- Was there any uncovered courtyard in your shelter in the past and then you covered it?
[ ] Yes [ ] No

18- IF YES, why you covered it? (please write the reason in the space below)
....

Shelter No.:........................ OLD SHELTERS Date:......................

************ THERMAL ENVIRONMENT ************

19- Please assign a rating for thermal comfort at your shelter **in summer** while there is no cooling appliances work. Tick ✓ what is applied to you.(please write the floor number in which each space is located and the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Floor No.	Hot	Warm	Slightly Warm	Comfort	Slightly Cool	Cool	Cold
Kitchen									
Uncovered court									
Covered court									
Room1	....								
Room2	....								
Room3	....								
Room4	....								
Room5	....								

20- Using the list below, indicate the reasons that make your shelter hot in summer and mark them in order of their influences, where 1 = the most influential reason. (please indicate just what do you think is applied to you)

[ ] I do not know
[ ] Great heat gain through roof
[ ] The area of my shelter is small
[ ] Great heat gain through walls
[ ] Too much sunshine comes in through windows
[ ] Ventilation through windows is poor
[ ] too much sunshine comes in through the courtyard
[ ] The roof & external walls are exposed to solar radiation most of the time
[ ] Other reasons, please specify...

21- How is the air humidity in your shelter in summer?
[ ] Too Humid [ ] Humid [ ] Adequate [ ] Dry [ ] Too Dry

22- How is the air circulation in your shelter in summer?
[ ] Still [ ] Good circulation [ ] Too much circulation

23- How often does the sunshine enter your shelter in summer?
[ ] Always [ ] Often [ ] Seldom [ ] Never

24- How do you rate the intensity of solar radiation in your shelter in summer?
[ ] Too Much [ ] Adequate [ ] Poor [ ] No solar radiation

25- Do you have control over sunshine entered to your shelter in summer?
[ ] Yes [ ] No

26- How often do you open windows in summer?
[ ] Always [ ] Often [ ] Seldom [ ] Never

27- Indicate in the table below when you open windows in summer. (Check all that apply)

6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-02 am	2-4 am	4-6 am

28- Using the list below, indicate the reasons that you open windows in summer and mark them in order of their importance for you, where1= the most important reason.(please indicate just what is applied to you)

[ ] To let sunshine in
[ ] To increase cross ventilation
[ ] To let fresh air enter
[ ] To break monotony
[ ] To increase room spaciousness
[ ] To maintain visual contact to the outside
[ ] To increase the level of light
[ ] Let you know what the weather is
[ ] Let you see what is going on outside
[ ] Other, Please specify ....

29- How often do you use the windows for cross ventilation in summer? (cross ventilation means the circulation of fresh air through the openings (apertures) such as from open window to another window or to open door)
[ ] Always [ ] Often [ ] Seldom [ ] Never

30- Using the list below, indicate the reasons that you close windows in summer and mark them in order of their importance for you, where1= the most important reason. (Please indicate just what is applied to you)

[ ] To reduce outside noise
[ ] To reduce unpleasant smells
[ ] To reduce the heat from the sun
[ ] To avoid hazards (e.g. insects and mice)
[ ] To reduce hot air
[ ] To reduce dust
[ ] To reduce glare
[ ] To increase security
[ ] To decrease the level of visual stimulus from the outside
[ ] To increase visual privacy (Visual privacy means that no one outside can see you while you are at your shelter)
[ ] To increase speech privacy (Speech privacy means that no one outside can overhear you while you are taking at your shelter)
[ ] Other, Please specify...................................

2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

Shelter No.:......................... OLD SHELTERS Date:.....................

31- How often do you close the windows to reduce the penetrated solar radiation in summer?
[ ] Always [ ] Often [ ] Seldom [ ] Never

32- How about the size of your shelter windows, is it:
[ ] Big [ ] About Right [ ] Small

33- Indicate when you use the means in the table below for cooling purpose in summer. (please tick just what is applied to you)

	6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-2 am	2-4 am	4-6 am	Never used
Fan													
Natural ventilation													
Air conditioning													

34- Please assign a rating for thermal comfort at your shelter **in winter** while there is no heating appliances work. Tick ✓ what is applied to you (please write the floor number in which each space is located and the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Floor No.	Hot	Warm	Slightly Warm	Comfort	Slightly Cool	Cool	Cold
kitchen									
Uncovered court									
Covered court									
Room1	....								
Room2	....								
Room3	....								
Room4	....								
Room5	....								

35- Using the list below, indicate the reasons that make your shelter cold in winter and mark them in order of their influences, where 1 = the most influential reason. (please indicate just what do you think is applied to you)
[ ] I do not know
[ ] Great heat loss through walls
[ ] Great heat loss through roof
[ ] There is courtyard in my shelter
[ ] Great infiltration through windows and doors
[ ] Very little sunshine comes in through windows
[ ] My shelter is shaded by the surrounding shelters
[ ] Other reasons, please specify ....

36- How is the air humidity in your shelter in winter?
[ ] Too humid [ ] Humid [ ] Adequate [ ] Dry [ ] Too Dry

37- How is the air circulation in your shelter in winter?
[ ] Still [ ] Moderate circulation [ ] Too much circulation

38- Do you have control over air circulation in winter?
[ ] Yes [ ] No

39- How often does the sunshine enter your shelter in winter?
[ ] Always [ ] Often [ ] Seldom [ ] Never

40- How do you rate the intensity of solar radiation in your shelter in winter?
[ ] Excellent [ ] Good [ ] Moderate [ ] Poor [ ] No solar radiation

41- Using the list below, indicate which you use for heating purpose in winter

	6-8 am	8-10 am	10-12 am	12-2 pm	2-4 pm	4-6 pm	6-8 pm	8-10 pm	10-12 pm	12-2 am	2-4 am	4-6 am	Never used
Charcoal													
Wood													
Kerosene fire													
Gas fire													
Electric fire													
Air conditioning													

42- In terms of thermal comfort, in which season (winter or summer) do you think your shelter is better
[ ] In summer [ ] In winter [ ] The same

3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

Shelter No.:......................... OLD SHELTERS Date:......................

*************** VISUAL ENVIRONMENT ***************

43- How do you rate the natural light condition in your shelter **in summer** while there is no artificial light turned on? (please write the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Very Dim	Dim	Slightly Dim	Neutral	Slightly Bright	Bright	Very Bright
kitchen								
Uncovered court								
Covered court	....							
Room1	....							
Room2	....							
Room3	....							
Room4	....							
Room5								

44- How often does the amount of natural light in your shelter in summer allow you to see clearly?
[ ] Always [ ] Often [ ] Seldom [ ] Never

45- How often does the daylight in summer cause glare strong enough to bother you?
[ ] Always [ ] Often [ ] Seldom [ ] Never

46- How satisfied are you with the visual comfort of the daylight in summer? (Visual comfort occurs when the amount of light is sufficient and without any glare, reflections or contrast)
[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

47- Does the quality of natural light in your shelter in summer have a negative effect on your performance?
[ ] No effect at all [ ] Slight effect [ ] Moderate effect [ ] Large effect [ ] Very much effect

48- How often do you use only the light from the windows in summer?
[ ] Always [ ] Often [ ] Seldom [ ] Never

49- How do you rate the natural light condition in your shelter **in winter** while there is no artificial light turned on? (please write the name of every room as you called them in your shelter; as example, boys room, guest room, east room, rear room...etc)

	Room Name	Very Dim	Dim	Slightly Dim	Neutral	Slightly Bright	Bright	Very Bright
Kitchen								
Uncovered court								
Covered court	....							
Room1	....							
Room2	....							
Room3	....							
Room4	....							
Room5								

50- How often does the amount of natural light in your shelter in winter allow you to see clearly?
[ ] Always [ ] Often [ ] Seldom [ ] Never

51- How often does the daylight in winter cause glare strong enough to bother you?
[ ] Always [ ] Often [ ] Seldom [ ] Never

52- How satisfied are you with the visual comfort of the daylight in winter? (Visual comfort occurs when the amount of light is sufficient and without any glare, reflections or contrast)
[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

53- Does the quality of natural light in your shelter in winter have a negative effect on your performance?
[ ] No effect at all [ ] Slight effect [ ]Moderate effect [ ] Large effect [ ]Very much effect

54- How often do you use only the light from the windows in winter?
[ ] Always [ ] Often [ ] Seldom [ ] Never

55- Indicate in the table below when the artificial lights turned on in your shelter. (Please indicate just what is applied to you)

	5-6 am	6-7 am	7-8 am	8-9 am	9-10 am	10-11 am	11-12 am	12-1 pm	1-2 pm	2-3 pm	3-4 pm	4-5 pm	5-6 pm	6-7 pm	7-8 pm
In summer															
In winter															

56- Do you have control over the natural light in your shelter?
[ ] Yes [ ] No

4444444444444444444444

Shelter No.:......................... OLD SHELTERS Date:......................

57- When you are looking out of the window, do you experience that your view is restricted by any of the following elements?

	Very much restriction	Large restriction	Moderate restriction	Slight restriction	No restriction at all
By the window size					
By the height of window sill					
By the surrounding buildings					

58- Which of the following best describe the view out of the windows of your shelter? (Check all that apply)

[ ] Pleasant [ ] Boring [ ] Spacious [ ] Limited [ ] Simple

59- How much is the view outside important for you?

[ ] Not at all [ ] Slightly [ ] Moderately [ ] Largely [ ] Very much

60- How satisfied are you with the visual privacy in your shelter? (Visual privacy means that no one outside can see you while you are at your shelter)

[ ] Very Satisfied [ ] Satisfied [ ] Moderate [ ] Dissatisfied [ ] Very Dissatisfied

*************** ACOUSTIC ENVIRONMEN***************

61- What is the source of noise in your shelter? (Check all that apply)

[ ] Outdoor mechanical noise (such as joinery workshops, metal workshops, factories)

[ ] Outdoor traffic noise
[ ] Children playing in neighbouring areas

[ ] Internal noise
[ ] People talking in neighbouring areas

[ ] People passing in the street
[ ] Other, please specify...........

62- Does the distraction from noise bother you?

[ ] Not at all [ ] Slightly [ ] Moderately [ ] Largely [ ] Very much

63- How do you rate the noise level in your shelter?

[ ] Too much noise [ ] Noisy [ ] Neutral [ ] Calm [ ] Very calm

64- How satisfied are you with the noise level in your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

65- How much is the speech privacy important for you? (Speech privacy means that no one outside can overhear you while you are taking at your shelter)

[ ] not important [ ] slightly important [ ] moderately important [ ] largely important [ ] very much important

66- How often do you overhear your neighbours' private conservation?

[ ] Always [ ] Often [ ] Seldom [ ] Never

********** OTHER ENVIRONMENTAL FACTORS *********

67- How do you rate the amount of space/ area of your shelter?

	Very narrow	Narrow	Adequate	Spacious	Very Spacious
Rooms					
Uncovered court					
Covered court					
Kitchen					
Bath					

68- How satisfied are you with the amount of space/ area of your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

69- Which of the following is applied to the air in your shelter? (Check all that apply)

[ ] Stuffy air [ ] Unpleasant smells [ ] Too little ventilation [ ] Dusty air [ ] Fresh air [ ] Stale smelling air

70- How satisfied are you with the air quality in your shelter?

[ ] Very Satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied [ ] Very Dissatisfied

71- How do you rate the security level of your shelter?

