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BUILDING SIMULATION & OPTIMIZATION 2016

BIOGRAPHIES

Chair: Neveen Hamza

Neveen is a Senior Lecturer in Architecture and Programme Director: MSc in Sustainable Buildings and Environments in the School of Architecture, Planning and Landscape. She is the current Vice-Chair of IBPSA-England and has been elected for this position since 2010. She is on the Board of Directors for the journal of renewable energy among others and on the Board of Directors for a number of organizations working on net Zero energy building conservation. She has over 80 research publications and research grants in the field of building and urban energy performance evaluation in developed and developing countries.

Chair of Scientific Committee: Chris Underwood

Chris Underwood is professor of Energy Modelling for the Built Environment at Northumbria University in Newcastle upon Tyne. He is an internationally-recognised expert in HVAC plant and controls and urban renewable energy systems. He has published over 100 research and scholarly outputs including 5 books and book chapter contributions. He is a former editorial board chairman of the CIBSE journal Building Services Engineering Research and Technology and holds CIBSE's Dufton and Napier-Shaw medals for contributions to research.

KEYNOTE SPEAKERS

Harsh Thapar

CEnv. MIEnvSc . MSc . BArch
Performance Driven Design: Simulation, Experiments and more

Harsh Thapar is an Associate at Foster and Partners. He works in the Specialist Modelling Group, which is an in house research and development team involved with complex geometry, environmental design research and innovation for projects.

He joined Foster+Partners in 2007 upon completing his MSc from Architectural Association School in London (AA), where he studied Sustainable Design. Harsh worked for leading architectural practises in India after his BArch degree at School of Planning and Architecture, New Delhi. He became a licensed architect in India and was involved in successful execution of Commercial and Hospital buildings for prominent Indian clients like Unitech. He was the project architect for India's first energy rated green hospital building in New Delhi for Fortis Healthcare.

His MSc research at the AA was focussed on design of 'Urban Form for Hot Climates'. For this he travelled extensively in UAE carrying out field measurements, surveys and technical simulation work. His research developed solutions for increasing outdoor comfort in hot humid climate and used advanced simulation software to test the hypothesis. He presented his research at the Passive and Low Energy Architecture Conference at Dublin on 2008 and was published.

At Foster+Partners, he has worked on low energy building design and sustainable Urban Form design on numerous projects like Hangzhou Financial District, China , Ireo Masterplan India etc. He has worked extensively on Masdar City, in Abu Dhabi, where he carried out field studies to understand outdoor comfort performance. These have been widely published. He was accepted as Member of Institute of Environmental Sciences, UK and became a Chartered Environmentalist in 2014.

Ian Beausoleil-Morrison

BPS: How did we get to where we are today and what are the key challenges for the future?

Ian Bausoliel-Morison is a professor in the faculty of Engineering and Design in Carlton University, Ottawa, Canada. He holds the Canada research Chair in Innovative Energy Systems for residential buildings. He is co-founder and has been co-editor of the Journal for Building Performance Simulation since its establishment in 2008.

Ian held various roles in the IBPSA world organization, an IBPSA-World director since 2004, and a Vice president from 2006- 2010, then president from 2010-2015. He was awarded a IBPSA-fellow status in 2015 He has been a n operating agent for the international Energy Agency Energy conservation in Buildings Implementation Agreement, is past chair of ASHRAE's technical committee 4.7 on energy calculations. He has also been a theme leader for the Canadian research networks on solar buildings and is a member of the EPSRC peer review college.

Prior to joining Carlton in 2007, Ian worked for 16 years for Canmet ENERGY, where he led a team of researchers who developed models for innovative energy systems, such as micro-cogeneration and developed simulation tools for industry.

His research interests include solar housing, seasonal thermal storage, micro-generation and understanding occupants' behaviour. Currently is the lead investigator of the Urbandale Centre for Home Energy research, a research House situated on the Carlton University campus, that is dedicated to the study of solar-thermal and other innovative energy systems for radically reducing the dependence of housing on fossil fuels.

Maria Nesdale

ARB, RIBA, LEED® BD+C
Education Practice Area Leader, Senior Associate

As a Firmwide Leader of the Education Practice Area, in Gensler, London, Maria guides teams in designing enhanced educational environments that deliver a vastly enhanced learning experience for students of all levels. A Senior Associate and Registered Architect, Maria is highly regarded as a specialist in her field. She was invited to participate on the World Architecture News awards jury panel for education in 2012 and the World Architecture News Effectiveness Awards in 2013. She earned a B.A. (Hons) in Architecture at the University of Portsmouth and a Diploma in Architecture at the University of Westminster, where she also pursued Postgraduate Certificate Professional Practice in Architecture.

