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Energy Efficiency Optimization in Residential Buildings Using Thermal Insulation Blocks: Case Study in Cairo, Egypt

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Keywords.
Thermal Performance.
Energy Efficiency.
Building Envelopes.
Brickwork and Blockwork.
Thermal Insulation Blocks.

Abstract.

Thermal insulation blocks have recently been highly considered in hot weather countries - where temperature can reach high levels - according to their low thermal conductivity that can result in a considerable reduction in the demand for building HVAC systems energy and its related negative impacts to the surrounding environments. The paper concerns recognizing the capabilities of applying thermal insulation blocks in building envelopes in Cairo, Egypt to enhance whole-building performance and conserve environments. The study opted for making a comparative performance analysis on six types of building envelopes of a prototype residential building located in Cairo, Egypt by simulating the building model using building performance simulation software (Design Builder Software Ltd – V. 7.0.0.116 – Educational Version). Four use conventional bricks and blocks; the fifth type uses advanced light sand blocks. The sixth type uses thermal insulation blocks to detect the effects of using thermal insulation blocks on a building's thermal performance and energy consumption. The performance comparative analysis results referred to a huge amount of heat transfer from and to building interior spaces caused by building external walls in the conventional building envelopes that should be treated to improve building thermal performance; by using thermal insulation blocks study observes a reduction of heat transfer from 41.61% to 65.08% that results in a reduction of energy consumption from 4.27% to 13.32%. Because of the study approach, the study proves that using thermal insulation blocks in a building's envelope can enhance the building's thermal performance and thus reduce the building's energy consumption and related CO_2 emissions, operating costs, environmental pollution, and other negative impacts on the surrounding environments. Therefore, researchers are encouraged to evaluate the proposed propositions further.

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1. Introduction

Building energy consumption and its related environmental concerns have been of considerable interest in recent years to produce sustainable buildings that achieve users' needs while conserving environments and resources. [1] The building sector are consuming about 42% of the energy in Egypt for various operating systems, especially in HVAC systems which should be considered to conserve energy, reduce CO_2 emissions, and decrease environmental negative impacts. [4]. The building envelope is an essential element that controls whole-building performance because it controls the relationship between the internal environments and outdoor environmental negative impacts that directly affect the building's energy efficiency. Therefore, choosing and applying environmentally friendly materials for building envelopes is critical to enhancing overall building performance. [10] Thermal insulation blocks make a non-negligible contribution to the built environments because they are considered green construction materials that achieve renewable, recyclable, and reusable materials and can be used indefinitely without negatively affecting the surrounding environment. [2] [6] [9] [12] So, this study is concerned with recognizing and analysing the capabilities of using thermal insulation blocks in building envelope construction materials to enhance whole-building performance and conserve natural, economic, and social environments.

2. Methodology

Energy consumption in residential buildings in Cairo, Egypt became one of the critical issues to consider these days according to the huge amount of energy they consume especially in HVAC systems to achieve suitable indoor thermal comfort for users in the local hot arid climate. That leads to the necessity of using an alternative building material in the building's envelope to decrease the external heat gain and its related negative impacts. This study aims to evaluate the use of thermal insulation blocks as an alternative to conventional brick and block material for building envelope construction to improve thermal performance and decrease energy consumption and operating costs. Comparative performance analysis of a proposed prototype residential building case study located in Cairo; Egypt was simulated using building performance simulation software (Design Builder Software Ltd - V. 7.0.0.116 – Educational Version). This analysis was conducted on six alternative types of external walls brick or block; the first four types were using conventional bricks and blocks, the fifth type was using advanced light sand blocks, and the sixth type was using thermal insulation blocks to detect the benefits of using thermal insulation blocks for enhancing building thermal performance.

3. Literature Review

Thermal insulation blocks are produced using concrete blocks filled with low-thermal conductivity mineral wool or polystyrene foam to enhance the block's thermal performance. [3] [7] [9] Many papers discussed the properties of thermal insulation blocks from materials properties, moulding, fabrication, and other manufacturing views. [2] [11] Some papers studied the usage of thermal insulation blocks to enhance the building's thermal performance by applying them as an alternative to conventional brick and blocks. [6] [12]

This research will focus on analysing the benefits of using thermal insulation blocks in Cairo, Egypt to enhance the thermal performance of buildings, decrease building energy consumption, and conserve surrounding environments.

4. Brickwork and Blockwork in Buildings

Brickwork and blockwork are important construction materials for all types of buildings worldwide both in developed and developing countries. They are used as a structural material in bearing walls buildings or as a filling material between structure elements in skeleton buildings. [9] Selecting the suitable type of bricks or blocks for the surrounding environments is important according to their strength, thermal, moisture resistance, acoustical properties, and local availability to achieve a high-performance building with conserving environments. [12] Several types of clay and concrete bricks and blocks are locally produced in the study location scope Cairo, Egypt as follows:

4.1. Clay Bricks and Blocks

Clay bricks and blocks are produced from constituents of brick-making clays such as silica and alumina with varying quantities of chalk, lime, iron oxide, and other minor constituents according to their source. The main processes of manufacturing clay bricks and blocks start from extracting the raw material, forming processes, drying, and firing. Typical clay bricks and blocks can be produced both as a solid shape with a density of 1850 kg/m^3 or as a hollow shape with a density of 1790 kg/m^3, an estimated thermal conductivity of about 0.600 W/mK, and specific heat of about 900 J/kgK. [2] [9] [12]

4.2. Concrete Bricks and Blocks

Concrete bricks and blocks are produced from natural dense aggregates including crushed granite, limestone, gravel, fly ash, and a fine mix of sand mixed with aluminium powder, Portland cement, and water. The main processes of manufacturing concrete bricks and blocks are cast mixed into moulds, vibrated, cured, and dried. The hydrogen gas generated by the dissolution of the metal powder produces a non-interconnecting cellular structure. Typical concrete bricks and blocks can be produced both as a solid shape with a density of 2000 kg/m^3 and estimated thermal conductivity of about 1.400 W/mK or as a hollow shape with a density of 1140 kg/m^3 and estimated thermal conductivity of about 1.600 W/mK and specific heat about 900 J/kgK. [2] [9] [12]

4.3. Light Sand Blocks

Light sand blocks are produced from raw materials of approximately 90% silica sand, hydrated lime, crushed flint, and water. It is fire-resistant, mould resistant, sound-proofed, and thermal insulated. The main processes of manufacturing light sand blocks are cast mixed into moulds and hydraulic pressing and transferred to the kilns where the lime particles interact with the fine sand grains from this interaction a substance called hydrated calcium silicate is produced which is the material that binds the sand particles. Typical light sand blocks can be produced as a solid shape with a density of 650 kg/m^3, an estimated thermal conductivity of about 0.350 W/mK, and specific heat of about 900 J/kgK. [2] [9] [12]