[ ] Very high [ ] High [ ] Moderate [ ] Low [ ] Very low

72- Do you have solar heating water system implemented in your shelter?

[ ] Yes [ ] No

If No, What is the reason? (Check all that apply)

[ ] I do not desire [ ] I cannot afford its cost [ ] Other reasons, please specify.........................

73- If YES, how many panels? (Please write the number inside the box)

..................Panels

5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

Shelter No.:......................... OLD SHELTERS Date:......................

74- In which months dose the system provide you with the adequate amount of hot water. (Check all that apply)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

75- Do you use other means for heating the water?

[ ] Yes [ ] No

If Yes, what do you use?..

***************** GENERAL*****************

76- Suppose you could make changes to your overall shelter environment. Using the list below, indicate the changes you would make in order of preference, where 1 = the most preferred. (please indicate just what you would make)

[ ] Less noise [ ] Better natural light [ ] More speech privacy [ ] More view out
[ ] More area [ ] Better ventilation [ ] More visual privacy [ ] More comfortable temperatures
[ ] Fresh air [ ] More security [ ] Other (please specify)...................

77- Please add any additional comments about your shelter environment and about any features, you like or dislike in your shelter.

....

....

....

....

....

78- Do you agree for further survey to be taken place on your shelter in the future?

[ ] Yes [ ] No

Thank you for answering this questionnaire and we declare that the whole information which will be collected are only for research purpose and will be kept completely confidential.

Researcher
SANAA Y. H. SALEH
BSc in Architectural Engineering
MSc in Architecture and Renewable Energy
PhD Research Student
Department of Architecture and Built Environment
The University Of Nottingham

The University of Nottingham

استبيان

عوامل البيئة الداخلية في بيوت اللاجئين

الأخوة الكرام / الأخوات الكريمات القاطنين في مخيم جباليا

إن هذا الاستبيان يهدف إلى معرفة رأي اللاجئين الفلسطينين في الظروف البيئية داخل بيوتهم لتقييم مدى كفاءتها, و يُعد هذا الاستبيان جزء من بحث لإعداد رسالة الدكتوراه الذي تقوم به المهندسة سناء يوسف صالح بإشراف جامعة نوتينجهام في بريطانيا. و سيتم تحليل نتائج هذا الاستبيان في هذا البحث باستخدام طرق علمية أكاديمية متطورة يعقبه عمليات تحليلية دقيقة لهذه البيوت باستخدام برامج كمبيوتر متخصصة ذات تقنيات عالية .

ونلفت عنايتكم بأن هذا البحث هو الأول من نوعه والذي يعنى و يهتم ببيوت اللاجئين الفلسطينين في المخيمات آملين أن يتم من خلاله تحديد الجوانب التي بحاجة الي تحسين في هذه البيوت و المتعلقة بالارتياح الحراري, والإضاءة الطبيعية, و التهوية, و غيرها من الأمور البيئية نظرًا لتأثيرها الكبير على النواحي الصحية والاجتماعية والاقتصادية و النفسية, و من ثم إيجاد الحلول و المعالجات التكنولوجية التي ستساعد المهندسين في تصميم بيوت مريحة و ذات كفاءة عالية.

لذا نأمل في تعاونكم معنا بتعبئة هذا الاستبيان الذي يستغرق حوالي 30-40 دقيقة و نرجو منكم تحري الدقة في إجاباتكم التي سيتم تحليلها باهتمام بالغ لما لها من تأثير كبير على نتائج هذا البحث, و نوَد أن ننوه هنا أنه لا يوجد إجابات صحيحة أو إجابات خاطئة, و أن ما نريده في هذا الاستبيان هو الإدلاء بآرائكم في البيوت التي تسكنونها .

و لكم منا جزيل الشكر و التقدير

الباحثة
المهندسة / سناء يوسف صالح
بكالوريوس في الهندسة المعمارية
ماجستير في العمارة و الطاقة المتجددة
طالبة دكتوراه في تكنولوجيا البناء
جامعة نوتينجهام
بريطانيا






رقم البيت: .... **بيوت حديثة** التاريخ: ....

نلفت انتباه الأخوة الكرام و الأخوات الكريمات أن هذا الاستبيان يتكون من عدة مقاطع كالتالي:
أولا : معلومات عامة
ثانياً: البيئة الحرارية
ثالثاً: البيئة البصرية
رابعاً: البيئة الصوتية
خامساً: أمور بيئية أخرى
سادساً: عموميات

إرشادات :الرجاء ضع الإشارة [ ] أمام الإجابة التي تراها مناسبة .

*******************أولا: معلومات عامة*******************

-1 ما هو جنسك؟
[ ] ذكر [ ] أنثى

-2 كم عمرك ؟ (من فضلك اكتب العمر في الفراغ)
..................سنوات

-3 كم سنة أنت ساكن في هذا البيت لغاية الآن؟ (من فضلك اكتب عدد السنوات في الفراغ)
..................سنوات

-4 كم بطاقة تموين لديكم في البيت؟ (من فضلك اكتب الرقم في الفراغ)
............بطاقة تموين

-5 كم عدد الأشخاص الذين يسكنون هذا البيت؟ (من فضلك اكتب العدد في الفراغ)
...........الذين أعمارهم 15 عاما أو أقل ....الذين أعمارهم أكثر من 15 عام

-6 كم عدد طوابق بيتك؟ (من فضلك اكتب عدد الطوابق في الفراغ)
.... طابق

-7 كم مساحة كل طابق ؟(من فضلك اكتب الإجابة في الفراغ)
.......م2 الطابق الأول ...... م2 الطابق الثاني ....م2 الطابق الثالث ....م2 الطابق الرابع

-8 كم عدد الغرف في كل طابق؟(من فضلك اكتب عدد الغرف في الفراغ) (ملاحظة :الغرف تشمل غرف النوم و غرف الضيوف و غرف المعيشة)
.... في الطابق الأول .... في الطابق الثاني .... في الطابق الثالث .... في الطابق الرابع

-9 في أي سنة (عام) أعادت وكالة الغوث بناء هذا البيت؟ (من فضلك اكتب السنة في الفراغ)
....

-10 هل هناك أي إضافات أو تعديلات قمتم ببنائها في البيت؟
[ ] نعم [ ] لا

-11 إذا كانت هناك إضافات ,كم عدد الغرف و الطوابق التي تم إضافتها ؟(من فضلك اكتب العدد في الفراغ)
.........طوابق .... غرف

-12 إذا كانت هناك تعديلات, فما هي؟ (من فضلك اكتب التعديلات في الفراغ)
....

-13 ما هي مواد البناء المستخدمة في بناء الجدران في بيتك ؟(حدد كل ما ينطبق عليك)
[ ] حجر اسمنتي [ ] حجر رملي (بلدي) [ ] مواد أخرى (من فضلك حدد)...............................

-14 ما هي مواد البناء المستخدمة في الأسقف في بيتك؟(حدد كل ما ينطبق عليك)
[ ]زينكو [ ]اسبست [ ] قرميد [ ]صبة باطون [ ]ألواح خشب [ ] مواد أخرى (من فضلك حدد)..................

-15 ما هي مواد البناء المستخدمة في الأرضيات في بيتك؟(حدد كل ما ينطبق عليك)
[ ] بلاط [ ] كراميكا [ ] مـدة [ ] مواد أخرى (من فضلك حدد)...............................

-16 ماذا تستخدم لتفرش الأرض في بيتك في فصل الصيف ؟ (حدد كل ما ينطبق عليك)
[ ] موكيت [ ] سجاد [ ] حصيرة [ ] لا شئ [ ] أشياء أخرى (من فضلك حدد)..........................

-17 ماذا تستخدم لتفرش الأرض في بيتك في فصل الشتاء ؟ (حدد كل ما ينطبق عليك)
[ ] موكيت [ ] سجاد [ ] حصيرة [ ] لا شئ [ ] أشياء أخرى (من فضلك حدد)..........................

-18 ما هو نوع الشبابيك في بيتك ؟ (حدد كل ما ينطبق عليك)
[ ] أباجور ألمنيوم [ ] أباجور زجاج [ ] حديد [ ] زجاج و خشب(مزدوجة)
[ ] أباجور بلاستيك [ ] زجاج [ ] خشب [ ] أنواع أخرى (من فضلك حدد)..........................

رقم البيت: ....   بيوت حـديثـة   التاريخ: ....

***************** ثانياً:البيئــة الحــراريـــة *****************

-19 ما هو شعورك بمدى الإرتياح الحراري في بيتك في فصل الصيف بدون استخدام أي وسيلة للتهوية (مثل المروحة) أو التبريد (مثل المكيف).
(من فضلك حدد شعورك الحراري بوضع الإشارة (✓)، و اكتب رقم الطابق لكل فراغ مثل الأول, الثاني, الثالث و هكذا. و اكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	الطابق	بارد جداً	بارد	بارد قليلا	مريح	حار قليلا	حار	حار جداً
المطبخ									
غرفة 1	....								
غرفة 2	....								
غرفة 3	....								
غرفة 4	....								
غرفة 5	....								

-20 باستخدام القائمة في الأسفل حدد الأسباب التي تجعل بيتك حاراً في فصل الصيف مع ترتيب الأسباب بناءً على تأثيرها و إعطاء السبب الأكثر تأثيراً رقم [1] و رقم [2] للأقل و هكذا .(من فضلك حدد فقط ما تعتقد أنه ينطبق على بيتك)

[ ]لا أعرف   [ ] سقف بيتي و جدرانه الخارجية معرَضة لأشعة الشمس معظم الوقت
[ ] التهوية من الشبابيك قليلة   [ ] أشعة شمس كثيرة تدخل من الشبابيك
[ ] مساحة بيتي صغيرة   [ ] الحرارة تنتقل عبر الجدران بشكل كبير
[ ] الحرارة تنتقل عبر السقف بشكل كبير   [ ] أسباب أخرى(من فضلك حددها)...

-21 كيف تقيم رطوبة الهواء في بيتك في فصل الصيف؟

[ ] رطب جدا   [ ] رطب   [ ] ملائم   [ ] جاف   [ ] جاف جداً

-22 كيف تقيم حركة الهواء في بيتك في فصل الصيف؟

[ ] حركة قليلة (ساكن)   [ ] حركة جيدة   [ ] حركة شديدة

-23 ما معدل دخول أشعة الشمس في بيتك في فصل الصيف؟

[ ] دائماً   [ ] أحياناً   [ ] نادراً   [ ] لا تدخل أبداً

-24 كيف تقيم شدة أشعة الشمس في بيتك في فصل الصيف؟

[ ] كبيرة جداً   [ ] ملائمة   [ ] قليلة   [ ] لا يوجد أشعة شمس

-25 ما معدل فتح الشبابيك في بيتك في فصل الصيف ؟

[ ] دائماً   [ ] أحياناً   [ ] نادراً   [ ] أبداً

-26 حدد في الجدول في الأسفل متى تفتح الشبابيك في فصل الصيف ؟(اختر كل ما ينطبق عليك بوضع الإشارة (✓)

8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساءً	4-2 مساءً	6-4 مساءً	8-6 مساءً	10-8 مساءً	12-10 مساءً	2-12 صباحا	4-2 صباحا	6-4 صباحا

-27 باستخدام القائمة في الأسفل ,حدد الأسباب التي تجعلك تقوم بفتح الشبابيك في فصل الصيف مع ترتيب هذ الأسباب حسب أهميتها لك و إعطاء السبب الأكثر أهمية رقم [1], و رقم [2] للأقل أهمية و هكذا. (من فضلك حدد فقط ما ينطبق عليك)

[ ] للسماح بدخول الهواء النقي   [ ] للاستمتاع بالنظرإلى الخارج   [ ] للسماح لأشعة الشمس بالدخول
[ ] لكسر الملل   [ ] لزيادة الإضاءة الطبيعية   [ ] لزيادة التهوية الطبيعية (لخلق تيارات هواء داخل البيت)
[ ] لمعرفة أحوال الطقس   [ ] لزيادة الإحساس باتساع الغرفة   [ ] لمعرفة ما يحدث في الخارج
[ ] أسباب أخرى (من فضلك حددها)...