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PAPERS IN PROCEEDINGS ONLY

CORRELATION BETWEEN RETROFITTING BUILDING ENVELOPE AND THERMAL IMPROVEMENT ON SOCIAL HOUSING IN HOT-ARID CLIMATE

Ali Sedki[1], Neveen Hamza[2], and Theo Zaffagnini[3]
[1]Assistant professor, Beirut Arab University, Lebanon
[2]Senior lecturer, Newcastle University, UK
[3]Associate professor, Ferrara University, Italy

ABSTRACT

This study examines the effectiveness of a combined strategy of retrofitting building envelope using an agricultural residue (maize) as an external insulation material and natural ventilation behaviours to improve indoor thermal comfort in a residential building. A prototype for a social housing multi-storey building is selected in the hot arid climate of Cairo, Egypt. Building performance simulation using IES<VE> (the produced version of 2013) is used to predict the effectiveness of adding an external organic insulation material on the building envelope. Behaviours of natural ventilation are then included to predict a naturalistic approach for indoor thermal management. The simulation was conducted in a typical floor apartment that facing the warmest south orientation. Results revealed that -comparing to the base case - an improvement of 5.5% happened in winter period when applying external insulation only, while this percentage reduced to be 4.4% when applying the combined strategy. Further, this combined strategy was effective in summer period as it has improved indoor comfort by 58.3% while an improvement of 10.2% occurred when applying external insulation only. In addition, during spring-autumn period, the strategy was not effective as it made an improvement in indoor comfort by 6.0% from the base case and by 1.9% when applying external insulation only.

INTRODUCTION

As practices of building with high thermal mass mud walls disappeared by time in favour of contemporary construction materials that offer less time lag properties, it is essential to consider a combination of fabric insulation with a strategy for natural ventilation to improve indoor thermal conditions in hot arid climates (Roaf, 2001)

It is acknowledged that using external insulation, thermal mass (El-Hefnawi, 2000) with light colours external surfaces, shading devices (Gado, 2000 andAttia,2010) minimizing window to wall ratio (Hamza et al, 2001) and using nocturnal ventilation (Givoni,1998) will yield positive results in terms of thermal comfort and energy efficiency in various climatic zones in Egypt.

Technical interventions in this study focus on the building's envelope as the moderator between the indoor and outdoor environments. Accordingly, minimizing heat gain in a hot arid climate, through the building envelope is essential for reducing cooling energy demand. In a climate with large diurnal (day-night) temperature swings, this study looks at the impact of improving building fabric thermal insulation combined with natural ventilation behaviours to passively reduce cooling energy demand.

INSULATING MATERIALS CHARACTERISTIC PROPERTIES

Characteristics that influence insulant's performance are thermal conductivity, thermal resistance, transmittance, specific heat capacity and density. However, these criteria are extended in this study to include:

- The ecological aspect of this material (materials derived from organic or recycled sources and which do not use high levels of energy during production);
- Availability of raw materials for local production;
- Possibility of economic material production and;
- Natural organic material (from animals or plants).

This study focuses on the application of natural organic materials to improve thermal comfort and energy efficiency in the case study buildings for the following reasons:

1. Natural insulation materials do not underperform when compared to manmade synthetic insulation. Further, they are renewable and sustainable materials.
2. The CO_2 footprint of natural organic insulation is considerably less than other forms of synthetic insulation materials.
3. The specific heat capacity, for a large number of natural fibre insulation materials, exceeds 2000 J/Kg.K, while, for mineral wool is only 800 J/Kg.K and for plastic insulations is 1400 J/Kg.K. when taking into account the high density of the majority of natural insulation

materials, then, the thermal mass of natural insulants such as wood fiber, cellulose and hemp is higher than other forms of insulants with the same R- value.

4. There is a future possibility to produce natural insulants in Egypt as it has a large amount of agricultural waste (El-Shimi, 2005). Through Public-Private Partnership (PPP) and tax reliefs, the government can incentivise private construction firms to use agricultural residues to manufacture natural-based insulation materials.

previous studies show that maize stalks are considered the second highest agricultural residues in Egypt (El-Shimi, 2005; El-Mashad, 2003). In addition, the world production from corn stalks and cobs is 600 million tons in 2003 that exceeded rice and wheat, and it is being produced widely as compressed insulation boards (Panyakaew S.; Fotios S., 2008). Maize was selected as an insulation material for the case study. Table (1) below shows that the by-product of wheat constitutes the largest proportion of total wastes of agricultural products in Egypt, its application to this study was overlooked for the above reasons, furthermore, there is no evidence - to the best of the researcher's knowledge - that it is produced as an insulation materials for buildings yet.