4.4. Thermal Insulation Blocks

Thermal insulation blocks are produced using conventional concrete blocks filled with low-thermal conductivity mineral wool or polystyrene foam to enhance the block's thermal performance. They can provide fire protection, thermal insulation, sound insulation, and sound absorption properties. The chosen type of thermal insulation blocks in this study can be produced as two outer layers of 0.095 m thick concrete block with a density of 2000 kg/m^3, an estimated thermal conductivity of about 1.400 W/mK, and specific heat of about 900 J/kgK filled with 0.060 m thick polystyrene foam layer with a density of 35 kg/m^3, an estimated thermal conductivity of about 0.034 W/mK, and specific heat of about 1300 J/kgK. [2] [3] [6] [7] [9] [11]

5. Case Study Analysis

This study considers the effect of using thermal insulation blocks in a proposed prototype residential building's envelope located in Cairo, Egypt, to improve the building's envelope thermal performance by enhancing its insulation systems. These insulation systems directly affect the heat flows from and to the building's interior spaces, affecting the building's HVAC cooling and heating loads and its related energy consumption, CO_2 production, environmental pollution, and other negative impacts on surrounding environments.

Testing the performance of the building's envelope materials can be achieved by simulating the prototype residential building using local conventional systems in Cairo, Egypt - such as lighting, HVAC, domestic hot water (DHW), and others that operate similar buildings - and comparing the results of using conventional envelope materials with the results of using thermal insulation blocks that will calculate and analyze by building performance simulation software (Design Builder Software Ltd - V. 7.0.0.116 – Educational Version) and using weather data file of Cairo, Egypt to detect the effects of using thermal insulation blocks on building performance.

The prototype residential building is proposed to be located in a new residential compound in Cairo, Egypt with five residential floors, four apartments per floor, an occupancy density of 0.0196 people/m^2, a footprint area of 446.87 m^2, a total building area of 2,247.01 m^2, floor height of 3.0 m, building internal volume of 4,511.60 m^3, energy supplies of electricity and natural gas, HVAC systems of an individual split HVAC system, and with conventional residential building construction, materials, internal zones, and operating schedules. *(Figure 01)*

The strategy of the simulation will be to compare the results of simulating five conventional residential buildings (type A, B, C, D, and E) with the same building using thermal insulation blocks in building envelope material (type F) that calculate and analyze by building performance simulation software (Design Builder Software Ltd - V. 7.0.0.116 – Educational Version) to detect the benefits of using thermal insulation blocks for enhancing whole building performance.

This simulation process will calculate many elements such as cooling design analysis, heating design analysis, site data analysis, comfort analysis, internal gains, solar analysis, fabric and ventilation analysis, fuel breakdown analysis, fuel totals analysis, CO_2 production analysis, the system loads analysis, and embodied and equivalent Carbon analysis.

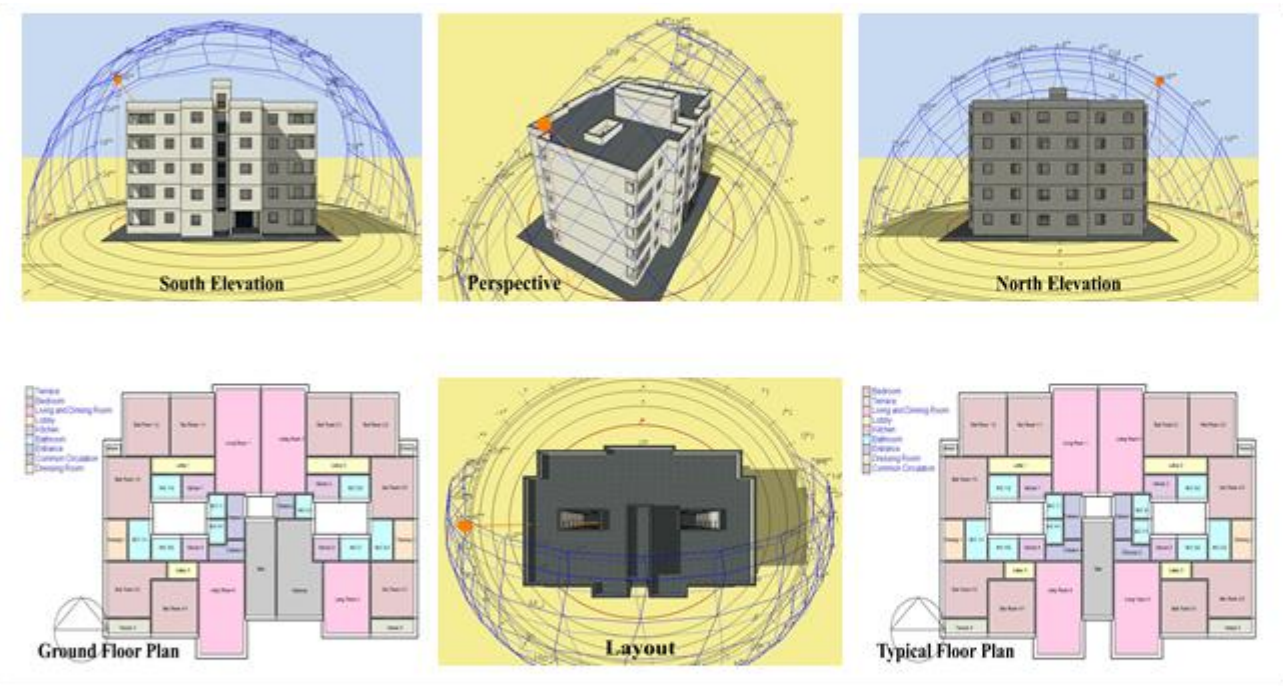


Figure (01) Prototype Residential Building Model [8]

5.1. Building Type (A)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick solid clay bricks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 0.656 m^2K/W and U-Value = 1.524 W/m^2K. *(Figure 02) (Table 01) (Table 02)*

By analysing the building type (A) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 2,705.035 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 3,165.845 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 21,299.019 Wh/m^2. *(Figure 03)*