-28 ما معدل استخدامك للشبابيك للتهوية الطبيعية (تيارات الهواء) في فصل الصيف ؟(التهوية الطبيعية هنا تعني حركة الهواء النقي خلال الفتحات, مثلا من شباك مفتوح إلى شباك آخر مفتوح, أو من شباك مفتوح إلى باب مفتوح)

[ ] دائماً   [ ] أحياناً   [ ] نادراً   [ ] أبداً

-29 باستخدام القائمة في الأسفل, حدد الأسباب التي تجعلك تقوم بإغلاق الشبابيك في فصل الصيف مع ترتيب هذه الأسباب حسب أهميتها لك و إعطاء السبب الأكثر أهمية رقم [1], و رقم [2] للأقل أهمية, و هكذا. (من فضلك حدد فقط ما ينطبق عليك)

[ ] لمنع دخول الغبار   [ ] للتقليل من دخول الهواء الحار   [ ] لتقليل الوهج من الإضاءة الطبيعية
[ ] لمنع دخول الروائح غير الجيدة   [ ] لزيادة الأمن   [ ] لتجنب الأخطار كالحشرات و الفئران
[ ] للتقليل من دخول حرارة الشمس   [ ] لتقليل سماع الضجة من الخارج   [ ] لتقليل الإثارة بالنظر الى ما يحدث في الخارج
[ ] لزيادة الخصوصية البصرية (الخصوصية البصرية هنا تعني أن تكون غير مكشوف في بيتك من قبل الآخرين خارج البيت)
[ ] لزيادة الخصوصية في الكلام (الخصوصية في الكلام هنا تعني أنه عندما تتكلم في بيتك لا يسمعك جيرانك أو الناس في الخارج)
[ ] أسباب أخرى(من فضلك حددها)...

2222222222222222222222222

رقم البيت: .... بيوت حـديثـة التاريخ: ....

-30 ما معدل إغلاق الشبابيك للتقليل من أشعة الشمس في فصل الصيف؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-31 ما رأيك بحجم الشبابيك في بيتك؟ هل هو:

[ ] كبير [ ] مناسب [ ] صغير

-32 حدد أوقات استخدامك وسائل التهوية و التبريد الموضحة في الجدول في بيتك في فصل الصيف. (من فضلك حدد ما ينطبق عليك بوضع الإشارة✓)

وسيلة التهوية والتبريد	8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساءً	4-2 مساءً	6-4 مساءً	8-6 مساءً	10-8 مساءً	12-10 مساءً	2-12 صباحا	4-2 صباحا	6-4 صباحا	لا يستخدم أبدا
هواية (مروحة)													
تهوية طبيعية (تيارات الهواء)													
مكيف													

-33 ما هو شعورك بمدى الإرتياح الحراري في بيتك في **فصل الشتاء** بدون استخدام أي وسيلة للتدفئة. (من فضلك حدد شعورك الحراري بوضع الإشارة (✓). و اكتب رقم الطابق لكل فراغ مثل الأول, الثاني, الثالث و هكذا. و اكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	الطابق	بارد جداً	بارد	بارد قليلاً	مريح	حارقليلاً	حار	حار جداً
المطبخ									
غرفة 1	....								
غرفة 2	....								
غرفة 3	....								
غرفة 4	....								
غرفة 5	....								

-34 باستخدام القائمة في الأسفل حدد الأسباب التي تجعل منزلك بارداً في فصل الشتاء مع ترتيب الأسباب بناءً على تأثيرها و إعطاء السبب الأكثر تأثيراً رقم [1] و رقم [2] للأقل و هكذا .(من فضلك حدد فقط ما تعتقد أنه ينطبق على بيتك)

[ ] لا أعرف [ ] أشعة شمس قليلة تدخل من الشبابيك [ ] تسرب كبيرللهواء من الثقوب وحواف الشبابيك والأبواب

[ ] تسرب برودة كثير من السقف [ ] تسرب برودة كثير من الجدران [ ] المنازل المحيطة ببيتي تمنع وصول الشمس إليه

[ ] أسباب أخرى(من فضلك حددها)...

-35 كيف تقيم رطوبة الهواء في بيتك في فصل الشتاء؟

[ ] رطب جداً [ ] رطب [ ] ملائم [ ] جاف [ ] جاف جداً

-36 كيف تقيم حركة الهواء في بيتك في فصل الشتاء؟

[ ] حركة قليلة (ساكن) [ ] حركة متوسطة [ ] حركة شديدة

-37 ما معدل دخول أشعة الشمس في بيتك في فصل الشتاء؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] لا تدخل أبداً

-38 كيف تقيم شدة أشعة الشمس في بيتك في فصل الشتاء؟

[ ] ممتازة [ ] جيدة [ ] متوسطة [ ] قليلة [ ] لا يوجد أشعة شمس

-39 حدد أوقات استخدامك الوسائل في الجدول الآتي للتدفئة في بيتك في فصل الشتاء. (من فضلك حدد ما ينطبق عليك بوضع الإشارة (✓))

وسيلة التدفئة	8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساءً	4-2 مساءً	6-4 مساءً	8-6 مساءً	10-8 مساءً	12-10 مساءً	2-12 صباحا	4-2 صباحا	6-4 صباحا	لا يستخدم أبدا
فحم													
حطب (خشب)													
مدفأة كيروسين													
مدفأة غاز													
مدفأة كهربية													
مكيف													

-40 بالنسبة للارتياح الحراري , في أي فصل (صيفاً أم شتاءً) تعتقد أن بيتك أفضل؟

[ ] في فصل الصيف أفضل [ ] في فصل الشتاء أفضل [ ] نفس الشيئ صيفاً و شتاءً

3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

رقم البَيت: .... بيوت حـديثـة التاريخ: ....

********************ثالثاً:البيئــة البـصـريــة********************

-41 كيف تقيم مستوى الإضاءة الطبيعية في بيتك في **فصل الصيف** خلال النهار بدون استخدام أي إضاءة كهربائية؟ (من فضلك حدد ما ينطبق على بيتك بوضع الإشارة (✓) واكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	معتم جداً	معتم	معتم قليلا	وسط	ساطع قليلا	ساطع	ساطع جداً
المطبخ								
الممرات								
غرفة 1	....							
غرفة 2	....							
غرفة 3	....							
غرفة 4	....							
غرفة 5	....							

-42 هل كمية الإضاءة الطبيعية في بيتك في فصل الصيف تسمح لك بالرؤية بوضوح؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-43 ما معدل إنزعاجك من الإضاءة الطبيعية المفرطة و ما تسببه من وهج و لمعان في فصل الصيف؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-44 كم أنت راض عن مستوى الارتياح البصري للإضاءة الطبيعية في بيتك في فصل الصيف ؟ (الارتياح البصري يعني هنا الرضا بالإضاءة من حيث كميتها و خلوها من العيوب كالوهج الشديد أو الإنعكاسات)

[ ] راض جدا [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

-45 هل جودة الإضاءة الطبيعية في بيتك في فصل الصيف لها تاثيرات سلبية على ممارستك للأعمال اليومية (كالحركة و القراءة و غيرها) ؟

[ ] لا تأثيرسلبي أبدا [ ] تأثيرسلبي قليل [ ] تأثيرسلبي متوسط [ ] تأثيرسلبي كبير [ ] تأثيرسلبي كبير جدا

-46 ما معدل استخدامك للشبابيك لتوفير الإضاءة الطبيعية داخل البيت خلال النهار في فصل الصيف؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-47 كيف تقيم مستوى الإضاءة الطبيعية في بيتك في **فصل الشتاء** خلال النهار بدون استخدام أي إضاءة كهربائية؟ (من فضلك حدد ما ينطبق على بيتك بوضع الإشارة (✓) واكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	معتم جداً	معتم	معتم قليلا	وسط	ساطع قليلا	ساطع	ساطع جداً
المطبخ								
الممرات								
غرفة 1	....							
غرفة 2	....							
غرفة 3	....							
غرفة 4	....							
غرفة 5	....							

-48 هل كمية الإضاءة الطبيعية في بيتك في فصل الشتاء تسمح لك بالرؤية بوضوح؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-49 ما معدل إنزعاجك من الإضاءة الطبيعية المفرطة و ما تسببه من وهج و لمعان في فصل الشتاء؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-50 كم أنت راض عن مستوى الارتياح البصري للإضاءة الطبيعية في بيتك في فصل الشتاء؟ (الارتياح البصري يعني هنا الرضا بالإضاءة من حيث كميتها و خلوها من العيوب كالوهج الشديد أو الإنعكاسات)

[ ] راض جدا [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

-51 هل جودة الإضاءة الطبيعية في بيتك في فصل الشتاء لها تاثيرات سلبية على ممارستك للأعمال اليومية (كالحركة و القراءة و غيرها) ؟

[ ] لا تأثيرسلبي أبدا [ ] تأثيرسلبي قليل [ ] تأثيرسلبي متوسط [ ] تأثيرسلبي كبير [ ] تأثيرسلبي كبير جدا

-52 ما معدل استخدامك للشبابيك لتوفير الإضاءة الطبيعية داخل البيت خلال النهار في فصل الشتاء؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-53 حدد أوقات استخدامك الإضاءة الصناعية في بيتك؟ (من فضلك حدد ما ينطبق عليك بوضع الإشارة ✓)

	6-5 صباحا	7-6 صباحا	8-7 صباحا	9-8 صباحا	10-9 صباحا	11-10 صباحا	12-11 صباحا	1-12 مساءً	2-1 مساءً	3-2 مساءً	4-3 مساءً	5-4 مساءً	6-5 مساءً	7-6 مساءً	8-7 مساءً
في فصل الصيف															
في فصل الشتاء															

-54 هل تستطيع أن تتحكم في مستوى الإضاءة الطبيعية في بيتك؟

[ ] نعم [ ] لا

4444444444444444444444444444444444

رقم البيت: .... بيوت حـديثـة التاريخ: ....