Table 1
Agricultural residues in Egypt (Hamdy, 1998)

CROPE	TOTAL WASTES (1000 TON)
Wheat	5998
Maize	3814
Sugar Cane	3634
Rice, Paddy	2724
Tomatoes	1441
Seed Cotton	835
Broad Beans, Dry	467
Sugar Beets	440
Potatoes	380
Wheat	5998

CASE STUDY TECHNICAL DETAILS BEFORE AND AFTER INTERVENTION

The case study is a six storey prototypical residential buildings for housing medium income families in Egypt. This section explains in details the building envelope in terms of thermal behaviour before and after adding the insulation. Each floor includes six apartments. Each apartment consists of a living room, two bedrooms, one kitchen and one bathroom. Figures 1 & 2 show the typical floor plan and the cross sections with the critical thermal points of the building envelope that will be presented before and after the interventions.

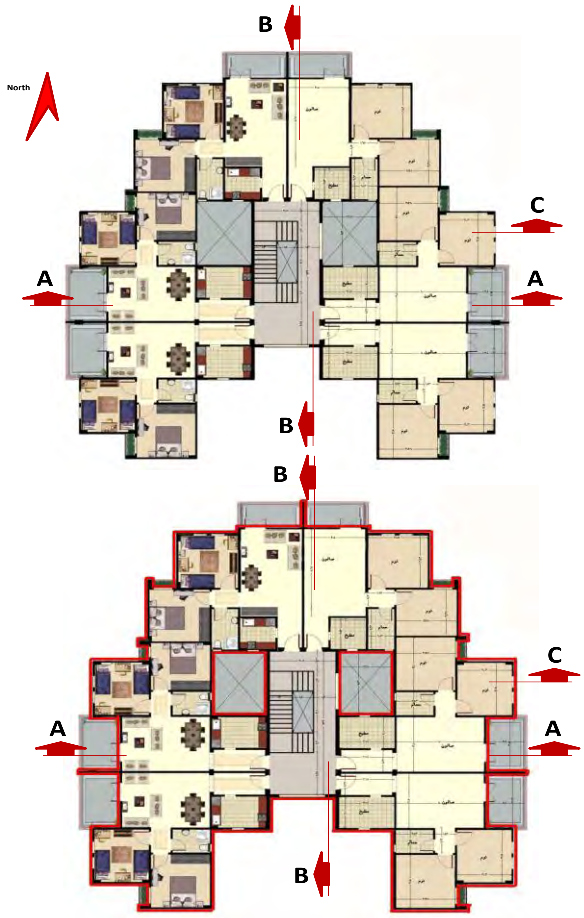


Figure 1 Case study floor plan before (above) and after adding insulation around external walls (below)

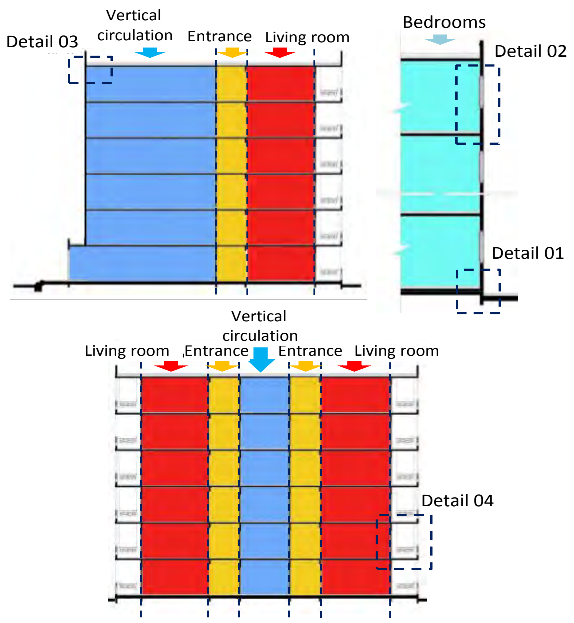
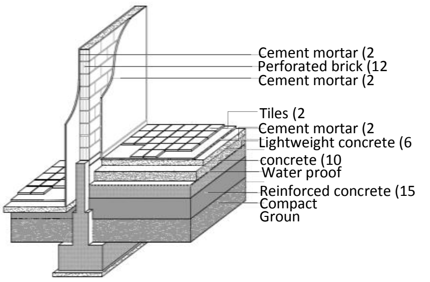


Figure 2 Case study sections showing the critical thermal points that are zoomed in table 2

Before intervention (Status-quo)

The following details (table 2) show the critical points in the building envelope before adding external insulation material (status-quo).