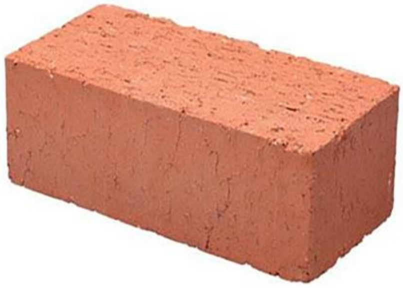


Figure (02) Solid Clay Bricks

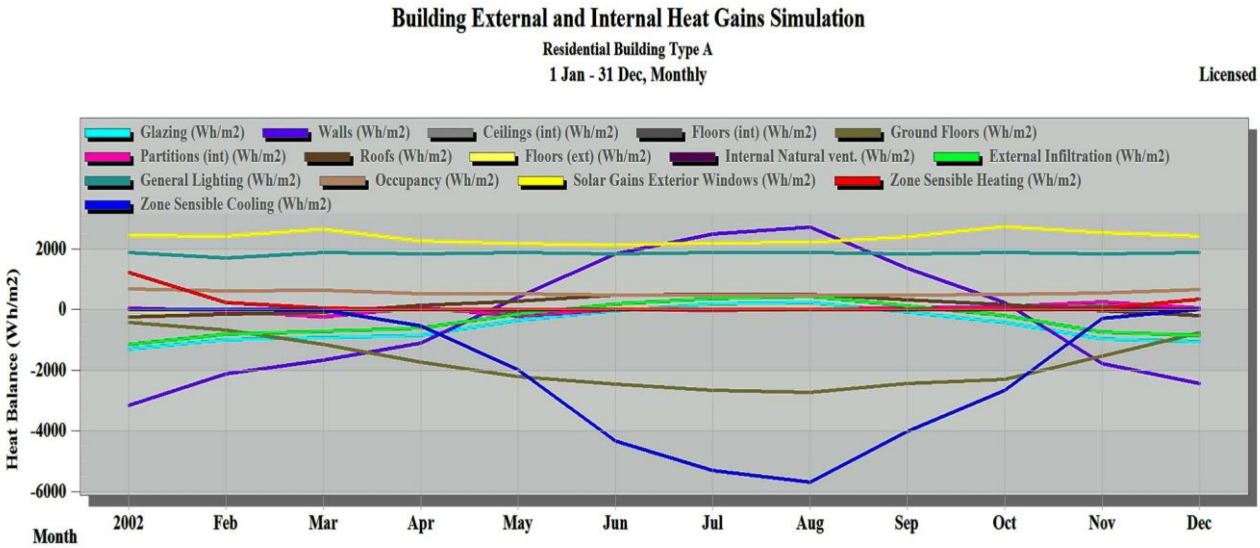


Figure (03) Building Type (A) Heat Gains Analysis [8]

5.2. Building Type (B)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick hollow clay bricks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 0.656 m^2K/W and U-Value = 1.524 W/m^2K. *(Figure 04) (Table 01) (Table 02)*

By analysing the building type (B) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 2,703.053 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 3,168.050 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 21,299.042 Wh/m^2. *(Figure 05)*

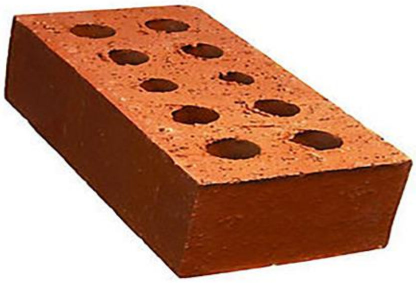


Figure (04) Hollow Clay Bricks

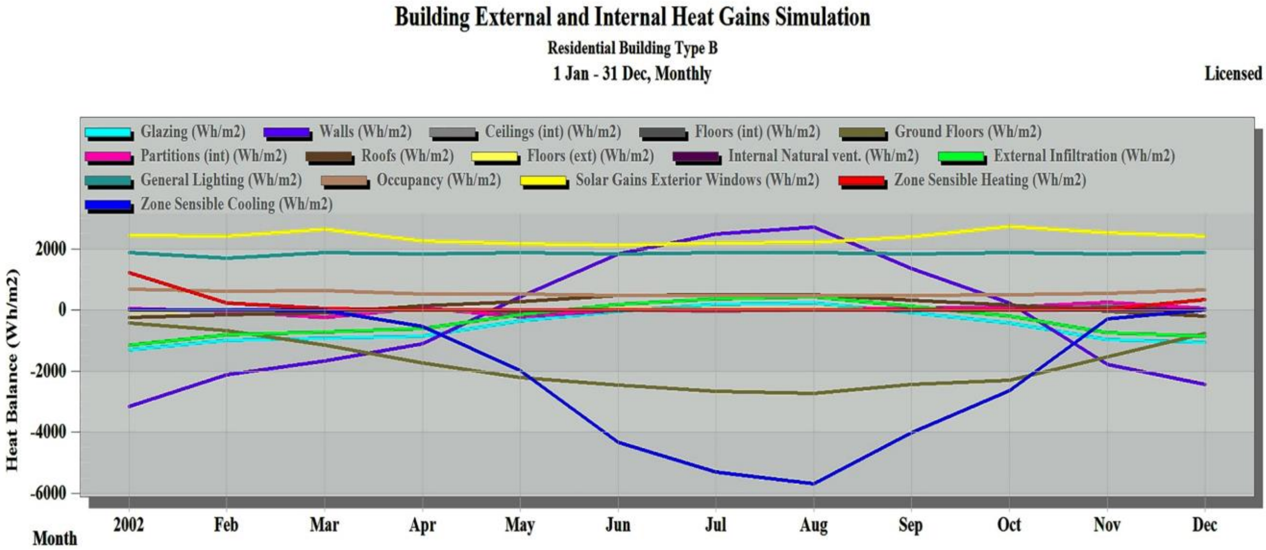


Figure (05) Building Type (B) Heat Gains Analysis [8]

5.3. Building Type (C)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick solid concrete blocks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 0.418 m^2K/W and U-Value = 2.392 W/m^2K. *(Figure 06) (Table 01) (Table 02)*

By analysing the building type (C) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 3,816.741 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 4,076.813 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 28,020.697 Wh/m^2. *(Figure 07)*

Figure (06) Solid Concrete Blocks

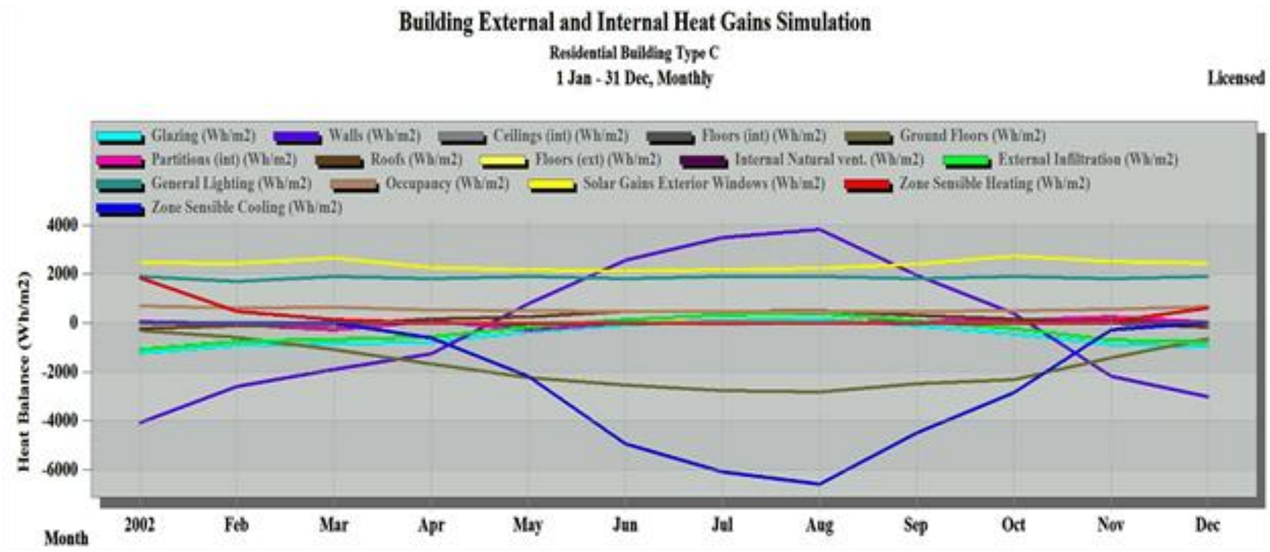


Figure (07) Building Type (C) Heat Gains Analysis [8]

