EVALUATING THE OCCUPANTS SATISFACTION REGARDING THE THERMAL PERFORMANCE OF COMMON PRACTICES IN APARTMENT BUILDINGS' ENVELOPES IN HEBRON, PALESTINE

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ABSTRACT

Building envelope highly influences the levels of energy required to achieve thermal comfort and occupants' satisfaction. A proper envelope design through the selection of the proper material leads to better indoor air quality, life cycle performance, and energy efficiency. The thermal performance of a building is a result of the interaction between its construction features along with the climatic conditions of the site. The envelopes layering, materials selection, air cavity, and construction methods determine its capability of transmitting, storing, or emitting heat which is often neglected in the design process in Palestine.
In Hebron, Palestine; due to the continuing increase of population rates and the limited ability of urban expansion due to geographical limitations referring to political reasons; apartment buildings are becoming more prominent in the latest building tendency. Currently, residential buildings are suffering from the lack of thermal comfort measures and other poor indoor environment quality indicators.
This paper introduces an evaluation study for occupants' satisfaction regarding the apartment buildings in Hebron, Palestine through the assessment of the occupants' satisfaction regarding the indoor environment measures in the Mediterranean climate. Multistorey buildings consisting of multiple apartments were included in an intensive field survey to analyse the thermal properties and capabilities of these buildings' envelopes in the common practices in Hebron city.

KEYWORDS: Building envelope, occupants' satisfaction, apartment buildings, Mediterranean climate.

INTRODUCTION

Modern architecture nowadays tends to use larger windows and a larger ratio of curtain walls in different building types, with no consideration for the indoor environment; which has created indoor environment problems and thermal discomfort, leading to increased use of electrical ventilation, heating, and cooling; therefore, excessive energy consumption Specificata fonte non valida.. Statistics have stated that HVAC systems in standard buildings are responsible for more than 50% of the global annual energy consumption Specificata fonte non valida..

(Monna, Barlet, Haj Hussein, Bruneau, & Baba, 2019) Performed an evaluating study of thermal comfort for residential buildings in summer and winter in Palestine from a user-based approach. The paper was based on quantitative measurements for typical multi-story apartment buildings in Palestine. The study further depended on a qualitative survey of inhabitants' satisfaction with their dwellings. The paper does not discuss any interventions or construction solutions for enhancing the residents' satisfaction. The study concludes that the perceived comfort level seems more related to the inhabitants' psychological feeling of powerlessness than to real thermal comfort, which confirms that inhabitants may tend to adapt to the surrounding indoor environment rather than enhance it.

The Palestinian building sector's construction techniques have changed significantly in the last decade; modern techniques, reinforced concrete, and stone cladding have widely spread in Palestine. These practices have led to lowering thermal comfort in the indoor environment of the modern buildings due to certain thermal properties of the buildings' envelope, which implies larger heating and cooling burdens which increase the energy consumption (Khammash, 2002).

This paper introduces an evaluating study for occupants' satisfaction levels depending on the assessment of occupants' predicted mean votes regarding the indoor environment measures in apartments buildings in Hebron city which presents a sample for apartments buildings in Palestine. Multistorey buildings consisting of multiple apartments were included in an intensive field survey to analyze the thermal properties and capabilities of these buildings' envelopes in the common practices in Hebron city in reference to the local climatic conditions.

The study performs as an analytical assessment for the apartment's buildings in Hebron governorate. A questionnaire survey for multistorey apartment buildings' occupants had been conducted; to investigate the levels of comfort and satisfaction for this building typology in Hebron. The questionnaire allows a more accurate estimation of the levels of thermal satisfaction and a more precise determination of the most used cooling and heating patterns in apartments as a result to certain design matters.

Thermal Comfort and Building Envelope

Thermal comfort is one of the international trends for energy saving design scope as well as achieving high quality internal spaces is an architectural and interior design inquirySpecificata fonte non valida.. Indoor environment quality has a great impact on occupants' productivity, health, and wellbeing since people of modern society are spending most of their time indoor Specificata fonte non valida. Specificata fonte non valida.. Studies concerning thermal comfort goes back to the 19th century; back when Haldane studied design temperatures in England in 1905 (Georgiou, 2015). The definition of thermal comfort continued to gain further attention in the 20th century when comfort was referred to as a 'shelter' protecting users from severe environmental conditions Specificata fonte non valida.. Thermal comfort has started gaining wider eco in the fields of research and had been increasingly highlighted as an international concern since 2006Specificata fonte non valida..

Definition of thermal comfort

Thermal comfort is defined according to ASHRAE standards as the conditions providing a satisfactory state of mind in response to the surrounding thermal environment Specificata

fonte non valida.. Occupants are considered thermally comfortable when they can practice their intended activities comfortably within the indoor environment Specificata fonte non valida..