Table 2
Case study details before intervention (status-quo)

<table>
<tr><th>DETAIL</th><th>DRAWINGS</th></tr>
<tr><td>Detail 1 wall ground floor connection Detail</td><td>
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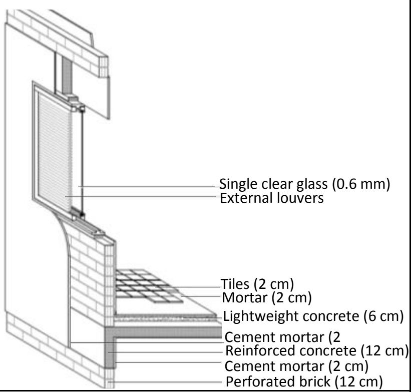
<tr><td>Detail 2 window wall typical floor connection Detail (from outdoors)</td><td>
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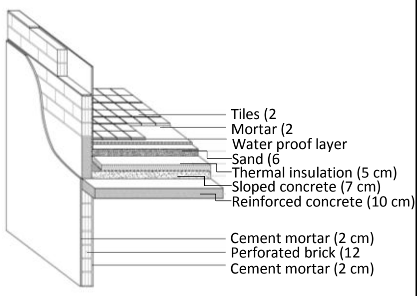
<tr><td>Detail 4 roof wall connection</td><td>
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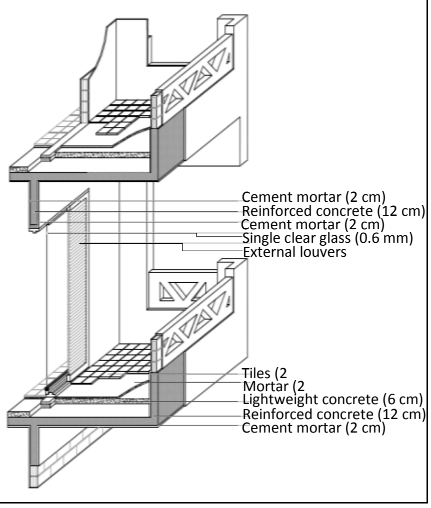
<tr><td>Detail 5 balcony wall connection Detail</td><td>
</td></tr>
</table>

Tables 3 and 4 shows the thermal properties for the external wall and roof layers. Figures 3 and 4 show the predicted thermal behaviour of the wall and roof during the lowest recorded outdoor temperature in winter and highest recorded outdoor temperature in summer. According to IES<VE> data base for Cairo weather profile (the hourly average temperatures during 28 years), the lowest recorded average temperature was 7 ˚C, average external relative humidity was 87%and the highest average recorded temperature was 41.3 ˚C, average external relative humidity was 14%. Noticeably, the graphs show the poor thermal performance of the building envelope.

Table 3
Thermal properties of external wall layers

NO.	THICKNESS	MATERIALS (IN TO OUT)	λ (W/MK)	R (M²K/W)	U-VALUE (W/M²K)
		Thermal contact resistance		0.130	7.7
1	2	Plaster paint	0.25	0.008	125
2	20	cement render	1.40	0.014	71.4
3	120	Clay brick	0.60	0.182	5.5
4	20	cement render	1.40	0.014	71.4
5	2	Plaster paint	0.25	0.008	125
		Thermal contact resistance		0.040	25
	164	Whole component		0.396	2.53

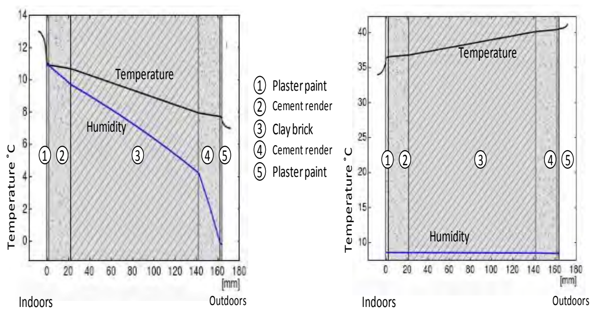


Figure 3 Thermal behaviour of the external wall during the lowest recorded temperature (on the left) and the highest recorded temperature (on the right)

Table 4
Thermal properties for roof layers

NO.	THICKNESS	MATERIALS (IN TO OUT)	λ (W/MK)	R (M²K/W)	U-VALUE (W/M²K)
		Thermal contact resistance		0.130	7.7
1	2	Plaster paint	0.25	0.008	125

2	20	cement mortar	1.40	0.014	71.4
3	100	Reinforced concrete	2.50	0.040	25
4	70	Sloped concrete	1.30	0.054	18.5
5	2	Water proof			
6		Insulation panels of maize fiber	0.036	1.7	0.58
7	60	sand	2.00	0.030	33.3