5.4. Building Type (D)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick hollow concrete blocks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 0.396 m^2K/W and U-Value = 2.527 W/m^2K. *(Figure 08) (Table 01) (Table 02)*

By analysing the building type (D) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 3,934.012 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 4,237.967 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 28,817.347 Wh/m^2. *(Figure 09)*

Figure (08) Hollow Concrete Blocks

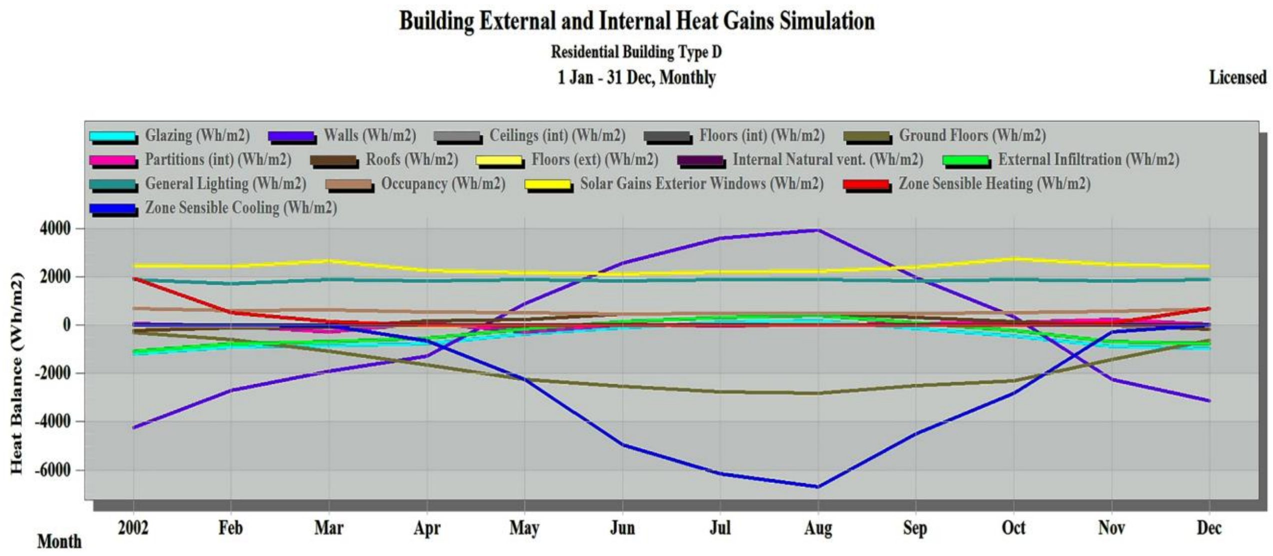


Figure (09) Building Type (D) Heat Gains Analysis [8]

5.5. Building Type (E)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick light sand blocks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 0.954 m^2K/W and U-Value = 1.049 W/m^2K. *(Figure 10) (Table 01) (Table 02)*

By analysing the building type (E) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 1,986.596 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 2,577.317 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 16,759.986 Wh/m^2. *(Figure 11)*

Figure (10) Light Sand Blocks

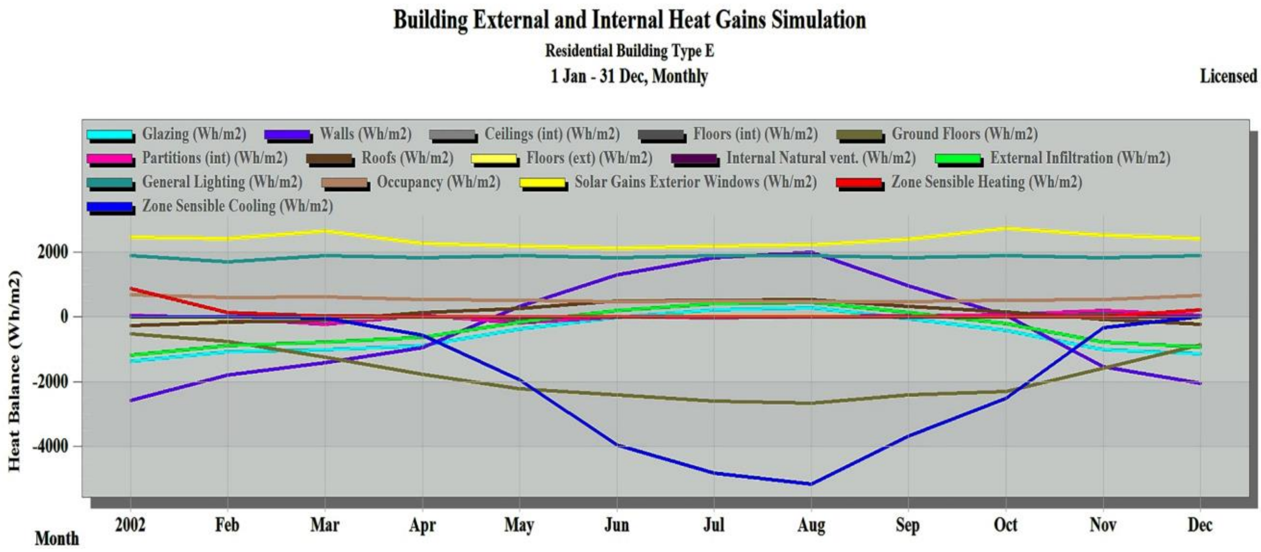


Figure (11) Building Type (E) Heat Gains Analysis [8]

5.6. Building Type (F)

In this building type, a whole building performance was simulated on the prototype residential building using 0.25 m thick thermal insulation blocks finished with conventional 0.03 m external and 0.02 m internal sand cement plaster and painting that estimated total R-Value = 2.140 m^2K/W and U-Value = 0.467 W/m^2K. *(Figure 12) (Table 01) (Table 02)*