-55 هل عندما تنظر إلى الخارج من الشبابيك وأنت في بيتك تواجه أي معوقات للرؤية بواسطة الأشياء المذكورة في الجدول التالي؟(من فضلك حدد ما ينطبق عليك بوضع الإشارة ✓)

معوقات الرؤية	أبداً لا	قليلا	متوسطا	كثيرا	كثيرا جدا
حجم الشباك					
ارتفاع الشباك					
المباني المحيطة ببيتك					

-56 كيف تقيم المنظر الخارجي (البيئة الخارجية) الذي تراه من خلال شبابيك بيتك؟ (من فضلك حدد كل ما ينطبق عليك)

[ ] مبهج [ ] ممل [ ] فسيح [ ] محدود [ ] بسيط

-57 ما مدى أهمية المنظر خارج البيت (البيئة الخارجية) بالنسبة إليك؟

[ ] غير مهم بتاتاً [ ] مهم قليلاً [ ] مهم [ ] مهم كثيرا [ ] مهم كثيرا جدا

-58 كم أنت راض عن مستوى الخصوصية البصرية في بيتك ؟ (الخصوصية البصرية هنا تعني أن تكون غير مكشوف في بيتك من قبل الأخرين خارج البيت)

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

****************** رابعاً:البيئـــة الصـوتيـــة ******************

-59 ما هو مصدر الضجيج (الضوضاء) في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] ناس يتكلمون في الجوار [ ] أطفال يلعبون في الجوار [ ] ناس يمرون في الشارع

[ ] حركة السيارات في الخارج [ ] ضجيج من داخل البيت [ ] آلات ميكانيكية (مثل محددة, منجرة, مصنع..... إلخ)

[ ] مصادر أخرى (حددها من فضلك)..

-60 هل الضجة (الضوضاء) تضايقك؟

[ ] أبداً [ ] قليلا [ ] وسط [ ] كثيرا [ ] كثيرا جدا

-61 كم تقيم مستوى الضجيج في بيتك؟

[ ] ضجيج عالٍ جداً [ ] ضجيج عالٍ [ ] ضجيج مقبول [ ] هادئ [ ] هادئ جداً

-62 كم أنت راض عن مستوى الضجيج (الضوضاء) في بيتك؟

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-63 ما مدى أهمية الخصوصية في الكلام بالنسبة إليك؟ (الخصوصية في الكلام هنا تعني أنه عندما تتكلم في بيتك لا يسمعك جيرانك أو الناس في الخارج)

[ ]غير مهمة أبداً [ ] مهمة قليلاً [ ] مهمة بشكل متوسط [ ] مهمة كثيرا [ ] مهمة كثيرا جدا

-64 هل تسمع أصوات جيرانك عندما يتحدثون؟

[ ] دائماً [ ] أحياناً [ ] نادرا [ ] أبدا

*****************خـامسـاً: أمـور بيئيـــة أخـرى *****************

-65 كيف تقيم مساحة بيتك؟(من فضلك حدد ما ينطبق علي بيتك بوضع الإشارة ✓ في الجدول التالي)

	ضيق جدا	ضيق	مناسب	واسع	واسع جدا
الغرف					
الممرات					
المطبخ					
الحمام					

-66 كم أنت راض عن مساحة بيتك؟

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-67 أي من الآتي ينطبق على طبيعة الهواء في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] هواء خانق [ ] روائح غير جيدة [ ] تهوية قليلة جداً [ ] هواء مليئ بالغبار [ ] هواء نقي [ ] هواء عفن

-68 كم أنت راض عن جودة الهواء في بيتك؟

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-69 كيف تقيم مستوى الأمن في بيتك؟

[ ] كبير جداً [ ] كبير [ ] متوسط [ ] قليل [ ] قليل جدا

-70 هل لديك نظام تسخين مياه شمسي (حمام شمسي) في بيتك؟

[ ] نعم [ ] لا

إذا كانت الإجابة لا. ماسبب عدم وجود نظام تسخين مياه شمسي في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] لا أرغب في ذلك [ ] لا أستطيع دفع ثمنه [ ] أسباب أخرى (من فضلك حددها)...

-71 إذا كانت الإجابة نعم. كم عدد اللوحات (المرايا)؟ (من فضلك اكتب الرقم في الفراغ)

.... لوحات

5555555555555555555555555

رقم البيت: .... **بيوت حـديثـة** التاريخ: ....

72- **في أي الشهور يزودك نظام تسخين المياه الشمسي بكمية مياه ساخنة كافية لك؟** (حدد ما ينطبق عليك بوضع الإشارة ✓ في الجدول التالي)

يناير	فبراير	مارس	أبريل	مايو	يونيو	يوليو	أغسطس	سبتمبر	أكتوبر	نوفمبر	ديسمبر

73- **هل تستخدم أي وسيلة أخرى لتخسين المياه ؟**
[ ] نعم [ ] لا
إذا كانت الإجابة نعم. ماذا تستخدم ؟..

*****************سادساً: عموميات*****************

74- إفترض أنك تستطيع أن تقوم بتغييرات لتحسين البيئة الداخلية في بيتك. باستخدم القائمة في الأسفل حدد التحسينات التي ترغب بها مع ترتيبها حسب المفضل لك, مع إعطاء التغيير المفضل أكثر رقم *[1]*, و رقم *[2]* للأقل, و هكذا .(من فضلك حدد فقط ما تفضل أن تقوم بتغيره)

[ ] حرارة مريحة أكثر [ ] ضجة أقل [ ] إمكانية النظر إلى الخارج أكثر [ ] خصوصية بصرية أكثر
[ ] أمن أكثر [ ] مساحة أكبر [ ] خصوصية في الكلام أكثر [ ] إضاءة طبيعية أكثر
[ ]هواء نقي [ ] تهوية جيدة [ ] تحسينات أخرى (من فضلك حددها)......................................

75- بإستخدام القائمة في الأسفل, حدد الجوانب التي هي أفضل في بيتك الآن مما كانت عليه في بيتك القديم (أي قبل أن تقوم وكالة الغوث ببنائه)؟
(حدد ما ينطبق عليك بوضع الإشارة ✓ في الجدول التالي)

الأفضل	الحرارة	الخصوصية البصرية	الإضاءة الطبيعية	الضجة	المساحة	الخصوصية في الكلام	التهوية	الأمن	جودة الهواء	إمكانية النظر إلى الخارج	جوانب أخرى (حددها من فضلك ....
بيتي الآن أفضل											
البيت القديم أفضل											
نفس الشيئ											

76- من فضلك أضف أي ملاحظات أخرى عن البيئة داخل بيتك و عن أي شيئ تحبه أو لا تحبه في بيتك.
....
....
....
....
....

77- نشكركم جزيل الشكر على الإدلاء بآرائكم في هذا الإستبيان و التي سيتم دراستها بدقة بالغة وعناية فائقة, و نوَد التنويه بأن هذا الاستبيان سيعقبه عدة مراحل بحثية تقنية و ربما يحتاج الباحث زيارتكم مرة أخرى للحصول على المزيد من المعلومات لذا نوَد أن نستطلع مدى استعدادكم بالموافقة على ذلك.
[ ] موافق [ ] غير موافق

شكرا لكم على تعاونكم في ملء هذا الإستبيان و نؤكد لكم أن جميع المعلومات المأخوذة من هذا الاستبيان هي لهدف البحث العلمي فقط, ولن يتم نشر أي معلومات شخصية في أي وسيلة إعلامية.

الباحثة
المهندسة / سناء يوسف صالح
بكالوريوس في الهندسة المعمارية
ماجستير في العمارة و الطاقة المتجددة
طالبة دكتوراه في تكنولوجيا البناء
جامعة نوتينجهام
بريطانيا

6666666666666666666666666666

The University of Nottingham

استبيان

عوامل البيئة الداخلية في بيوت اللاجئين

الأخوة الكرام / الأخوات الكريمات القاطنين في مخيم جباليا

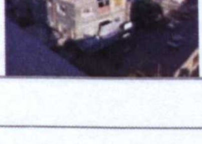
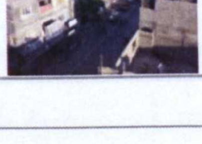
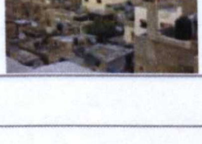
إن هذا الاستبيان يهدف إلى معرفة رأي اللاجئين الفلسطينين في الظروف البيئية داخل بيوتهم لتقييم مدى كفاءتها, و يُعد هذا الاستبيان جزء من بحث لإعداد رسالة الدكتوراه الذي تقوم به المهندسة سناء يوسف صالح بإشراف جامعة نوتينجهام في بريطانيا. و سيتم تحليل نتائج هذا الاستبيان في هذا البحث باستخدام طرق علمية أكاديمية متطورة يعقبه عمليات تحليلية دقيقة لهذه البيوت باستخدام برامج كمبيوتر متخصصة ذات تقنيات عالية .

ونلفت عنايتكم بأن هذا البحث هو الأول من نوعه والذي يعنى و يهتم ببيوت اللاجئين الفلسطينين في المخيمات آملين أن يتم من خلاله تحديد الجوانب التي بحاجة الي تحسين في هذه البيوت و المتعلقة بالارتياح الحراري, والإضاءة الطبيعية, و التهوية, و غيرها من الأمور البيئية نظرًا لتأثيرها الكبير على النواحي الصحية والاجتماعية والاقتصادية و النفسية, و من ثم إيجاد الحلول و المعالجات التكنولوجية التي ستساعد المهندسين في تصميم بيوت مريحة و ذات كفاءة عالية.

لذا نأمل في تعاونكم معنا بتعبئة هذا الاستبيان الذي يستغرق حوالي **30-40** دقيقة و نرجو منكم تحري الدقة في إجاباتكم التي سيتم تحليلها باهتمام بالغ لما لها من تأثير كبير على نتائج هذا البحث, و نوَد أن ننوه هنا أنه لا يوجد إجابات صحيحة أو إجابات خاطئة, و أن ما نريده في هذا الاستبيان هو الإدلاء بآرائكم في البيوت التي تسكنونها .

و لكم منا جزيل الشكر و التقدير

الباحثة
المهندسة / سناء يوسف صالح
بكالوريوس في الهندسة المعمارية
ماجستير في العمارة و الطاقة المتجددة
طالبة دكتوراه في تكنولوجيا البناء
جامعة نوتينجهام
بريطانيا

رقم البيت: .... بيوت قـديـمـة التاريخ: ....

نلفت انتباه الأخوة الكرام و الأخوات الكريمات أن هذا الاستبيان يتكون من عدة مقاطع كالتالي:
أولا : معلومـــات عـامـــة
ثـانـيـاً: الـبـيئــة الـحـراريـــة
ثـالـثـاً: الـبـيئــة الـبـصـريـــة
رابـعـاً: الـبـيئـة الـصـوتـيــة
خامساً: أمـور بيئيــة أخــرى
سادساً: عـمـومـيـات

إرشادات :الرجاء ضع الإشارة [✓] أمام الإجابة التي تراها مناسبة .

********************أولا: معلومـــات عـامـــة********************

-1 ما هو جنسك؟
[ ] ذكر [ ] أنثى

-2 كم عمرك ؟ (من فضلك اكتب العمر في الفراغ)
............سنوات

-3 كم سنة أنت ساكن في هذا البيت لغاية الآن؟ (من فضلك اكتب عدد السنوات في الفراغ)
...............سنوات

-4 كم بطاقة تموين لديكم في البيت؟ (من فضلك اكتب الرقم في الفراغ)
.... بطاقة تموين

-5 كم عدد الأشخاص الذين يسكنون هذا البيت؟ (من فضلك اكتب العدد في الفراغ)
..........الذين أعمارهم 15 عاما أو أقل ....الذين أعمارهم أكثر من 15 عام

-6 كم عدد طوابق بيتك؟ (من فضلك اكتب عدد الطوابق في الفراغ)
.... طابق

-7 كم مساحة كل طابق ؟(من فضلك اكتب الإجابة في الفراغ)
........م2 الطابق الأول .... م2 الطابق الثاني ....م2 الطابق الثالث ....م2 الطابق الرابع

-8 كم عدد الغرف في كل طابق؟(من فضلك اكتب عدد الغرف في الفراغ) (ملاحظة :الغرف تشمل غرف النوم و غرف الضيوف و غرف المعيشة)
.... في الطابق الأول .... في الطابق الثاني .... في الطابق الثالث .... في الطابق الرابع

-9 ما هي مواد البناء المستخدمة في بناء الجدران في بيتك ؟(حدد كل ما ينطبق عليك)
[ ] حجر اسمنتي [ ] حجر رملي (بلدي) [ ] مواد أخرى (من فضلك حدد)...