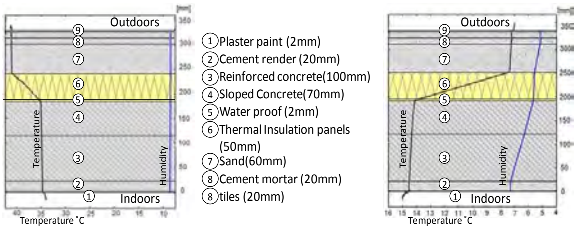


Figure 4Thermal behaviour of the roof during the lowest recorded temperature (on the left) and the highest recorded temperature (on the right)

After intervention

The following details in table 5 shows the critical points in the building envelop after adding the insulation material. Table 6 and figure 5 show the predicted thermal performance of the wall after adding external insulation. Different thicknesses of insulation were applied and simulated in the case study but there was no difference in thermal performance of the building envelop, accordingly, it was decided to apply the standard thickness of 6 cm of maize fiber panels.

Table 5

Case study details after intervention

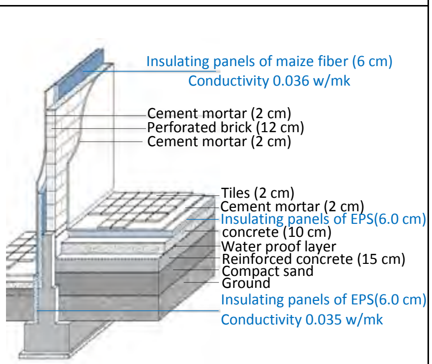
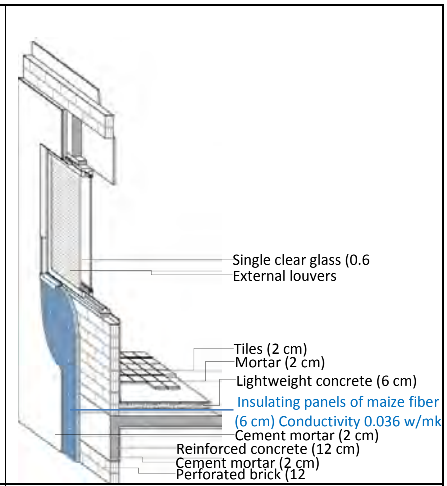
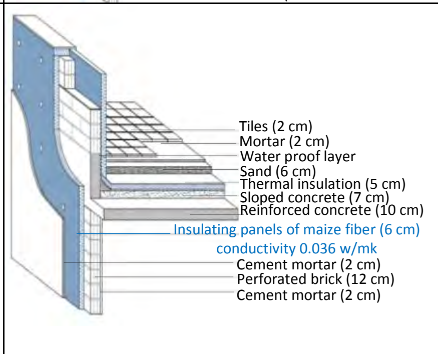
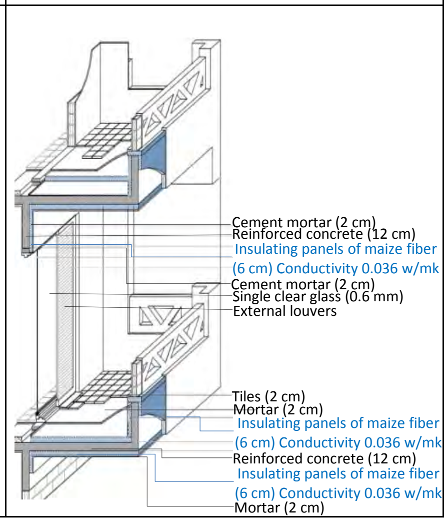
DETAIL	DRAWINGS
Detail 1 wall ground floor connection Detail	
Detail 3 window wall typical floor connection Detail (from outdoors)	
Detail 4 roof wall connection (external view)	
Detail 5 balcony wall connection Detail	

Table 6

External wall layer properties after adding insulation of maize fiber

NO.	THICKNESS	MATERIALS (IN TO OUT)	λ (W/MK)	R (M^2K/W)	U-VALUE (W/M^2K)
		Thermal contact resistance		0.130	7.7
1	2	Plaster paint	0.25	0.008	125
2	20	cement render	1.40	0.014	71.4
3	120	Clay brick	0.60	0.182	5.5
4	20	cement render	1.40	0.014	71.4

5	2	Plaster paint	0.25	0.008	125
6		Insulation panels of maize fiber	0.036	1.7	0.58
7	20	cement render	1.40	0.014	71.4
8	2	Plaster paint	0.25	0.008	125
		Thermal contact resistance		0.040	25
To tal	164	Whole component		2.12	0.47