Thermal comfort assessment indices

According to the ISO and ASHREA standards, the two main standard thermal comfort measuring indicators are the predicted mean votes (PMV) and the percentage of people dissatisfied (PPD) Specificata fonte non valida. Specificata fonte non valida.. The PMV depending on Fanger's experiments subjecting a group of occupants under the same circumstances thermal comfort measuring indices depended on providing a clear prediction for the levels of discomfort or dissatisfaction within a space through scaling levels from 'cold' to 'hot' on a seven-point scale from -3 to +3, where -3= cold, -2= cool, -1= slightly cool, 0= neutral, +1=slightly warm, +2= warm, and +3= hot. The PPD predicts the dominant percentage of people feeling 'too cold' or 'too hot'. According to Fanger people who responded within ranges of (-3, -2, +2, +3) were considered in discomfort and responses of (-1, 0, +1) were declared in comfort Specificata fonte non valida.. However, controlling, verification, and considering deviation implies applying indices among people from the same ethnic group and from the same geographic region, in a good health condition, and genuinely in the same age group whereby children are not considered Specificata fonte non valida..

Thermal comfort in residential buildings

Residential buildings are generally not comparable to the scaling approaches, the predicted mean votes (PMV) and the percentage of people dissatisfied (PPD) previously mentioned can be obtained using a questionnaires or personal interviews. According to Peeters, studies concerning thermal comfort in residential buildings can be based on distinguishing three different thermal zones depending on the thermal requirements of domestic spaces: bathrooms, bedrooms, and other zones including mainly the kitchen, living room and office Specificata fonte non valida..

Energy consumption and thermal comfort

International urbanization and rapid economic development are causing the world great challenges involving energy shortage. Residential buildings designs in the last few decades have been suffering from insufficient passive cooling or heating strategies and poor building envelopes' design creating inefficient systems suffering from lack of energy awareness. Humans' requirements of thermal comfort are improving, and people are tending to use air conditioners all year long Specificata fonte non valida.. Therefore, giving a more significant interest in thermal comfort highly improves occupants' production rates and saves energy (Georgiou, 2015). It was proven that the residential sector is consuming 31% of the global energy consumption. Thus, energy saving is becoming an international concern Specificata fonte non valida.;Specificata fonte non valida.. Recent studies have also shown high levels of energy consumption reaching up to 68% for mechanical heating and cooling to achieve thermal comfort Specificata fonte non valida..

Most residential buildings in Hebron are suffering from poor thermal insulation, which in term leads to significantly increase in the use of heating and cooling systems and relatively increase the energy consumption. According to Specificata fonte non valida. Palestinians may spend 3.5%-21.6% of their monthly income on heating less than 10% of their dwellings in winter. This along with other minor influencing factors has caused a continuous rise in the

levels of consumed energy in residential buildings in Hebron to reach around 43% of the total energy consumption and 38% of the greenhouse gas emissions (GHG) per year Specificata fonte non valida.. Which requires serious interventions for enhancing the indoor thermal comfort, which is considered directly related to lowering the levels of needed energy.

THERMAL COMFORT IN RESIDENTIAL BUILDINGS IN HEBRON

The study takes place in Hebron city, one of the largest Palestinian cities, located in the centric area of Palestine, to the south of Jerusalem. Hebron has a Mediterranean climate with hot summers and wet cold winter with temperatures reaching its peak of around 29°C in summer, temperatures has scored a minimum measure in winter of around 3°C and rarely below 0°C or above 32°C (Meteoblue weather , 2019); (Weather-Spark, 2019). In 2018 the maximum air temperature reached 21.9°C, the minimum air temperature was 13.7°C, and the mean air temperature was 17.3°C, the averages of air temperature in Hebron in 2010-2018. The average of relative humidity rates in Hebron was around 65% according to the statistics of the years 2010-2018 (PCBS, Averages of relative humidity in the westbank 2010-2018, 2018).

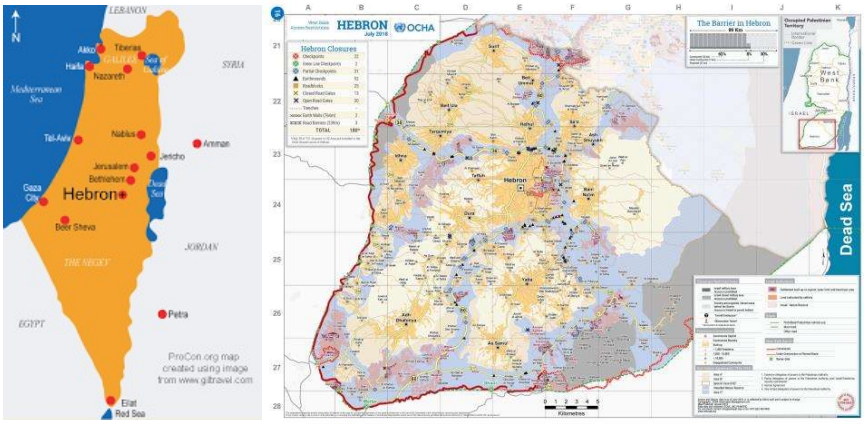

Figure 1 (Left): Palestine Map showing Hebron in the middle.
Figure 2 (Right): Hebron governorate map.
[online; 2018_OCHA_OpT_map_Hebron.jpg (2500×1768) (wikimedia.org)]