-10 ما هي مواد البناء المستخدمة في الأسقف في بيتك؟(حدد كل ما ينطبق عليك)
[ ]زينكو [ ]اسبست [ ] قرميد [ ]صبة باطون [ ]ألواح خشب [ ] مواد أخرى (من فضلك حدد)...............

-11 ما هي مواد البناء المستخدمة في الأرضيات في بيتك؟(حدد كل ما ينطبق عليك)
[ ] بلاط [ ] كراميكا [ ] مـدة [ ] مواد أخرى (من فضلك حدد)..

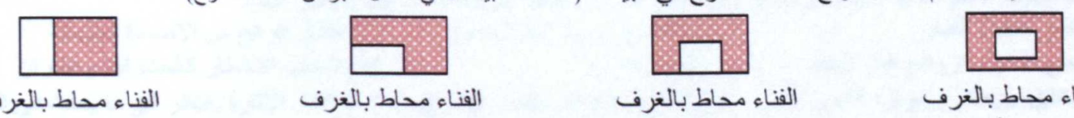
-12 ماذا تستخدم لتفرش الأرض في بيتك في فصل الصيف ؟ (حدد كل ما ينطبق عليك)
[ ] موكيت [ ] سجاد [ ] حصيرة [ ] لا شئ [ ] أشياء أخرى (من فضلك حدد)...........................

-13 ماذا تستخدم لتفرش الأرض في بيتك في فصل الشتاء ؟ (حدد كل ما ينطبق عليك)
[ ] موكيت [ ] سجاد [ ] حصيرة [ ] لا شئ [ ] أشياء أخرى (من فضلك حدد)...........................

-14 ما هو نوع الشبابيك في بيتك ؟ (حدد كل ما ينطبق عليك)
[ ] أباجورألمنيوم [ ] أباجور زجاج [ ] حديد [ ] زجاج و خشب(مزدوجة)
[ ] أباجور بلاستيك [ ] زجاج [ ] خشب [ ] أنواع أخرى (من فضلك حدد)..............................

-15 هل يوجد فناء مفتوح (غير مغطى) في بيتك في الوقت الحالي؟
[ ] نعم [ ] لا

-16 إذا كانت الإجابة نعم . حدد موقع الفناء المفتوح في البيت؟ (المساحة البيضاء في الشكل تعبرعن الفناء المفتوح)



الفناء محاط بالغرف من جميع الجهات	الفناء محاط بالغرف من ثلاث جهات	الفناء محاط بالغرف من جهتين	الفناء محاط بالغرف من جهة واحدة
[ ]	[ ]	[ ]	[ ]

-17 هل كان في بيتك في الماضي فناء مفتوح و قمتم بتغطيته؟
[ ] نعم [ ] لا

-18 إذا كانت الإجابة نعم . لماذا قمتم بتغطيته؟ (من فضلك اكتب السبب)
....

رقم البيت: .... بيوت قـديمـة التاريخ: ....

***************** ثانياً:البيئــة الحــراريـــة *****************

-19 ما هو شعورك بمدى الإرتياح الحراري في بيتك في فصل الصيف بدون استخدام أي وسيلة للتهوية (مثل المروحة) أوالتبريد (مثل المكيف).
(من فضلك حدد شعورك الحراري بوضع الإشارة (✓), و اكتب رقم الطابق لكل فراغ مثل الأول, الثاني, الثالث و هكذا. و اكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	الطابق	بارد جدا	بارد	بارد قليلا	مريح	حارقليلا	حار	حار جدا
المطبخ									
فناء مفتوح									
فناء مغطى									
غرفة 1	....								
غرفة 2	....								
غرفة 3	....								
غرفة 4	....								
غرفة 5	....								

-20 باستخدام القائمة في الأسفل حدد الأسباب التي تجعل بيتك حاراً في فصل الصيف مع ترتيب الأسباب بناءً على تأثيرها و إعطاء السبب الأكثر تأثيراً رقم [1] و رقم [2] للأقل و هكذا .(من فضلك حدد فقط ما تعتقد أنه ينطبق على بيتك)

[ ]لا أعرف [ ] أشعة شمس كثيرة تدخل من خلال الفناء المفتوح [ ] الحرارة تنتقل عبر الجدران بشكل كبير
[ ] التهوية من الشبابيك قليلة [ ] أشعة شمس كثيرة تدخل من الشبابيك [ ] الحرارة تنتقل عبرالسقف بشكل كبير
[ ] مساحة بيتي صغيرة [ ] سقف بيتي و جدرانه الخارجية معرَضة لأشعة الشمس معظم الوقت
[ ] أسباب أخرى(من فضلك حددها)..............................

-21 كيف تقيم رطوبة الهواء في بيتك في فصل الصيف؟
[ ] رطب جداً [ ] رطب [ ] ملائم [ ] جاف [ ] جاف جداً

-22 كيف تقيم حركة الهواء في بيتك في فصل الصيف؟
[ ] حركة قليلة (ساكن) [ ] حركة جيدة [ ] حركة شديدة

-23 ما معدل دخول أشعة الشمس في بيتك في فصل الصيف؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] لا تدخل أبداً

-24 كيف تقيم شدة أشعة الشمس في بيتك في فصل الصيف؟
[ ] كبيرة جداً [ ] ملائمة [ ] قليلة [ ] لا يوجد أشعة شمس

-25 هل تستطيع أن تتحكم في كمية أشعة الشمس التي تدخل بيتك في فصل الصيف؟
[ ] نعم [ ] لا

-26 ما معدل فتح الشبابيك في بيتك في فصل الصيف ؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-27 حدد في الجدول في الأسفل متى تفتح الشبابيك في فصل الصيف ؟(اختر كل ما ينطبق عليك بوضع الإشارة (✓)

8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساء	4-2 مساء	6-4 مساء	8-6 مساء	10-8 مساء	12-10 مساء	2-12 صباحا	4-2 صباحا	6-4 صباحا

-28 باستخدام القائمة في الأسفل, حدد الأسباب التي تجعلك تقوم بفتح الشبابيك في فصل الصيف مع ترتيب هذ الأسباب حسب أهميتها لك و إعطاء السبب الأكثر أهمية رقم [1], و رقم [2] للأقل أهمية و هكذا. (من فضلك حدد فقط ما ينطبق عليك)

[ ] للسماح بدخول الهواء النقي [ ] للاستمتاع بالنظرإلى الخارج [ ] للسماح لأشعة الشمس بالدخول
[ ] لكسر الملل [ ] لزيادة الإضاءة الطبيعية [ ] لزيادة التهوية الطبيعية (لخلق تيارات هواء داخل البيت)
[ ] لمعرفة أحوال الطقس [ ] لزيادة الإحساس باتساع الغرفة [ ] لمعرفة ما يحدث في الخارج
[ ] أسباب أخرى (من فضلك حددها).............................

-29 ما معدل استخدامك للشبابيك للتهوية الطبيعية (تيارات الهواء) في فصل الصيف ؟(التهوية الطبيعية هنا تعني حركة الهواء النقي خلال الفتحات, مثلا من شباك مفتوح إلى شباك أخر مفتوح, أو من شباك مفتوح إلى باب مفتوح)
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-30 باستخدام القائمة في الأسفل, حدد الأسباب التي تجعلك تقوم بإغلاق الشبابيك في فصل الصيف مع ترتيب هذه الأسباب حسب أهميتها لك و إعطاء السبب الأكثر أهمية رقم [1], و رقم [2] للأقل أهمية, و هكذا. (من فضلك حدد فقط ما ينطبق عليك)

[ ] لمنع دخول الغبار [ ] للتقليل من دخول الهواء الحار [ ] لتقليل الوهج من الإضاءة الطبيعية
[ ] لمنع دخول الروائح غير الجيدة [ ] لزيادة الأمن [ ] لتجنب الأخطار كالحشرات و الفئران
[ ] للتقليل من دخول حرارة الشمس [ ] لتقليل سماع الضجة من الخارج [ ] لتقليل الإثارة بالنظر الى ما يحدث في الخارج
[ ] لزيادة الخصوصية البصرية (الخصوصية البصرية هنا تعني أن تكون غير مكشوف في بيتك من قبل الآخرين خارج البيت)
[ ] لزيادة الخصوصية في الكلام (الخصوصية في الكلام هنا تعني أنه عندما تتكلم في بيتك لا يسمعك جيرانك أو الناس في الخارج)
[ ] أسباب أخرى(من فضلك حددها).............................

2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

رقم البيت: .... بيوت قـديمــة التاريخ: ....

31- ما معدل إغلاق الشبابيك للتقليل من أشعة الشمس في فصل الصيف؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

32- ما رأيك بحجم الشبابيك في بيتك؟ هل هو:

[ ] كبير [ ] مناسب [ ] صغير

33- حدد أوقات استخدامك وسائل التهوية و التبريد الموضحة في الجدول في بيتك في فصل الصيف. (من فضلك حدد ما ينطبق عليك بوضع الإشارة✓)

وسيلة التهوية والتبريد	8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساءً	4-2 مساءً	6-4 مساءً	8-6 مساءً	10-8 مساءً	12-10 مساءً	2-12 صباحا	4-2 صباحا	6-4 صباحا	لا يستخدم أبدا
هواية (مروحة)													
تهوية طبيعية (تيارات الهواء)													
مكيف													

34- ما هو شعورك بمدى الإرتياح الحراري في بيتك في **فصل الشتاء** بدون استخدام أي وسيلة للتدفئة. (من فضلك حدد شعورك الحراري بوضع الإشارة (✓). و اكتب رقم الطابق لكل فراغ مثل الأول, الثاني, الثالث و هكذا. و اكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	الطابق	بارد جداً	بارد	بارد قليلا	مريح	حارقليلا	حار	حار جداً
المطبخ									
فناء مفتوح									
فناء مغطى									
غرفة 1	....								
غرفة 2	....								
غرفة 3	....								
غرفة 4	....								
غرفة 5	....								

35- باستخدام القائمة في الأسفل حدد الأسباب التي تجعل منزلك بارداً في فصل الشتاء مع ترتيب الأسباب بناءً على تأثيرها و إعطاء السبب الأكثر تأثيراً رقم [1] و رقم [2] للأقل و هكذا .(من فضلك حدد فقط ما تعتقد أنه ينطبق على بيتك)

[ ] لا أعرف [ ] أشعة شمس قليلة تدخل من الشبابيك [ ] تسرب كبيرللهواء من الثقوب وحواف الشبابيك والأبواب

[ ] تسرب برودة كثير من السقف [ ] تسرب برودة كثير من الجدران [ ] المنازل المحيطة ببيتي تمنع وصول الشمس إليه

[ ] يوجد فناء مفتوح في بيتي [ ] أسباب أخرى(من فضلك حددها)...