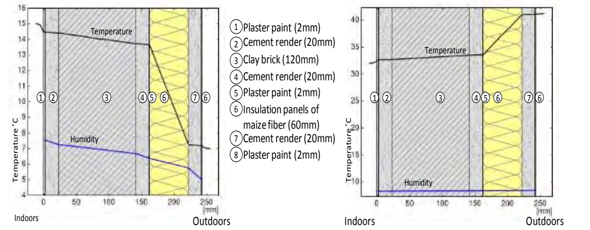


Figure 5 Thermal behaviour of the insulated external wall during the lowest recorded temperature (on the left) and the highest recorded temperature (on the right)

COMBINING INULSATION WITH NATURAL VENTILATION BEHAVIOURS

To examine the effectiveness of insulation retrofitting techniques with natural ventilation, natural ventilation behviours were applied. These behaviours were based on observational studies (Sedki, 2014). In winter, it was observed that occupants open the windows for short durations in the morning and afternoon when they come back from their work.This approximated to one hour for simulation reasons.

In summer the night purge ventilation was applied From 7:00 pm to 7:00 am. In consequence, the comparison made between the four scenarios shown in table (7).

Table 7

Case study simulation scenarios

SCENARIO NUMBER	DESCRIPTION
1	the base case (status-quo of the building with all windows are closed 24 hours)
2	the base case after adding external insulation of maize fiber and closing windows 24 hours
3	windows were opened from 8:00 to 9:00 and from 17:00 to 18:00 in winter and from 18:00 to 7:00 in summer without applying external insulation
4	the combination of scenarios (2) and (3)

Winter period

Homes in Cairo do not have central heating systems. Small electric heaters are used for heating spaces. This study looks at the possibility of passively increasing comfort in the winter period. the comparison was made among scenarios (1), (2), (3), and (4) shown in table 7.

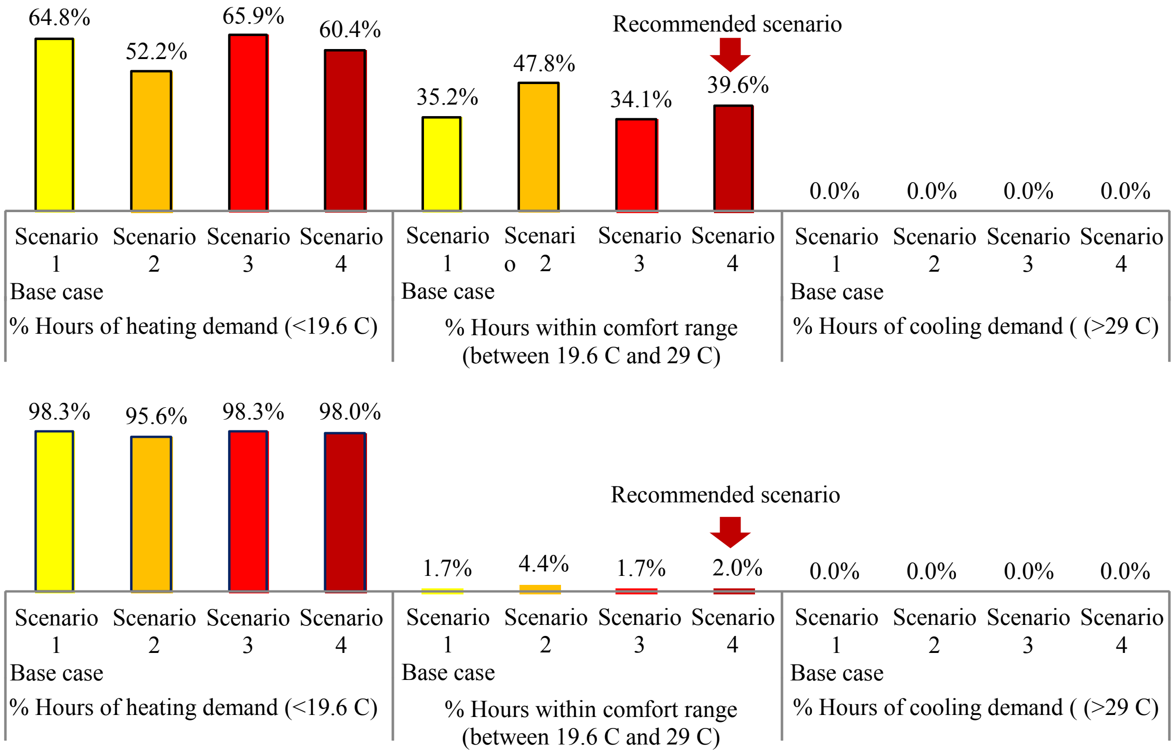


Figure 6 simulation results for the peak month of January (above) and conclusion of simulation results for the whole winter period (below)

In January, the peak heating dominated month in Cairo. Scenarios (1), (2), (3), and (4) achieved 1.7%, 4.4%, 1.7% and 2.0% respectively from total hours are within comfort range and 98.3%, 95.6%, 98.3% and 98.0% from total hours are of heating demand. Based on this comparison, there is no significant difference among all scenarios. Accordingly, none of them is effective during the month of January for the reference case under the climate condition of Cairo. Furthermore, scenario (2) achieved the highest range of comfort, however, it is not preferable because of indoor air quality reasons.