Buildings in Palestine mostly use stone as external cladding and interior decorating material. According to the Palestinian Bureau of statistics and the building license statistics in the first quarter of 2012, more than 743 new residential buildings, 157 new buildings of other functions, 248 residential buildings' extensions, and 43 existing buildings' extensions used stone as external cladding material (PBS, 2012). Stone is also considered the most durable construction material and highly encourages the Palestinian economy, neglecting the environmental side effects of the stone industry (Abu Hanieh, AbdElall, & Hasan, 2013). Stone was also used in traditional architecture, but with different construction methods; traditional architecture involved passive design solutions, which aimed to enhance the levels of thermal sensation using local, durable, sustainable, and environmentally friendly materials and methodsSpecificata fonte non valida.. Materials used in traditional and modern buildings are different in their physical properties, such as density, thermal conductivity, and heat transfer. Traditional buildings were built with natural, local, and sustainable raw materials such as

(mud, earth, and stone). Moreover, traditional buildings were built to be thermally heavy with thick walls and small openings and have taken the local climatic conditions into consideration to achieve thermal and acoustic comfort within the low economic possibilities. (Tawayha, Braganca, & Mateus, 2019). A study conducted in Jenin confirms the role of building envelope to reduce the consumed energy for heating and cooling in residential buildings. In a comparative analysis, the study concludes with a 46% in energy saving when comparing traditional buildings with a modern un-insulated building Specificata fonte non valida.. Traditional architecture and building strategies have depended on the region climatic conditions; therefore, designing walls, openings, shading devices was considered in reference to reducing heat gain in hot summer seasons and increasing solar intake in cold winter seasons Specificata fonte non valida.. The following two figures shows the contrast between old and new Hebron city urban context.

Figure 3: The old city of Hebron showing The Ibrahimic Mosque. (Hammouri, [online, 2020])
Figure 4: Hebron city center showing the modern building trends. (Hammouri, [online, 2021])

Traditional architecture when compared to modern building tendencies has proven to be more efficient in terms of thermal performance. According to (Baker , 2011), comparing the thermal transmittance (U-value) aids as a tool for evaluating the thermal performance. Depending on the thermal properties for certain building materials as shown in Table 1 below (PBC, 2015), the U-value was calculated for both modern and traditional building envelopes. The study further explained the envelope layering and thicknesses as shown in Table 2 as follows. The study has compared the thermal transmittance or a selected sample of an uninsulated modern building in Hebron the U-value equalled 3.75 (W/m^2. K). which is considered relatively high in comparison to a selected sample of traditional buildings which U- value equaled 1.81 (W/m^2. K) in reference to the Palestinian Building Code (PBC, 2015).

Table 1. Materials' thermal characteristics according to (PBC, 2015).

Material	Thickness (d) m	Thermal conductivity (k) W/m.k	Apparent mass density (ρ) kg/m^3	Thermal resistance (R) $m^2.K/W$
Old Stone	0.20	1.7	2250	0.11
New Stone	0.05	1.7	2250	0.03
Mud//Wadi gravel	0.60	1.50/0.3	1250	0.33
Concrete	0.20	1.75	2300	0.11
Concrete block	0.10	0.9	1400	0.11
Plaster	0.02	1.2	2000	0.016
Foam insulation	0.05	1.7	2250	0.03
Gypsum	0.02	0.21	1000	0.095

Table 2: Thermal transmittance of traditional and modern envelopes

	Wall section (outer to inner)	Thickness m	Thermal Transmittance (U-value) W/m². K
Traditional building envelopes	1. Stone	0.20	1.81
	2. Mud	0.60	
	3. Stone	0.20	
Uninsulated modern building envelopes	1. Stone	0.05	3.759
	2. Concrete	0.20	
	3. Concrete block	0.10	
	4. Plaster	0.02	

The thermal behaviour of stone in the modern building is not efficient as it was in the traditional buildings due to many reasons such as the small thickness of walls in comparison to that in traditional and high thermal transmittance of stone, stone mortar and concert because of using different mixtures in the concrete slurry, among these the Calcium hydroxide and Calcium Silicate; which enhances thermal insulation (Zheng & Wei, 2000). Enhancing techniques of stone walls' thermal characteristics include adding some insulation materials to the building elements composition (Khammash, 2002). For example Ca(OH)2, which is used in the stone mortar in traditional buildings, produces a lightweight thermal insulation material with high temperature resistance and excellent insulation properties with U value of 0.042-0.081 when added to the to the SiO2 and glass fibre, the mixture could be added for concrete and Portland cement mixtures (Kurbus, et al., 1984).