By analysing the building type (F) external walls heat gain and loss, the amount of heat gain in the summer peak month (August) was calculated as 1,083.333 Wh/m^2, the amount of heat loss in the winter peak month (January) was calculated as 1,515.558 Wh/m^2, and the total amount of heat gain and loss in a whole year was calculated as 9,785.604 Wh/m^2. *(Figure 13)*

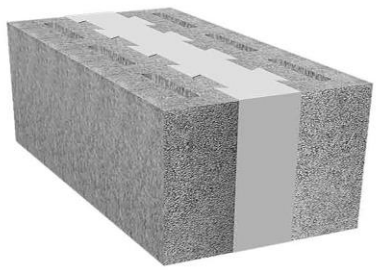


Figure (12) Thermal Insulation Blocks [11]

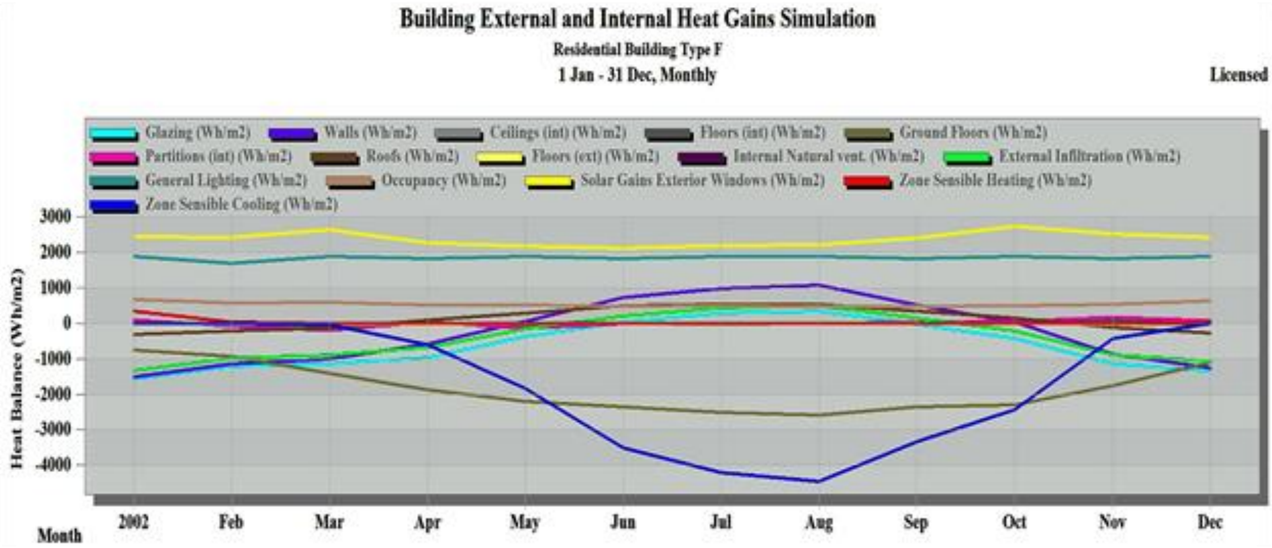


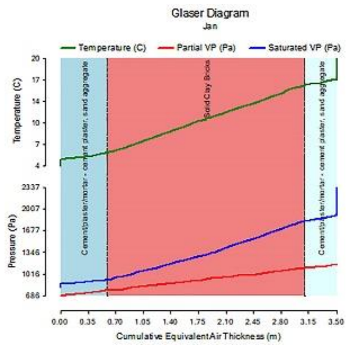
Figure (13) Building Type (F) Heat Gains Analysis [8]

Table (01): External Wall Types Construction Layers and Thermal Properties. [8]

	Wall Layers	**Wall Thermal Properties**	**Wall Temperature and Pressure Diagram**

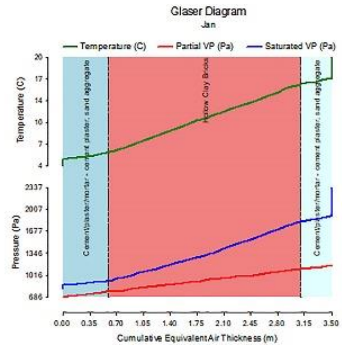
Wall Type (A)

Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	164.4480
Upper resistance limit (m2-K/W)	0.656
Lower resistance limit (m2-K/W)	0.656
U-Value surface to surface (W/m2-K)	2.057
R-Value (m2-K/W)	0.656
U-Value (W/m2-K)	**1.524**



Wall Type (B)

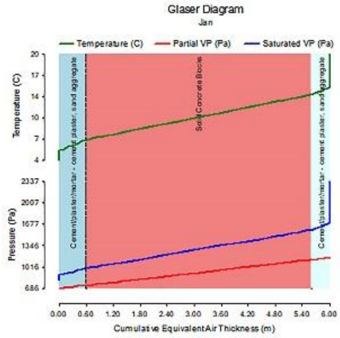
Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	160.1280
Upper resistance limit (m2-K/W)	0.656
Lower resistance limit (m2-K/W)	0.656
U-Value surface to surface (W/m2-K)	2.057
R-Value (m2-K/W)	0.656
U-Value (W/m2-K)	**1.524**



	Wall Layers	Wall Thermal Properties	Wall Temperature and Pressure Diagram

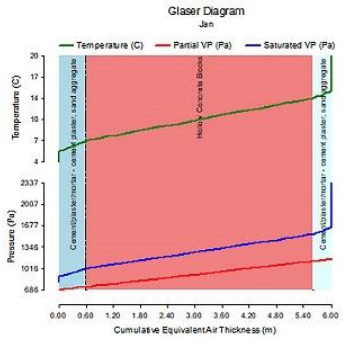
Wall Type (C)

Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	175.2480
Upper resistance limit (m2-K/W)	0.418
Lower resistance limit (m2-K/W)	0.418
U-Value surface to surface (W/m2-K)	4.032
R-Value (m2-K/W)	0.418
U-Value (W/m2-K)	**2.392**

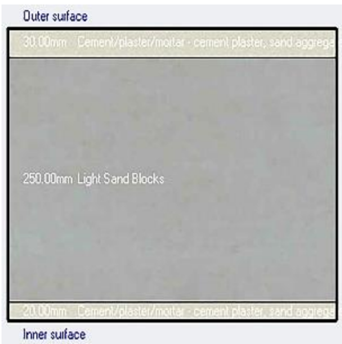


Wall Type (D)

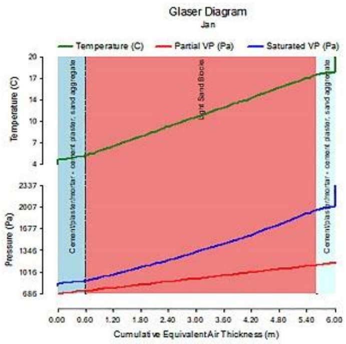
Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	113.3280
Upper resistance limit (m2-K/W)	0.396
Lower resistance limit (m2-K/W)	0.396
U-Value surface to surface (W/m2-K)	4.431
R-Value (m2-K/W)	0.396
U-Value (W/m2-K)	**2.527**