February, March, November, and December have got almost similar results of the month of January (Sedki, 2014).

From the above investigations for the whole period of winter months (the period of zero cooling demand in January, February, March, November and December) (Figure 6), among all presented scenarios, scenario (2) is the recommended one for indoor air quality reasons, however, it achieved the second highest range of comfort and it makes improvement by only 4.4% from the base case during all the total period of winter season. Consequently, this strategy is not much effective in winter season.

Summer period

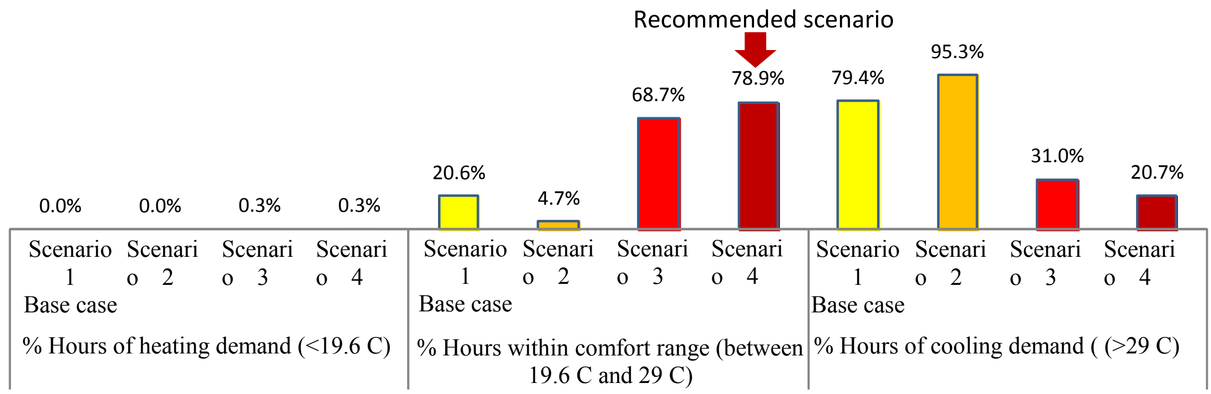
Homes in Cairo do not have central cooling systems. Rich people put air conditioning units for cooling spaces. The study seeks to passively increasing comfort for the low income class people who live in the case study buildings in summer period. the comparison was made among scenarios (1), (2), (3), and (4) shown in table 7.

In July (figure 7), this is one of the peak months of cooling demand in Cairo. Scenarios (1), (2), (3), and (4) achieved 8.7%, 0.0%, 61.4% and 71.5% from total hours are within comfort range and 91.3%, 100.0%, 38.6% and 28.5%from total hours are of cooling demand. Based on this comparison, thermal comfort was significantly improved comparing to the base case when combining the external insulation with an appropriate occupant behaviour of night purge ventilation in this month.

June, August, and September, have got almost parallel results of the month of July (Sedki, 2014).

From the above investigations for the whole period of summer months (the period of zero heating demand in June, July, August, and September) (Figure 7), the application of external insulation combined with an appropriate occupant behaviour of night purge ventilation on the case study (scenario 4) made an improvement in indoor thermal comfort by 58.3% from the base case during all the total period of summer season. Further, by comparing scenario 3 and 4, it shows that applying external insulation only made a slight improvement in indoor thermal comfort during the whole summer period, this illuminates the importance to combine it with occupant behavioural natural ventilation strategy.

Noticeably, in scenario 2 when apply external insulation on the case study with closed windows 24 hours, it gave negative effect in comfort level probably because it decreases heat loss by traping the internal heat gains inside the spaces and stop the heat exchange process through building envelop.