The study is focused on analysing apartments buildings since they form the most common building typology in Hebron and other Palestinian cities as previously mentioned, according to the Palestinian Central Bureau of Statistics the percentage of residential apartment's buildings has been increasing in the last two decades. The percentage has nearly doubled from 39.9% in the year 2000, and 53.7% in 2015, to 61.5% in 2017 (PCBS, Palestinian Bureau of statistics: Housing in Palestine, Annual report, 2017) as shown in Figure 5 below. The percent has increased to make the residential apartments the most common building typology in Palestine. This percentage equals 46.6% in Hebron (PCBS, Palestinian Bureau of statistics: Housing in Palestine, Annual report, 2017).

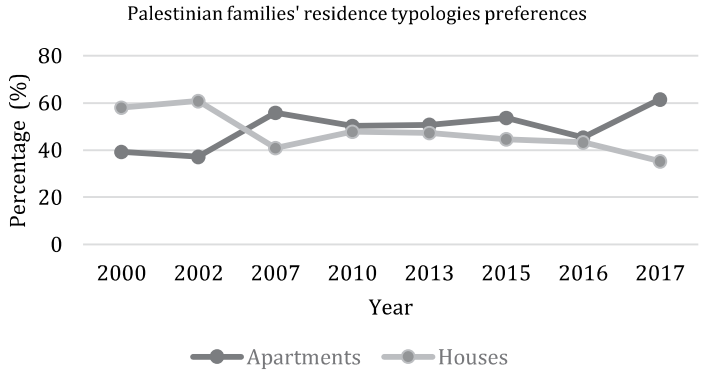

Figure 5: Palestinian families' residence typologies preferences.

Regarding the percentage distribution of households in Palestine by tenure of housing unit, around 84.6% of the Palestinians housing units were classified as owned houses according to the statistics of 2017; this percentage equaled 89.3% in Hebron in the same year (PCBS, Palestinian Bureau of statistics: Housing in Palestine, Annual report, 2017). Figure 6 proves the steady tendency of household ownership in Palestine in the last two decades.

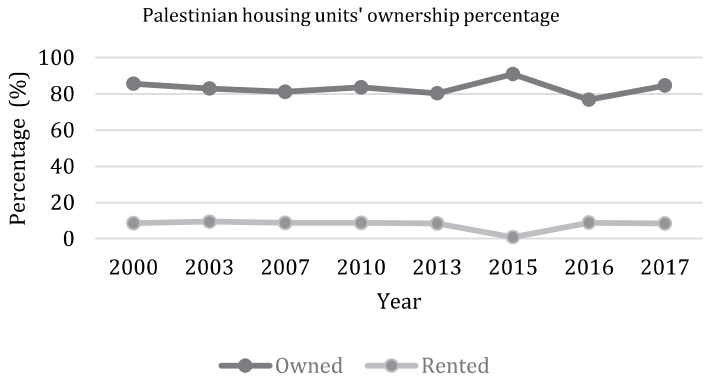

Figure 6: Palestinian housing units' ownership percentage

The illustrated measures shown in the graphs explain the motives for targeting owned apartment buildings for data collection in the physical field survey using questionnaires and field measurements, due to this reason, the questionnaire had included questions regarding the type and household of the housing units. The study has investigated owned residences rather than rented units to be more related to the current social fabric to extend the validity and the feasibility of the study which in term will better meet the Palestinian community's needs.

RESEARCH FINDINGS AND CONCLUSION

Data collection

Questionnaires are considered one of the most frequently used investigation methods for the evaluation of occupants' satisfaction and behaviour rates, moreover, there most cost effective. Monitoring the behaviours of users could be achieved in a low-intrusion level using questionnaires, and data could be collected on multiple levels explaining motivation for certain actions and practices (Hong, Yan, D'Oca, & Chen, 2016), (Wagner, O'Brien, & Dong, 2018). According to (Balvedi, Ghisi, & Lamberts, 2018), questionnaires are the recurrent method used in residential buildings. However, monitoring these self-reported behaviours must be through direct questions to avoid misinterpretations. Questionnaires were used as analytical tools or studies conducted to assess users in their dwellings, for example, (Andersen, Toftum, Andersen, & Oles, 2009) had employed a questionnaire to collect users replies inferring about Danish dwellings' openings, lighting, heating, and other analysed indoor environment controllers. (Feng, Yan, & Wang, 2015) had also used questionnaires' results to develop the building typical patterns through monitoring the habits of the residents affecting air conditioning consumption in living room and bedrooms of residential buildings. The first phase of data collection process has mainly depended on previous studies and literature review. Similar previous studies regarding thermal comfort were investigated to