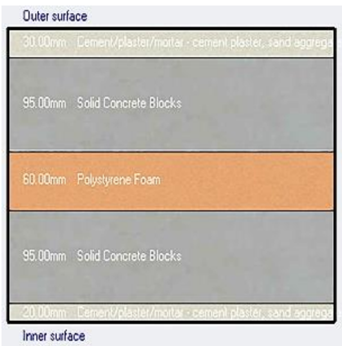
Wall Type (E)



Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	78.0480
Upper resistance limit (m2-K/W)	0.954
Lower resistance limit (m2-K/W)	0.954
U-Value surface to surface (W/m2-K)	1.276
R-Value (m2-K/W)	0.954
U-Value (W/m2-K)	**1.049**



Wall Type (F)



Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	175.2480
Upper resistance limit (m2-K/W)	2.140
Lower resistance limit (m2-K/W)	2.140
U-Value surface to surface (W/m2-K)	0.508
R-Value (m2-K/W)	2.140
U-Value (W/m2-K)	**0.467**

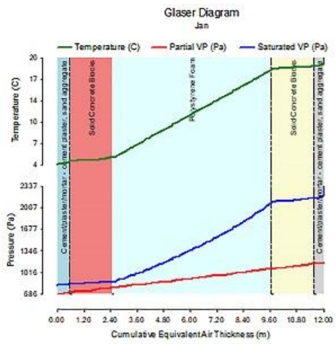


Table (02): External Wall Types Layers and Thermal Characteristics. [6] [8] [9] [11] [12]

Wall Type	Total Thickness (mm)	Layers	Thickness (mm)	Thermal Conductivity (W/mK)	Specific Heat (J/kgK)	Density (kg/m³)	R-Value (m²K/W)	U-Value (W/m²K)
Type (A)	300	Sand Cement Plaster	30	0.720	900	1860	0.656	1.524
		Solid Clay Bricks	250	0.600	900	1850		
		Sand Cement Plaster	20	0.720	900	1860		
Type (B)	300	Sand Cement Plaster	30	0.720	900	1860	0.656	1.524
		Hollow Clay Bricks	250	0.600	900	1790		
		Sand Cement Plaster	20	0.720	900	1860		
Type (C)	300	Sand Cement Plaster	30	0.720	900	1860	0.418	2.392
		Solid Concrete Blocks	250	1.400	900	2000		
		Sand Cement Plaster	20	0.720	900	1860		
Type (D)	300	Sand Cement Plaster	30	0.720	900	1860	0.396	2.527
		Hollow Concrete Blocks	250	1.600	900	1140		
		Sand Cement Plaster	20	0.720	900	1860		
Type (E)	300	Sand Cement Plaster	30	0.720	900	1860	0.954	1.049
		Light Sand Blocks	250	0.350	900	650		
		Sand Cement Plaster	20	0.720	900	1860		
Type (F)	300	Sand Cement Plaster	30	0.720	900	1860	2.140	0.467
		Solid Concrete Blocks	95	1.400	900	2000		
		Polystyrene Foam	60	0.034	1300	35		
		Solid Concrete Blocks	95	1.400	900	2000		
		Sand Cement Plaster	20	0.720	900	1860		

6. Results and Discussion

By simulating and analysing the results of a whole prototype residential building simulation located in Cairo, Egypt using building performance simulation software (Design Builder Software Ltd - V. 7.0.0.116 – Educational Version), this study focuses on building thermal envelope performance by analysing the results of six types of building envelopes (type A, B, C, D, E, and F) and the study observed that the heat gain and loss is differs using bricks and blocks types by varying values.

The building’s external wall type’s total yearly heat gain and loss are calculated: *(Figure 14)*

- Wall type (A) = 21,299.019 Wh/m^2 (using solid clay bricks in external walls).
- Wall type (B) = 21,299.042 Wh/m^2 (using hollow clay bricks in external walls).
- Wall type (C) = 28,020.697 Wh/m^2 (using solid concrete blocks in external walls).
- Wall type (D) = 28,817.347 Wh/m^2 (using hollow concrete blocks in external walls).
- Wall type (E) = 16,759.986 Wh/m^2 (using light sand blocks in external walls).
- Wall type (F) = 9,785.604 Wh/m^2 (using thermal insulation blocks in external walls).

This differs in external wall's heat gain and loss directly affects building HVAC system loads that affect building electricity consumption.

The building's total yearly electricity consumption is calculated: *(Figure 15)*

- Wall type (A) = 40,665.718 Wh/m2 (using solid clay bricks in external walls).
- Wall type (B) = 40,667.405 Wh/m2 (using hollow clay bricks in external walls).
- Wall type (C) = 43,072.954 Wh/m2 (using solid concrete blocks in external walls).
- Wall type (D) = 43,344.562 Wh/m2 (using hollow concrete blocks in external walls).
- Wall type (E) = 39,247.840 Wh/m2 (using light sand blocks in external walls).
- Wall type (F) = 37,570.948 Wh/m2 (using thermal insulation blocks in external walls).

These results prove that using thermal insulation blocks in a building's external walls reduces heat gain and loss that decreasing building energy consumption by 7.61% compared to using solid clay bricks, 7.61% compared to using hollow clay bricks, 12.77% compared to using solid concrete blocks, 13.32% compared to using hollow concrete blocks, and 4.27% compared to using light sand blocks.

From these results study can conclude that using thermal insulation blocks in a building's external walls can enhance building envelope thermal performance and increase the building's energy efficiency from 7.61% to 13.32 compared to using conventional clay and concrete bricks and blocks and 4.27% than using light sand blocks that make it the optimum type for this building's envelope in the surrounding environments.