36- كيف تقيم رطوبة الهواء في بيتك في فصل الشتاء؟

[ ] رطب جداً [ ] رطب [ ] ملائم [ ] جاف [ ] جاف جداً

37- كيف تقيم حركة الهواء في بيتك في فصل الشتاء؟

[ ] حركة قليلة (ساكن) [ ] حركة متوسطة [ ] حركة شديدة

38- هل تستطيع أن تتحكم في حركة الهواء داخل بيتك في فصل الشتاء؟

[ ] نعم [ ] لا

39- ما معدل دخول أشعة الشمس في بيتك في فصل الشتاء؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] لا تدخل أبداً

40- كيف تقيم شدة أشعة الشمس في بيتك في فصل الشتاء؟

[ ] ممتازة [ ] جيدة [ ] متوسطة [ ] قليلة [ ] لا يوجد أشعة شمس

41- حدد أوقات استخدامك الوسائل في الجدول الآتي للتدفئة في بيتك في فصل الشتاء. (من فضلك حدد ما ينطبق عليك بوضع الإشارة (✓))

وسيلة التدفئة	8-6 صباحا	10-8 صباحا	12-10 صباحا	2-12 مساءً	4-2 مساءً	6-4 مساءً	8-6 مساءً	10-8 مساءً	12-10 مساءً	2-12 صباحا	4-2 صباحا	6-4 صباحاً	لا يستخدم أبدا
فحم													
حطب (خشب)													
مدفأة كيروسين													
مدفأة غاز													
مدفأة كهربية													
مكيف													

42- بالنسبة للارتياح الحراري , في أي فصل (صيفاً أم شتاءً) تعتقد أن بيتك أفضل؟

[ ] في فصل الصيف أفضل [ ] في فصل الشتاء أفضل [ ] نفس الشيئ صيفاً و شتاءً

3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

رقم البيت: .... بيوت قـديمـة التاريخ: ....

*****************ثالثاً:البيئـــة البـصـريـــة*****************

-43 كيف تقيم مستوى الإضاءة الطبيعية في بيتك في **فصل الصيف** خلال النهار بدون استخدام أي إضاءة كهربائية؟ (من فضلك حدد ما ينطبق علي بيتك بوضع الإشارة (✓) واكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	معتم جداً	معتم	معتم قليلا	وسط	ساطع قليلا	ساطع	ساطع جداً
المطبخ								
فناء مفتوح								
فناء مغطى								
غرفة 1	....							
غرفة 2	....							
غرفة 3	....							
غرفة 4	....							
غرفة 5	....							

-44 هل كمية الإضاءة الطبيعية في بيتك في فصل الصيف تسمح لك بالرؤية بوضوح؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-45 ما معدل إنزعاجك من الإضاءة الطبيعية المفرطة و ما تسببه من وهج و لمعان في فصل الصيف؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-46 كم أنت راض عن مستوى الارتياح البصري للإضاءة الطبيعية في بيتك في فصل الصيف ؟ (الارتياح البصري يعني هنا الرضا بالإضاءة من حيث كميتها و خلوها من العيوب كالوهج الشديد أو الإنعكاسات)
[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

-47 هل جودة الإضاءة الطبيعية في بيتك في فصل الصيف لها تاثيرات سلبية على ممارستك للأعمال اليومية (كالحركة و القراءة و غيرها) ؟
[ ] لا تأثيرسلبي أبداً [ ] تأثيرسلبي قليل [ ] تأثيرسلبي متوسط [ ] تأثيرسلبي كبير [ ] تأثيرسلبي كبير جداً

-48 ما معدل استخدامك للشبابيك لتوفيرالإضاءة الطبيعية داخل البيت خلال النهار في فصل الصيف؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-49 كيف تقيم مستوى الإضاءة الطبيعية في بيتك في **فصل الشتاء** خلال النهار بدون استخدام أي إضاءة كهربائية؟ (من فضلك حدد ما ينطبق علي بيتك بوضع الإشارة (✓) واكتب اسم الغرفة كما تسميها في بيتك, مثل غرفة الأولاد– غرفة الضيوف– الغرفة الشرقية– الغرفة الخلفية.... إلخ)

	اسم الغرفة	معتم جداً	معتم	معتم قليلا	وسط	ساطع قليلا	ساطع	ساطع جداً
المطبخ								
فناء مفتوح								
فناء مغطى								
غرفة 1	....							
غرفة 2	....							
غرفة 3	....							
غرفة 4	....							
غرفة 5	....							

-50 هل كمية الإضاءة الطبيعية في بيتك في فصل الشتاء تسمح لك بالرؤية بوضوح؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-51 ما معدل إنزعاجك من الإضاءة الطبيعية المفرطة و ما تسببه من وهج و لمعان في فصل الشتاء؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-52 كم أنت راض عن مستوى الارتياح البصري للإضاءة الطبيعية في بيتك في فصل الشتاء؟ (الارتياح البصري يعني هنا الرضا بالإضاءة من حيث كميتها و خلوها من العيوب كالوهج الشديد أو الإنعكاسات)
[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

-53 هل جودة الإضاءة الطبيعية في بيتك في فصل الشتاء لها تاثيرات سلبية على ممارستك للأعمال اليومية (كالحركة و القراءة و غيرها) ؟
[ ] لا تأثيرسلبي أبداً [ ] تأثيرسلبي قليل [ ] تأثيرسلبي متوسط [ ] تأثيرسلبي كبير [ ] تأثيرسلبي كبير جداً

-54 ما معدل استخدامك للشبابيك لتوفيرالإضاءة الطبيعية داخل البيت خلال النهار في فصل الشتاء؟
[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبداً

-55 حدد أوقات استخدامك الإضاءة الصناعية في بيتك؟ (من فضلك حدد ما ينطبق عليك بوضع الإشارة ✓)

	6-5 صباحا	7-6 صباحا	8-7 صباحا	9-8 صباحا	10-9 صباحا	11-10 صباحا	12-11 صباحا	1-12 مساء	2-1 مساء	3-2 مساء	4-3 مساء	5-4 مساء	6-5 مساء	7-6 مساء	8-7 مساء
في فصل الصيف															
في فصل الشتاء															

-56 هل تستطيع أن تتحكم في مستوى الإضاءة الطبيعية في بيتك؟
[ ] نعم [ ] لا

4444444444444444444

رقم البيت: .... بيوت قـديـمـة التاريخ: ....

-57 هل عندما تنظر إلى الخارج من الشبابيك وأنت في بيتك تواجه أي معوقات للرؤية بواسطة الأشياء المذكورة في الجدول التالي؟(من فضلك حدد ما ينطبق عليك بوضع الإشارة ✔)

معوقات الرؤية	أبداً لا	قليلا	متوسطاً	كثيراً	كثيراً جدا
حجم الشباك					
ارتفاع الشباك					
المباني المحيطة ببيتك					

-58 كيف تقيم المنظر الخارجي (البيئة الخارجية) الذي تراه من خلال شبابيك بيتك؟ (من فضلك حدد كل ما ينطبق عليك)

[ ] مبهج [ ] ممل [ ] فسيح [ ] محدود [ ] بسيط

-59 ما مدى أهمية المنظر خارج البيت (البيئة الخارجية) بالنسبة إليك؟

[ ] غير مهم بتاتاً [ ] مهم قليلاً [ ] مهم [ ] مهم كثيراً [ ] مهم كثيراً جدا

-60 كم أنت راض عن مستوى الخصوصية البصرية في بيتك ؟ (الخصوصية البصرية هنا تعني أن تكون غير مكشوف في بيتك من قبل الأخرين خارج البيت)

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبداً

****************** رابعاً:البيئــة الصــوتيــة ******************

-61 ما هو مصدر الضجيج (الضوضاء) في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] ناس يتكلمون في الجوار [ ] أطفال يلعبون في الجوار [ ] ناس يمرون في الشارع

[ ] حركة السيارات في الخارج [ ] ضجيج من داخل البيت [ ] آلات ميكانيكية (مثل محددة, منجرة, مصنع, ... إلخ)

[ ] مصادر أخرى (حددها من فضلك)...

-62 هل الضجة (الضوضاء) تضايقك؟

[ ] أبداً [ ] قليلا [ ] وسط [ ] كثيراً [ ] كثيرا جدا

-63 كم تقيم مستوى الضجيج في بيتك؟

[ ] ضجيج عالٍ جدا [ ] ضجيج عالٍ [ ] ضجيج مقبول [ ] هادئ [ ] هادئ جداً

-64 كم أنت راض عن مستوى الضجيج (الضوضاء) في بيتك؟

[ ] راض جدا [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-65 ما مدى أهمية الخصوصية في الكلام بالنسبة إليك؟ (الخصوصية في الكلام هنا تعني أنه عندما تتكلم في بيتك لا يسمعك جيرانك أو الناس في الخارج)

[ ]غير مهمة أبدا [ ] مهمة قليلا [ ] مهمة بشكل متوسط [ ] مهمة كثيراً [ ] مهمة كثيرا جدا

-66 هل تسمع أصوات جيرانك عندما يتحدثون؟

[ ] دائماً [ ] أحياناً [ ] نادراً [ ] أبدا

******************خـامسـاً: أمـور بيئيــة أخــرى ******************

-67 كيف تقيم مساحة بيتك؟(من فضلك حدد ما ينطبق علي بيتك بوضع الإشارة ✔ في الجدول التالي)

	ضيق جداً	ضيق	مناسب	واسع	واسع جداً
الغرف					
الفناء المفتوح					
الفناء المغطى					
المطبخ					
الحمام					

-68 كم أنت راض عن مساحة بيتك؟

[ ] راض جداً [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-69 أي من الأتي ينطبق على طبيعة الهواء في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] هواء خانق [ ] روائح غير جيدة [ ] تهوية قليلة جداً [ ] هواء مليئ بالغبار [ ] هواء نقي [ ] هواء عفن

-70 كم أنت راض عن جودة الهواء في بيتك؟

[ ] راض جدا [ ] راض [ ] وسط [ ]غير راضي [ ] غير راضي أبدا

-71 كيف تقيم مستوى الأمن في بيتك؟

[ ] كبير جداً [ ] كبير [ ] متوسط [ ] قليل [ ] قليل جداً

-72 هل لديك نظام تسخين مياه شمسي (حمام شمسي) في بيتك؟

[ ] نعم [ ] لا

إذا كانت الإجابة لا. ماسبب عدم وجود نظام تسخين مياه شمسي في بيتك؟ (حدد كل ما ينطبق عليك)

[ ] لا أرغب في ذلك [ ] لا أستطيع دفع ثمنه [ ] أسباب أخرى (من فضلك حددها).......................................

-73 إذا كانت الإجابة نعم. كم عدد اللوحات (المرايا)؟ (من فضلك اكتب الرقم في الفراغ)

.... لوحات

5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5

رقم البيت: .... بيوت قــديمــة التاريخ: ....

-74 في أي الشهور يزودك نظام تسخين المياه الشمسي بكمية مياه ساخنة كافية لك؟ (حدد ما ينطبق عليك بوضع الإشارة ✓ في الجدول التالي)

يناير	فبراير	مارس	أبريل	مايو	يونيو	يوليو	أغسطس	سبتمبر	أكتوبر	نوفمبر	ديسمبر

-75 هل تستخدم أي وسيلة أخرى لتخسين المياه ؟

[ ] نعم [ ] لا

إذا كانت الإجابة نعم. ماذا تستخدم ؟...