indicate the used indices and measurement tools for thermal comfort, the phase of literature review has focused on the external walls as a main component of a building's envelope, explaining the physical and thermal properties to be considered in the subjected simulation model. Defining the thermal transmittance, the thermal heat transfer coefficient, the thermal mass, and the potential of thermal bridges occurrence were key elements to be solved during the simulation for a more thermally reliable external wall model.
The qualitative data collection extends to include field surveys and samples selection. This study included a physical field survey depending on systematic observations and personal interviews, to serve data collection regarding the occupants' thermal sensations and to better understand their perception of thermal comfort, and to better describe the current thermal conditions of residential buildings in Hebron, the survey also aims to explain the increasingly high demand of heating and cooling in residential apartments, which in term relates to the achievement of thermal comfort nowadays, and therefore excessive energy consumption. Moreover, the survey helps defining an essential first step of this research, which is the occupants' need for achieving better thermal comfort.
The field survey includes three methods of data collection; a) the qualitative data, which was collected through the interviews, questionnaires distribution, and on field observations b) the quantitative data was collected using physical field measurements in a group of selected samples for residential multi-story apartments' buildings in Hebron.

Questionnaires and personal interviews

The questionnaire and personal interviews aim to provide a better understanding and a wider perception of the thermal conditions in existing residential apartments in Hebron, occupants' thermal sensation, thermal preference, and thermal adaptation in their homes. The questionnaire included objective and subjective questions. Objective data included the gender and age and other collected information regarding the ownership, the typology, and area of the housing unit. Subjective variables included the level of satisfaction for occupants and their comfort indices. Along with their sensation and thermal preferences depending on Fanger's thermal sensation scale, thermal comfort was assessed on a scale from -2 (cold) to 2 (hot). Other questions aimed to provide a more detailed description for the building materials ad insulators commonly used in external walls in Hebron to help the establishment and validation of the simulation model.
According to (Krejcie & Morgan, 1970); (NEA, 1960) The National Education Association (NEA) has published a formula for domain and sample size determination. The method, called 'Small Sample technique', was developed due to the continuously increasing need of surveys, samples, and samples' sizing in different research activities.
The Small Sample technique had depended on the NEA's formula as shown in Equation 1 as follows.

$$s = X^2NP(1-P) \,/\, d^2(N-1) + X^2P(1-P) \quad \textbf{(1)}$$

- s is the required survey sample size.
- X^2 equals 3.841 from the table value of chi-square for 1 degree of freedom.
- N is the population size.
- P is the population proportion (0.50 provides the maximum sample size).
- d is the degree of accuracy which equals 0.05.

The study applies the small sample technique to determine the required questionnaires responses. The total population of Hebron governorate has exceeded 762500 in 2020, and 215500 in Hebron city in 2020 (PCBS, State of Palestine: Palestinian Central Bureau of Statistics, 2020). The total number of people living in residential apartments in Hebron was selected as the addressed population in relevance to the selected domain for the field survey, which equals 100423. Depending on Equation 1. The equation's inputs were: (N), the number of people living in residential apartments in Hebron, the population proportion (P) was considered 0.50 to give the maximum number of needed responses, and the degree of accuracy tolerance (d) was considered 5% (0.05); The number of maximum questionnaires responses (s) equaled 383 responses.
The paper introduces the evaluating analysis to the residences' opinions in reference to the responses of the collected questionnaires, 390 responses were collected depending on the previously determined sample size followed by an extended explanation to the content of the questionnaire.

The questionnaire's dimensions

The subjected occupants were asked to rate their homes in terms of the level of comfort they feel both in summer and winter. Demographic data was collected along with further information about the housing units to help determine the common building practices and the occupant's response toward it. The addressed residential buildings were selected among a group of multistorey residential buildings in different districts in Hebron city. Buildings from the eastern, western and the middle districts were randomly selected as domains. Questionnaires were distributed in person in October 2020 and all responses were collected as hard copies. The questionnaire was designed to include three main sections as summarised in Figure 7 below.