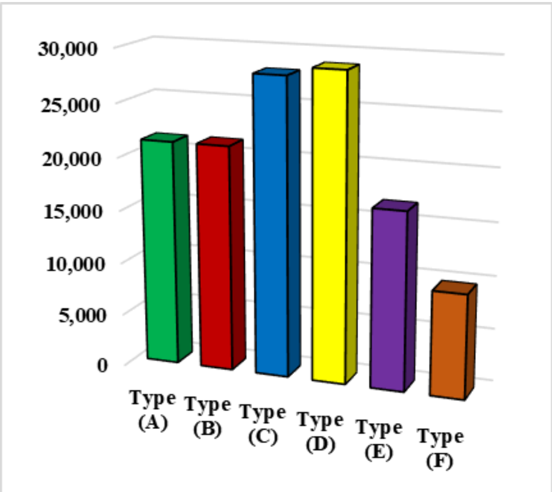


Figure (14)
External Wall Types Total Yearly Heat Gain and Loss (Wh/m^2)

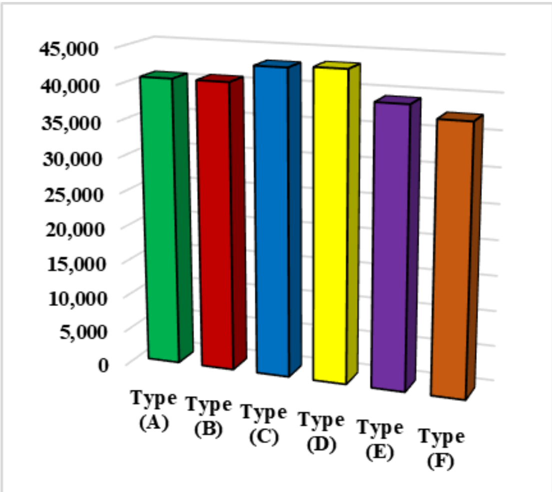


Figure (15)
Building Types Total Yearly Electricity Consumption (Wh/m^2)

7. Conclusions

Thermal insulation blocks make a non-negligible contribution to the built environments because it is considered one of the green construction materials that enhance the thermal performance of building envelopes thus reducing the building's operating energy consumption and can be used indefinitely without negatively affecting the surrounding environment.

This study evaluated the effect of using thermal insulation blocks in building envelope materials to enhance building thermal performance and thus improve building energy efficiency by decreasing heat transfer from and to building interior spaces and reducing HVAC system loads, energy consumption, and related negative impact in surrounding environments.

The whole prototype residential building simulation process results referred to a huge amount of heat transfer from and to building interior spaces caused by external walls in a conventional building that uses clay and concrete bricks and blocks (building types A, B, C, and D) and by using light sand blocks (building type E) that should be treated to improve building thermal performance and reduce building energy consumption.

By using thermal insulation blocks in external walls (building type F), the study observes a reduction of heat transfer and thus a reduction of energy consumption compared with other types of external walls: reduced heat transfer by 54.05% and reduced energy consumption by 7.61% than using solid clay bricks (building type A), reduced heat transfer by 54.05% and reduced energy consumption by 7.61% than using hollow clay bricks (building type B), reduced heat transfer by 65.08% and reduced energy consumption by 12.77% than using solid concrete blocks (building type C), reduced heat transfer by 66.04% and reduced energy consumption by 13.32% than using hollow concrete blocks (building type D), and reduced heat transfer by 41.61% and reduced energy consumption by 4.27% than using light sand blocks (building type E).

From these results, the study can conclude that the optimum type of bricks and blocks for the surrounding environments in Cairo, Egypt is building type (F) uses thermal insulation blocks which reduce building energy consumption from 4.27% to 13.32% and its related CO_2 production, operating costs, environmental pollutions, and other negative impacts.

Therefore, researchers are encouraged to evaluate the proposed propositions further.

8. Recommendations

This study is providing some recommendations for all sectors involved in the architecture and building construction field.

- Innovate and develop new alternative building materials that are expected to improve overall building performance.
- Expand the usage of the building’s performance simulation software and tools within all building’s lifecycle processes to be sure that the building will achieve high performance while conserving environments.
- Carefully design and select suitable building materials for the building envelope to control heat gain and loss and achieve high thermal performance for the building.
- Consider thermal insulation blocks when choosing buildings envelope construction materials to enhance building thermal performance and reduce energy consumption and operating cost.

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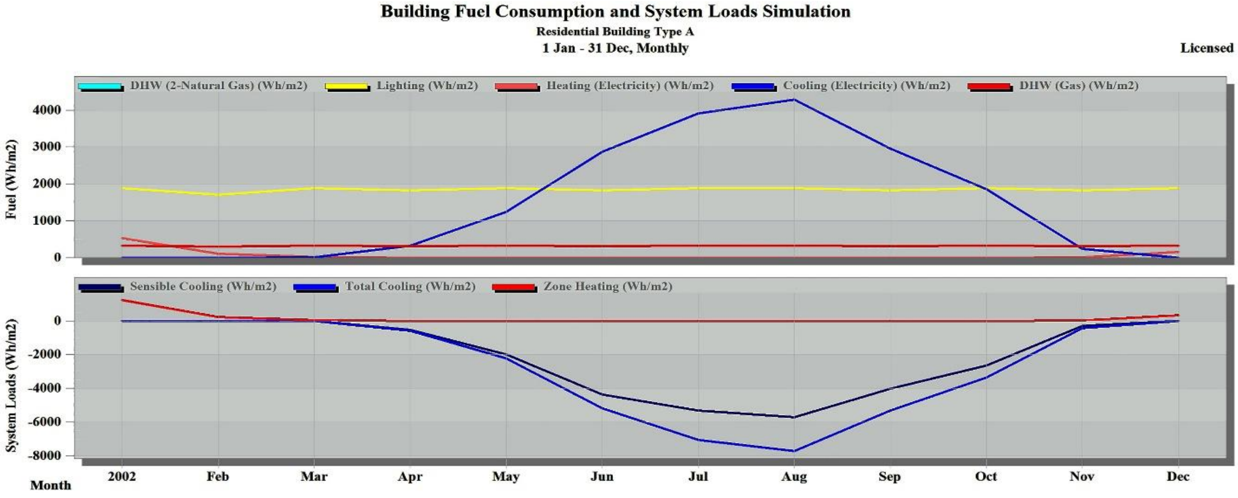
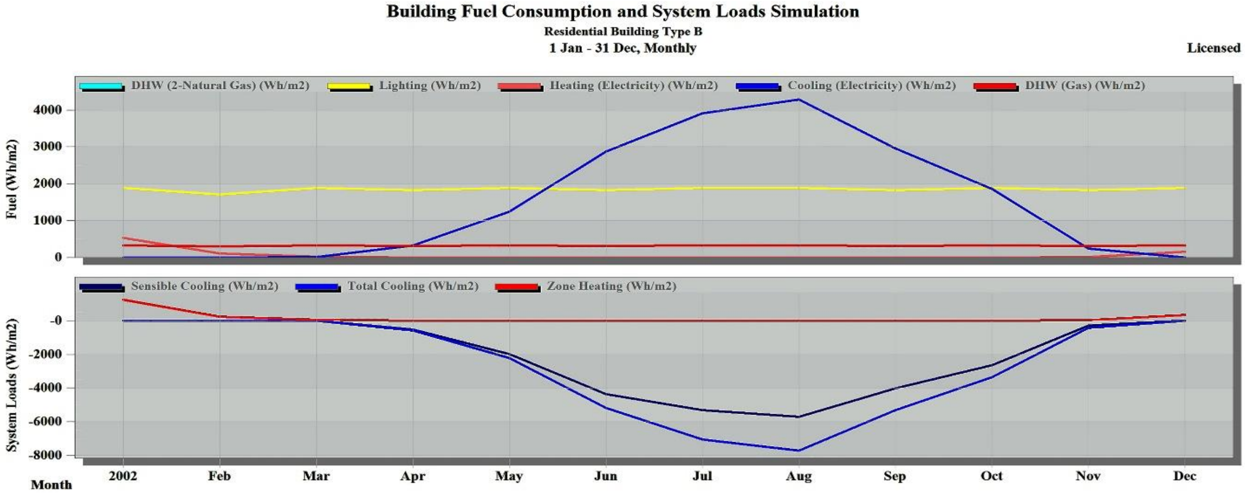
Appendix: Building Types Fuel Consumption and System Loads. [8]