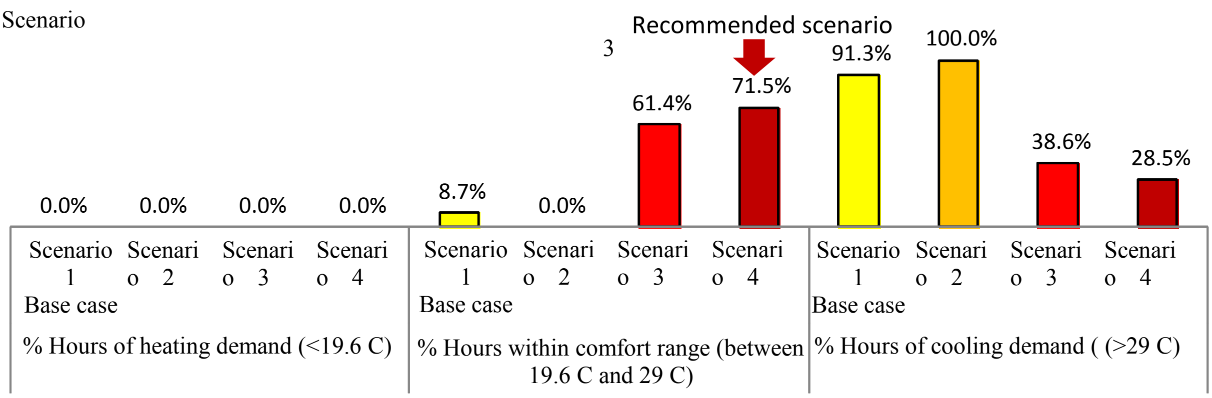


Figure 7 simulation results for the peak month of July (above) and conclusion of simulation results for the whole summer period (below)

Spring-Autumn period

This period was represented by the months of April, May and October. It is actually considered the most comfortable month in Cairo that need neither heating nor cooling. However, simulation results show that little percentages of heating or cooling demand are required to reach the hundred percent of comfort. This happens because of some flactuations in weather during these months in Cairo.

In figure 8 Scenarios (1), (2), (3), and (4) achieved 76.9%, 66.9%, 81.0% and 82.9% respectively from total hours are within comfort range, 3.1%, 0.0%, 7.8%, and 7.3% respectively from total hours are of heating demand and 20.0%, 33.1%, 11.2% and 9.8%from total hours respectively are of cooling demand.

Based on this comparison, thermal comfort was slightly improved comparing to the base case when combining the external insulation with an appropriate occupant behaviour of night purge ventilation (scenario 4) in theses months. Negative impact on comfort happened when applying external insulation only, that confirms the importance of natural ventilation to exchange heat between indoors and outdoors.

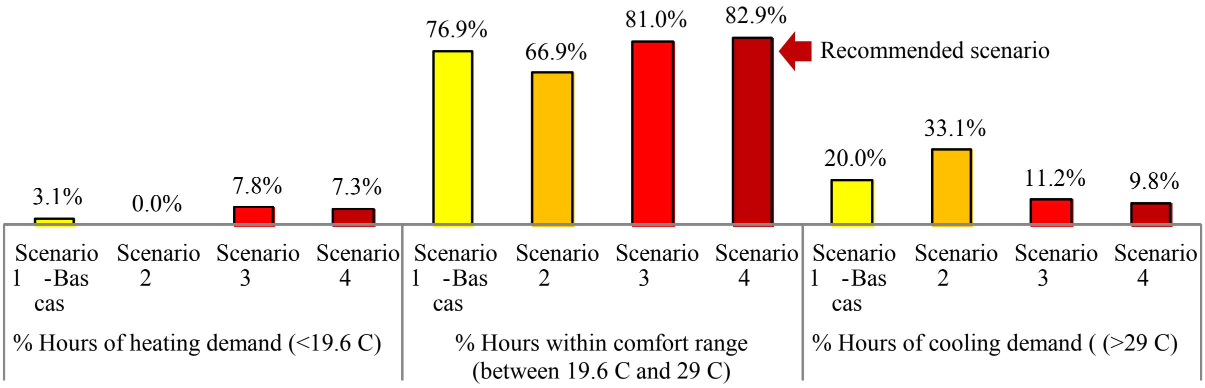


Figure 8 the conclusion of simulation results for the whole Spring-Autumn perio

CONCLUSIONS

This study examined the effectiveness of combining external insulation retrofitting technique made of a local organic insulation material with natural ventilation strategies on indoor thermal comfort. Natural ventilation scenario was applied according to occupants behaviour in winter as they opening windows in the morning and afternoon. In summer and spring-autumn period the night purge ventilation was applied.

In winter, Building performacne simulation results indicate that applying insulation on the base case scenario (windows closed 24 hours) achieved the highest improvement in comfort by 2.7% comparing to the base case, however, it is not preferable as it leads to poor indoor air quality.

The combined strategy of external insulation and ventilation achieved the second highest range of comfort hours passively and is better for indoor air quality (in terms of cooking odors and so on). However, with minor improvements by only 0.3% from the base case during the winter season.

For the summer months, the application of external insulation combined with night purge ventilation on the case study made an improvement in indoor thermal comfort by 58.3% from the base case. Further, external insulation only made a minor improvement, thus, the combined strategy is highly recommended in summer season. However, Same strategy achieved inconsequential improvement by 6% from the base case in spring-autumn period.

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