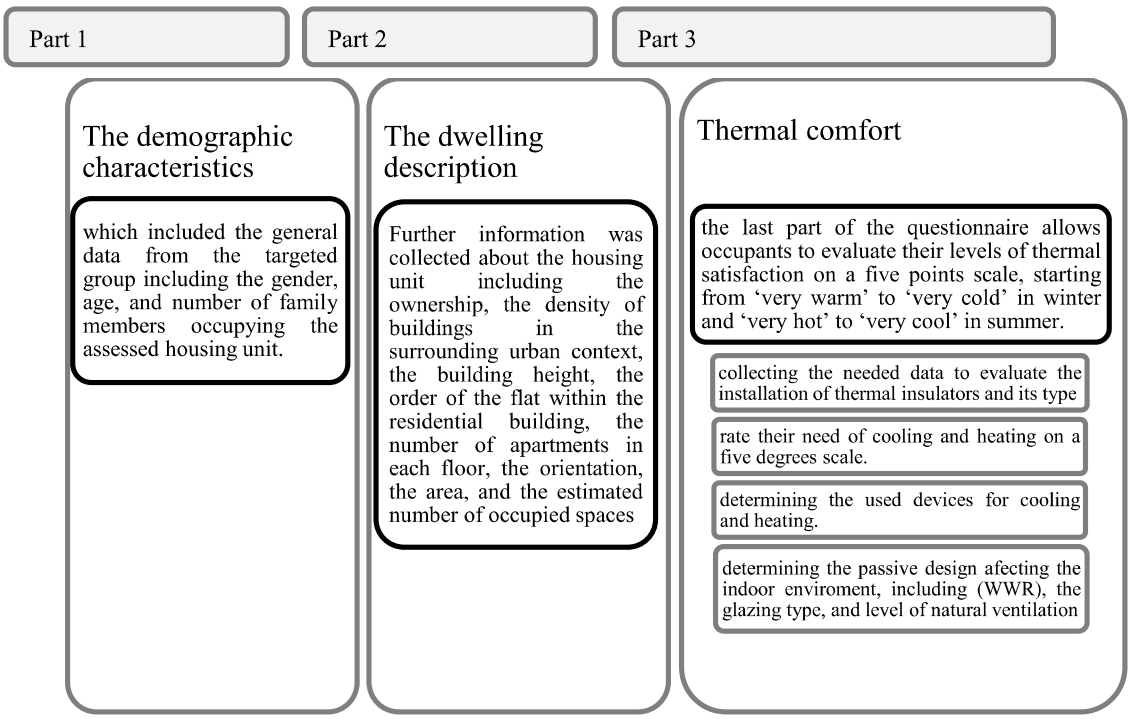

Figure 7: The questionnaire's dimensions

The questionnaire finally gathers answers regarding the occupants' intentions to install insulators or use any applicable thermal comfort enhancement methods to evaluate the levels of awareness toward the occupants' comfort.

Questionnaire results analysis

The questionnaire's first section summarizes the demographic data of the participates, results have shown that a percentage of 51.5% of the responses were recorded by female, which were mostly housewives, and 48.5% were males. In term of the age categories, 58.7% of the responses were recorded from occupants ranging between 18-40 years and 34.6% were between 18-49 years old, when the least percentage has represented the elderly. Gender and age percentages and differences explains the variations of thermal sensation due to different metabolism rates and rates of activity (Indraganti & Rao, 2009). The last question in this section is the number of family members which had an average of 6 persons in Hebron as in reference to the Palestinian Central Bureau of Statistics (PCBS) for the year 2020, which recorded maximum at the responses.

Table 3: the questionnaire's answers rates-section 1(The demographic characteristics)

Gender	**Females**	**Males**	
	51.5%	48.5%	
Age	**18-40 years**	**40-60 years**	**Above 60 years**
	58.7%	34.6%	20.3%
Number of family members	**1-3**	**3-6**	**More than 6**
	22.3%	58.2%	19.5%

Gender and age percentages and differences explains the variations of thermal sensation due to different metabolism rates and rates of activity (Indraganti & Rao, 2009). The last question in this section is the number of family members which had an average of 6 persons in Hebron according to the Palestinian Central Bureau of Statistics (PCBS) for the year 2020, which recorded maximum at the responses.

Table 4: the questionnaire's answers rates-section 2 (The dwelling description)

Building height	**3-5 floors**	**6 floors**	**7 floors and exceeding**	
	56.8%	20.8%	22.4%	
Number of apartments / floor	**1 apartment**	**2 apartments**	**3 apartments**	**4 apartments**
	21.1%	31.1%	20.1%	27.8%
Building's density in the urban surrounding	**Low density area**	**Middle dense area**	**High density area**	
	11.1%	50%	38.9%	
Apartment's location in reference to the building	**Lower apartment**	**Middle apartment**	**Higher floors**	
	14.2%	61.9%	23.8%	
Apartment's orientation (In reference to the majority of openings)	**Northern**	**Eastern**	**Southern**	**Western**
	16.8%	29.6%	26.7%	26.9%