******************سادساً: عموميات******************

-76 إفترض أنك تستطيع أن تقوم بتغييرات لتحسين البيئة الداخلية في بيتك. باستخدم القائمة في الأسفل حدد التحسينات التي ترغب بها مع ترتيبها حسب المفضل لك, مع إعطاء التغيير المفضل أكثر رقم [1], و رقم [2] للأقل, و هكذا .(من فضلك حدد فقط ما تفضل أن تقوم بتغيره)

[ ] حرارة مريحة أكثر [ ] ضجة أقل [ ] إمكانية النظر إلى الخارج أكثر [ ] خصوصية بصرية أكثر

[ ] أمن أكثر [ ] مساحة أكبر [ ] خصوصية في الكلام أكثر [ ] إضاءة طبيعية أكثر

[ ]هواء نقي [ ] تهوية جيدة [ ] تحسينات أخرى (من فضلك حددها)..

-77 من فضلك أضف أي ملاحظات أخرى عن البيئة داخل بيتك و عن أي شيئ تحبه أو لا تحبه في بيتك.

....

....

....

....

....

-78 نشكركم جزيل الشكر على الإدلاء بآرائكم في هذا الإستبيان و التي سيتم دراستها بدقة بالغة وعناية فائقة, و نوَد التنويه بأن هذا الاستبيان سيعقبه عدة مراحل بحثية تقنية و ربما يحتاج الباحث زيارتكم مرة أخرى للحصول على المزيد من المعلومات لذا نوَد أن نستطلع مدى استعدادكم بالموافقة على ذلك.

[ ] موافق [ ] غير موافق

شكرا لكم على تعاونكم في ملء هذا الإستبيان و نؤكد لكم أن جميع المعلومات المأخوذة من هذا الاستبيان هي لهدف البحث العلمي فقط, ولن يتم نشر أي معلومات شخصية في أي وسيلة إعلامية.

الباحثة
المهندسة / سناء يوسف صالح
بكالوريوس في الهندسة المعمارية
ماجستير في العمارة و الطاقة المتجددة
طالبة دكتوراه في تكنولوجيا البناء
جامعة نوتينجهام
بريطانيا

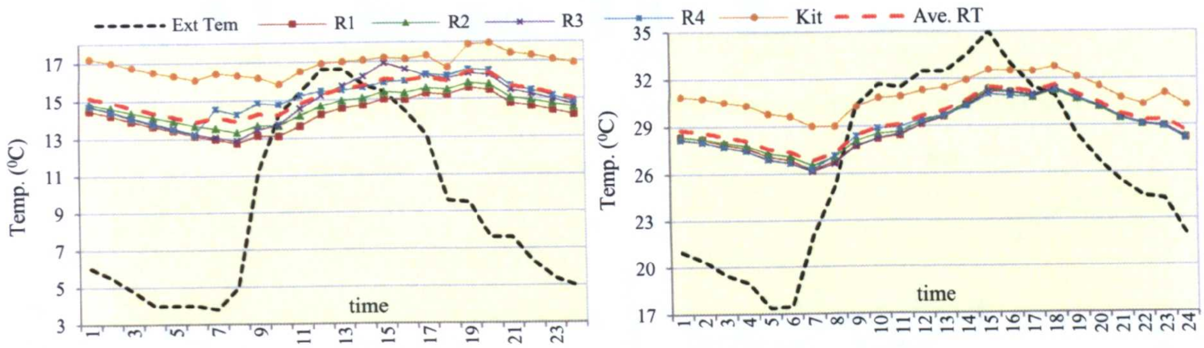
66666666666666666666

APPENDIX C

EXAMPLES OF SHELTERS` THERMAL ANALYSIS

APPENDIX C: EXAMPLES OF SHELTERS` THERMAL ANALYSIS

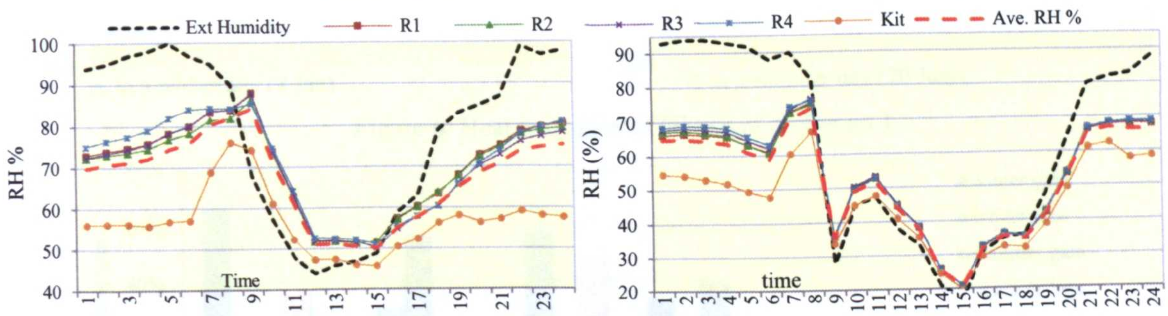
Results for Thermal Analysis of Shelter No.1



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 1: Resultant Temperature RT in shelter no.1



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 2: Relative Humidity RH in shelter no.1

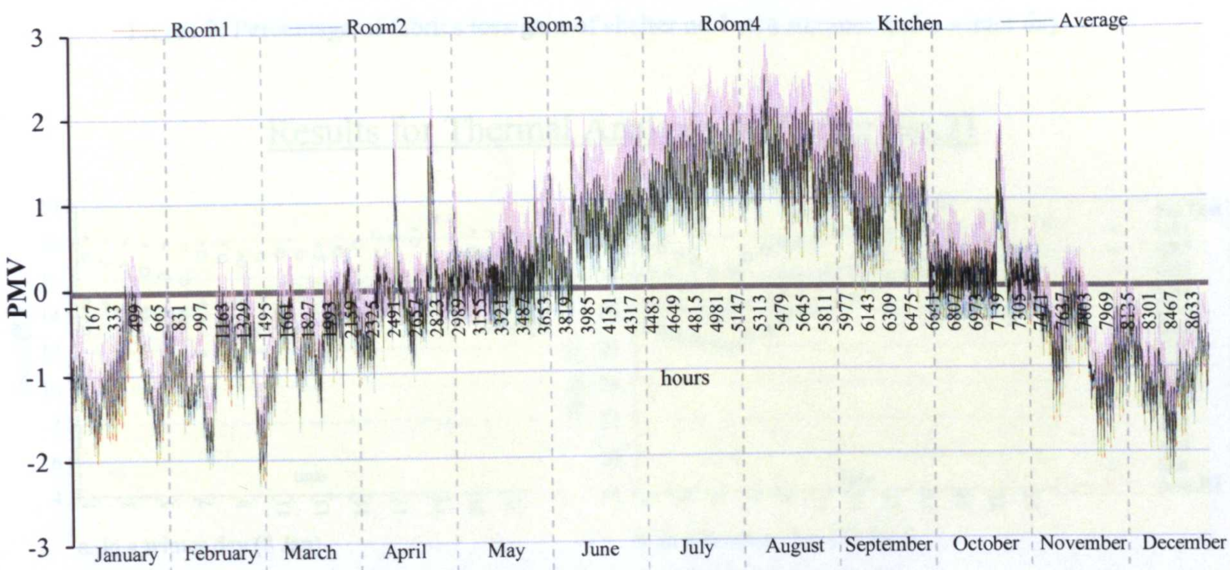
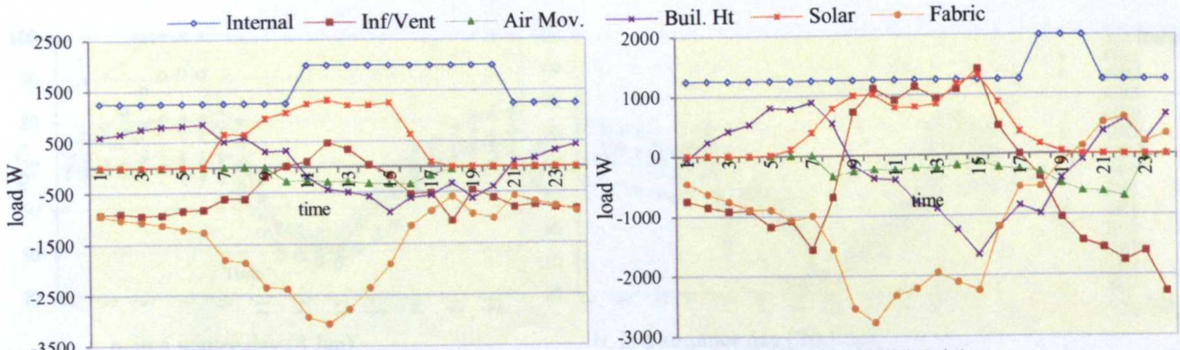


Figure 3: Hourly predicted mean vote PMV for shelter no.1



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 4: Loads breakdown in shelter no.1

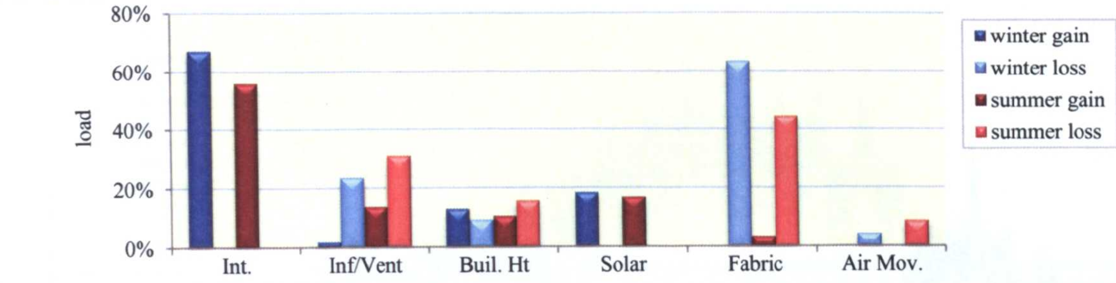
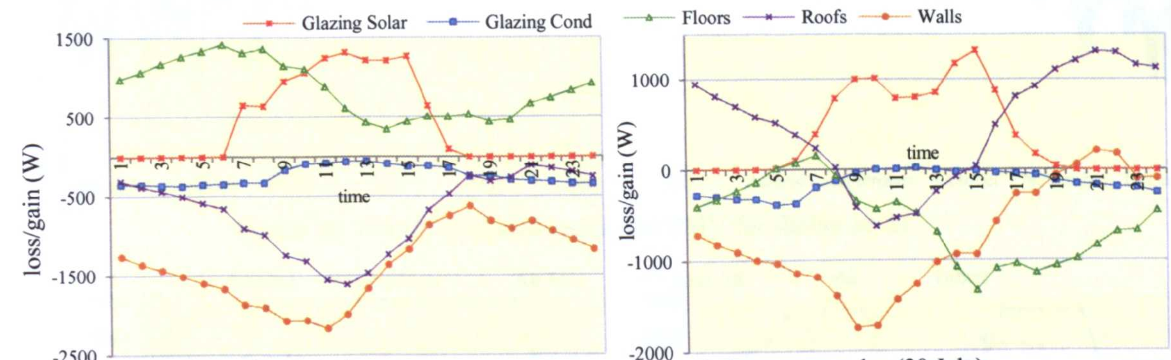


Figure 5: Percentage of loads breakdown in a summer and a winter day for shelter no.1



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 6: Heat loss/ gain of fabrics in shelter no.1

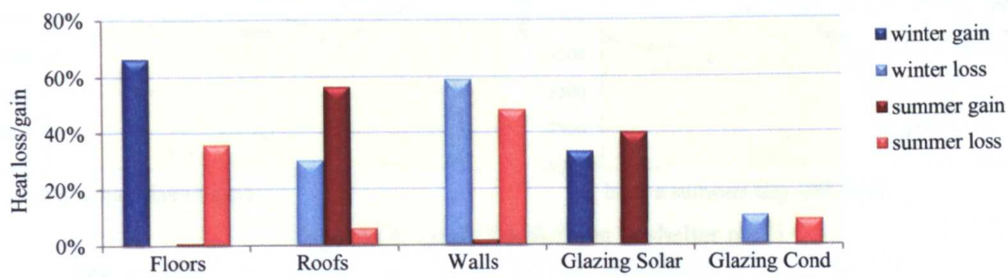
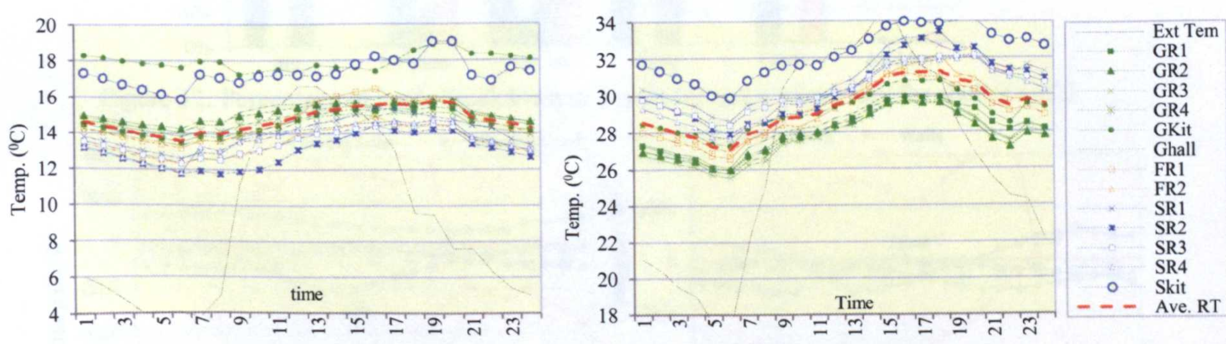


Figure 7: Percentage of fabrics loss/gain of shelter no.1 in a summer and a winter day

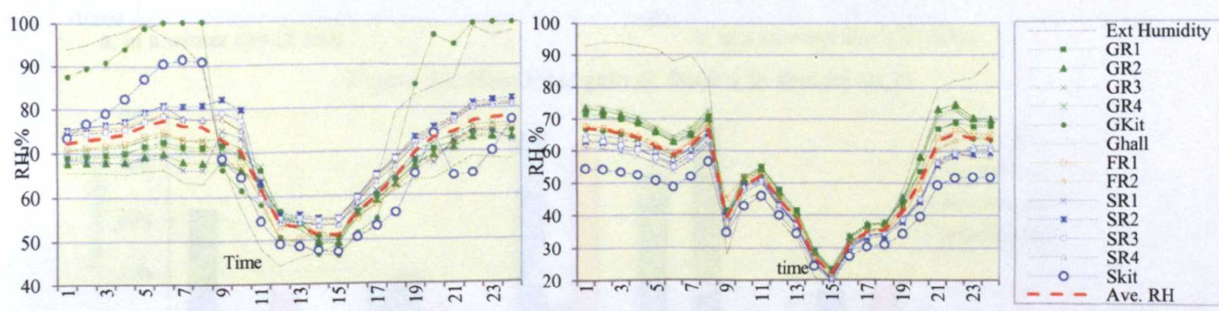
Results for Thermal Analysis of Shelter No.21



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 8: Resultant Temperature RT in shelter no.21



a. in a winter day (8 Jan)

b. in a summer day (20 July)

Figure 9: Relative Humidity RH in shelter no.21

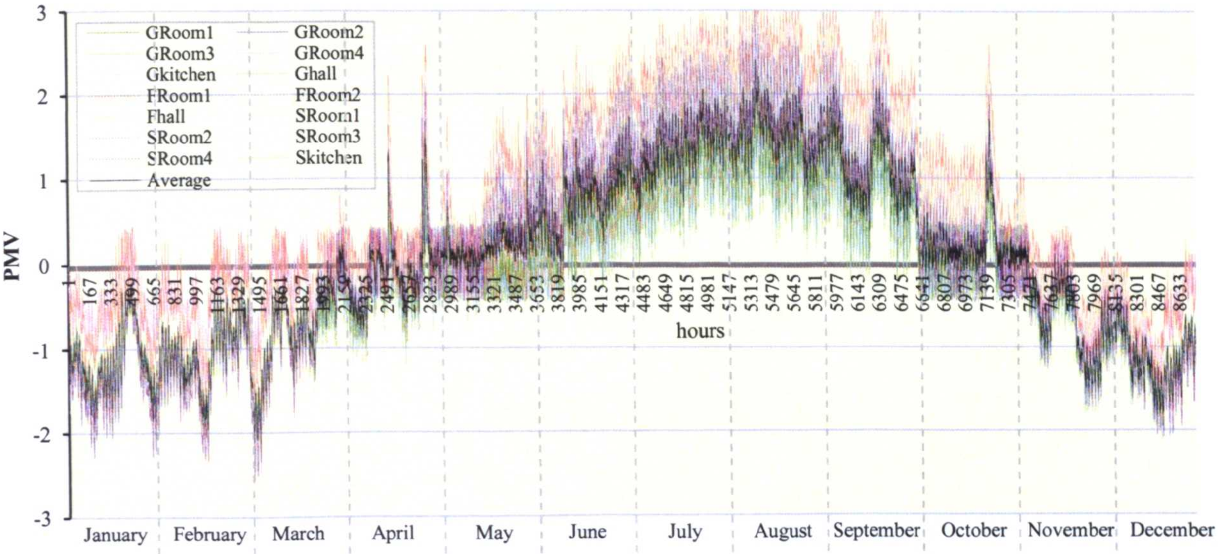


Figure 10: Hourly predicted mean vote PMV for shelter no.21

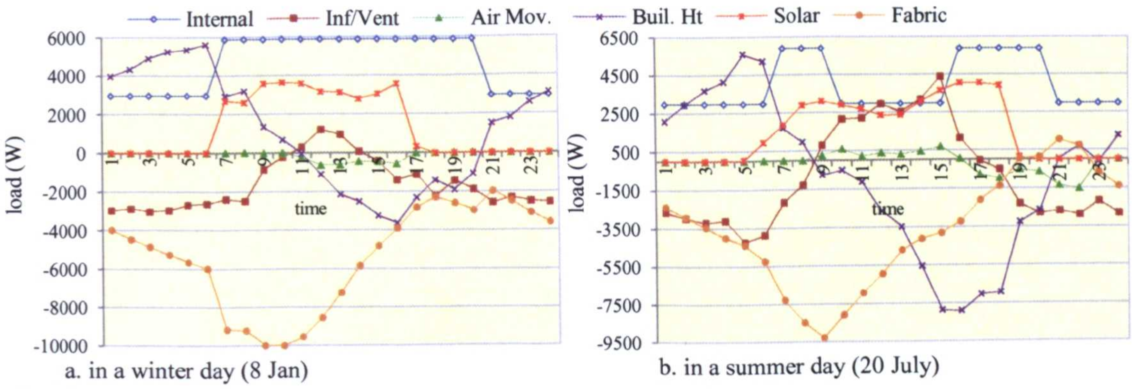


Figure 11: Loads breakdown in shelter no.21

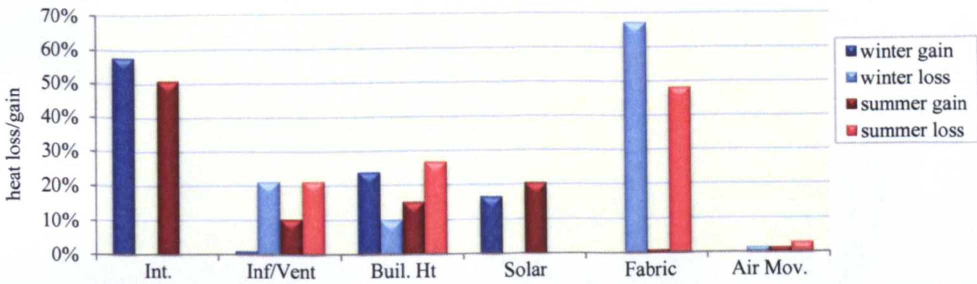


Figure 12: Percentage of loads breakdown in a summer and a winter day for shelter no.21

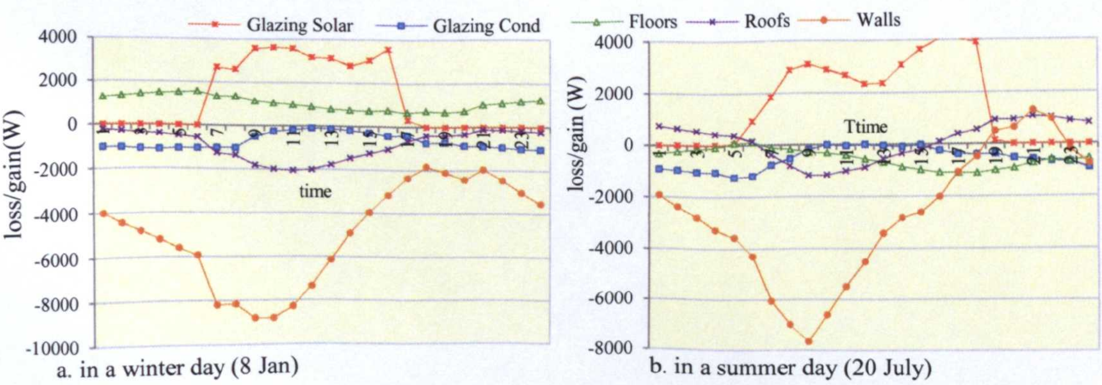


Figure 13: Heat loss/ gain of fabrics in shelter no.21

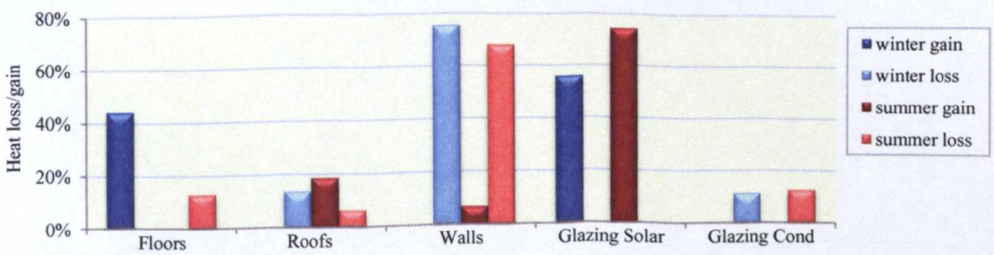


Figure 14: Percentage of fabrics loss/gain of shelter no.21 in a summer and a winter day