Apartment's area	**Less than 90m²**	**90m² - 120m²**	**120m² - 150m²**	**More than 150m²**
	3.1%	33.9%	39.6%	23.4%

Table 5: the questionnaire's answers rates-section 3 (Thermal comfort)

Occupant's rate for the indoor temperature in winter	**Very warm**	**Warm**	**Comfortable**	**Cold**	**Very cold**
	0.8%	8.2%	18%	51.4%	21.6%
Occupant's rate for the indoor temperature in summer	**Very hot**	**Hot**	**Comfortable**	**Cool**	**Very cool**
	19.1%	46.9%	29.6%	2.92%	1.46%
The installation of insulators	**Installed**	**Not installed**			
	49.7%	50.3%			
Type of insulation, if applied	**Hollow Block**	**Polystyrene boards**	**Polyurethane foam**		
	44.86%	26.46%	30.36%		
Occupant's rating for thermal comfort	**Excellent**	**Good**	**Moderate**	**Bad**	**Very bad**
	2.73%	20.8%	40.5%	30.5%	5.46%
The need or heating in winter	**Not needed**	**Low**	**Moderate**	**High**	**Very high**
	0.8%	2.5%	17.5%	48.6%	30.6%
The need or cooling in summer	**Not needed**	**Low**	**Moderate**	**High**	**Very high**
	10.3%	20.4%	33.8%	24.7%	10.8%
Used heating methods in winter	**Electricity**	**Gas**	**Fireplace**	**All mentioned**	**Other**
	18.5%	47.3%	9.8%	19.8%	4.6%
Used cooling methods in summer	**Windows**	**Fans**	**Air conditioning**	**All mentioned**	**Other**
	20.3%	34.4%	20%	25.4%	---
Openings size in reference to the walls area	**Very small**	**Small**	**Moderate**	**Large**	**Very large**
	3.7%	7.5%	63.2%	21.9%	3.7%
Installed type of glazing	**Single glazing**	**Double glazing**	**Triple glazing**		
	48.7%	47.7%	1.3%		
Occupant's rating to the natural ventilation	**Excellent**	**Good**	**Moderate**	**Bad**	**Very bad**
	17.3%	34.4%	38%	9.6%	0.7%
The ability and acceptance to the concept of installing thermal insulators	**Definitely**	**Yes**	**Maybe**	**No**	
	42.9%	42.7%	12.6%	1.8%	

Analyzing the third part of the questionnaire as shown in the attached table explains the occupants' dissatisfaction regarding their dwellings, which confirms the importance of the study.

Simulation model

Depending on the data collected from the field a simulation model was created using the design builder simulation and Energy plus thermal calculation software to further evaluate the current thermal comfort levels, the model was based on common building practices and materials referring to the survey's results.

- The analysed apartments were all built with concrete structures externally cladded with stone, with no heat insulation. Apartments internally had partitions of concrete hollow block finished with cement plaster on both sides. Slabs and floors were all reinforced concrete ribbed slabs finished with ceramic tiles of 6-8mm thick and plaster on the lower surface, which in term has served to calculate the thermal transmittance values (U-value) of external walls, slabs, and internal partitions resulting respectively as follows 2.81, 1.34 and 2.64 W/M^2. k.
- The average calculated window to wall ratio (WWR) depending on the architectural drawings has equaled 19%. Windows' height has ranged from 1.25-1.50m with single reflective glazing. All selected buildings were multi-story residential buildings with one or more residential apartments on each floor. Initial analysis has excluded roof floors and ground floors, the study investigates repeated middle floors.
- The simulation was run with no addition of any thermally insulating material. Results have shown a maximum indoor temperature of 29°C in July, and a minimum indoor temperature reaching 14°C as shown in the simulation results graph in Figure 8 shown below.

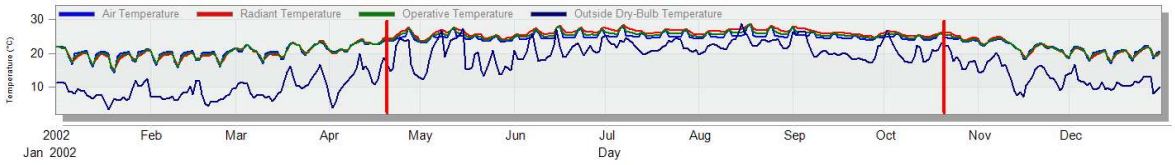

Figure 8: Temperature's simulation results for an apartment model in Hebron

Simulation results in reference to a space in an apartment have shown that the applied methods and building practices fall short to achieve the requirements on thermal comfort; as shown in the simplified results in reference to the air temperatures in Hebron, results have shown that the temperature falls to under 15°C in most days in winter, it however rises to around 30°C in most days of summer. Buildings also suffer from excessive cooling loads exceeding 10KW/H in the summer period and exceeding 15KW/H in August and a heating burden ranging from 5-8 KW/H in winter reaching its maximum in January and February of around 10KW/H.

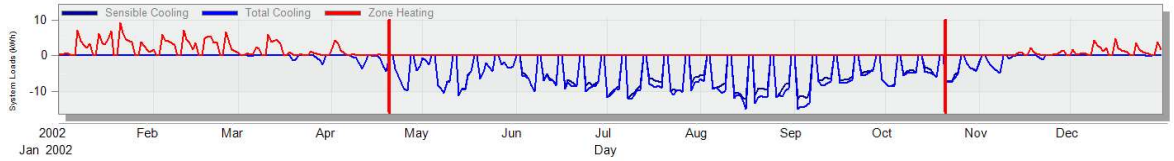

Figure 9: Cooling and heating loads simulation results for an apartment model in Hebron

Results have shown the potentials of condensation within the layers of the envelope which also requires solving. The introduced model was also evaluated in terms of condensation potential in winter as shown in Figure 10 as follows, which is expected to evaporate in summer.
The temperature is also shown to rapidly rise in the inner layers of the envelope which explains the indoor temperatures rising which confirms the essential role of installing insulators.

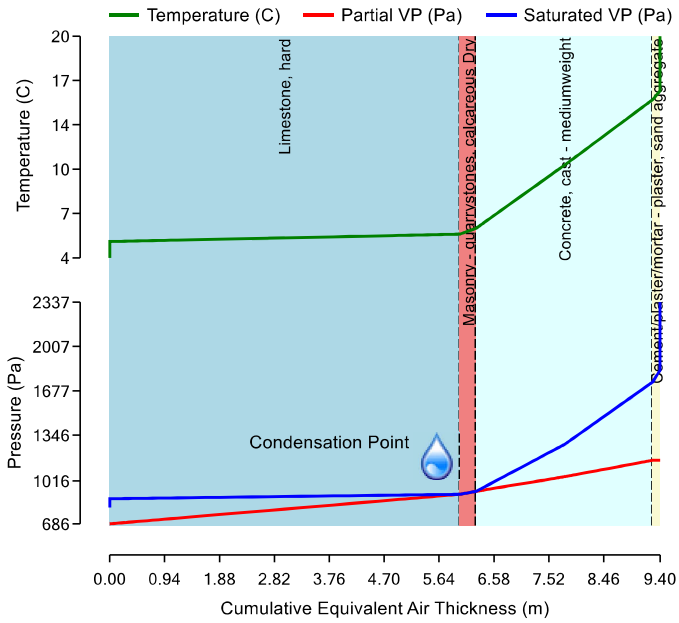

Figure 10: an external wall detail showing the potential of condensation and the temperature difference in the envelope

CONCLUSION

Thermal comfort is one of the key indoor environment indicators which essentially needs to be considered due to its direct relevance to occupants' comfort, health, and wellbeing. Apartment buildings have recently become a common building phenomenon in the city of Hebron, as well as in most of the Palestinian cities due to the lack of land and the increasing rates of population growth. Apartments have been increasingly suffering from the lack of thermal comfort parameters which should be further considered in building practices.

Questionnaires were one of the key evaluation methods used in the study to evaluate occupants' satisfaction rates through an evaluation of multiple parameters of the housing units. Results of the questionnaires show that high levels of cooling and heating in both summer and winter are relatively high, which implies larger burdens on the levels of consumed energy in residential buildings. Therefore, intensive studies are required in the field of enhancing residential buildings envelopes.

The study has shown that a percentage of 18% of residents have felt comfortable in their homes in winter, and 29.6% in summer. While others of 21.6% and 19.1% have rated their homes as very cold and very hot respectively. Results have also shown a percentage of 30.5% rating their homes as very bad in terms of thermal comfort.

The study had also proven an excessive amount of energy consumed in heating and cooling since the need for heating in winter was rated 'very high' by 30.6% of residents, while 24.7% rated their homes as 'hot' in summer and another 10.8% have answered as 'very hot', which was also confirmed through the simulation with a large amount of cooling and heating loads exceeding 10KW/H requiring interventions for enhancing the building envelopes layering and composites to lower the energy consumption.

While around 50% of the selected samples were uninsulated residential buildings, the results of the questionnaire had proven the high level of awareness among inhabitance and had shown a relatively high response to the acceptance of the concept of enhancing buildings' envelopes and installing insulators despite some limitations were defined in the open questions asked.
The study recommends further studies to take place to provide extended solutions for the development of residential buildings envelopes to enhance the indoor environment, the envelope's layers must include heat insulators with further analysis of the types and thicknesses of insulators along with calculations of thermal resistance providing considerations to solve the effect of condensation.

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