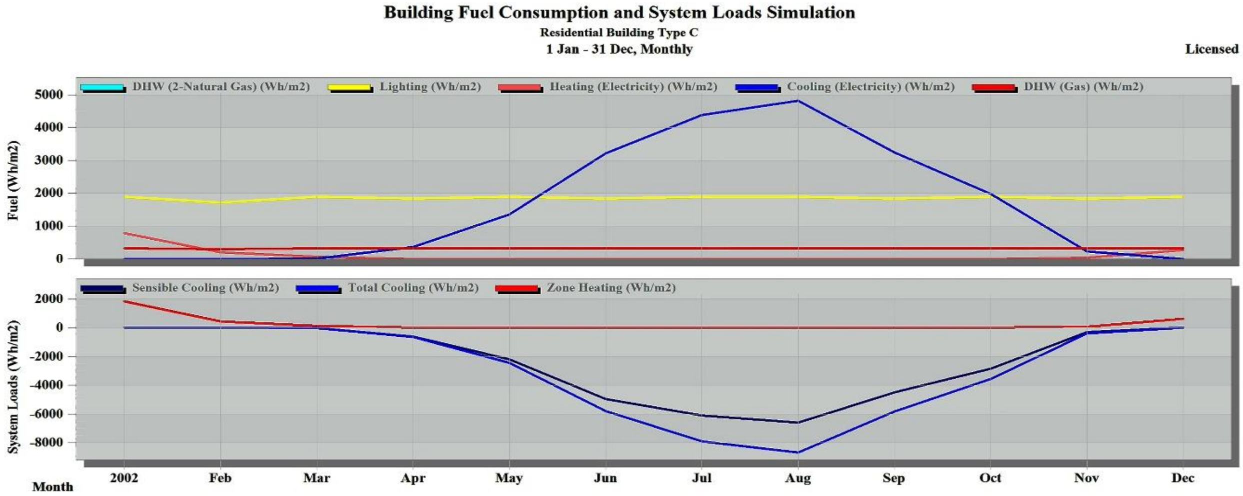
Building Type (A)



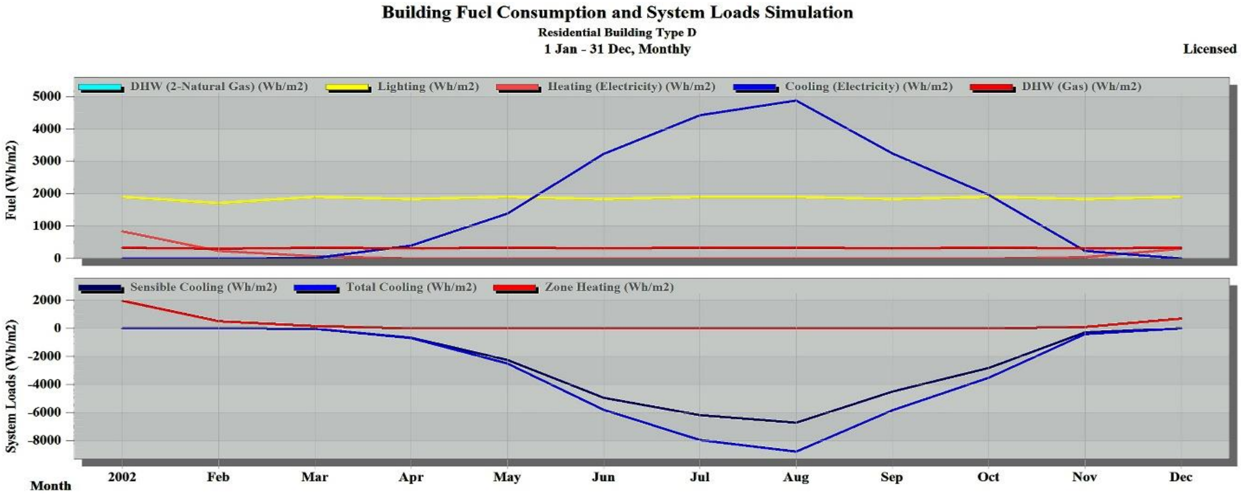
Building Type (B)



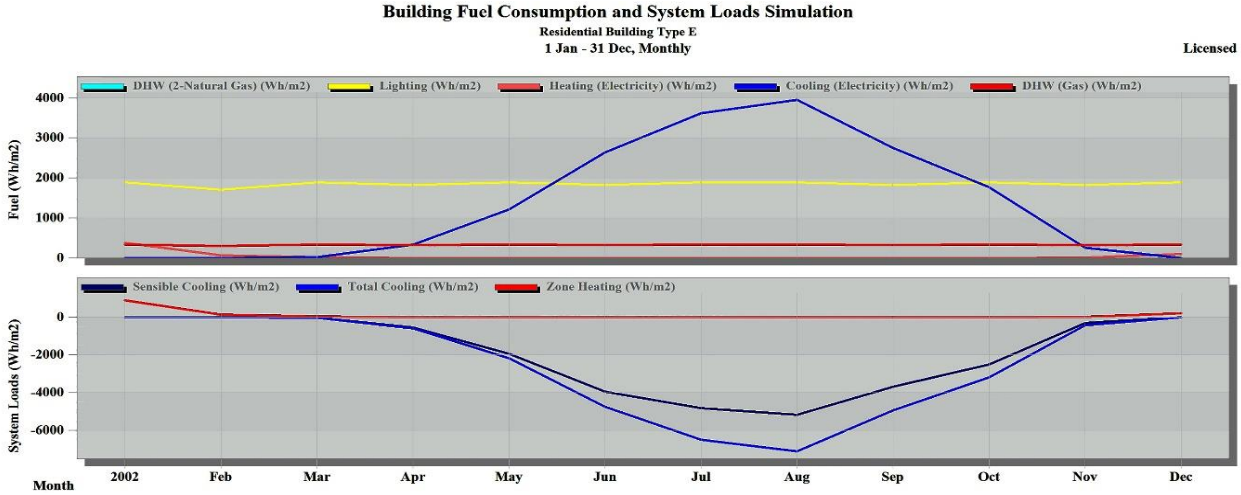
Building Type (C)



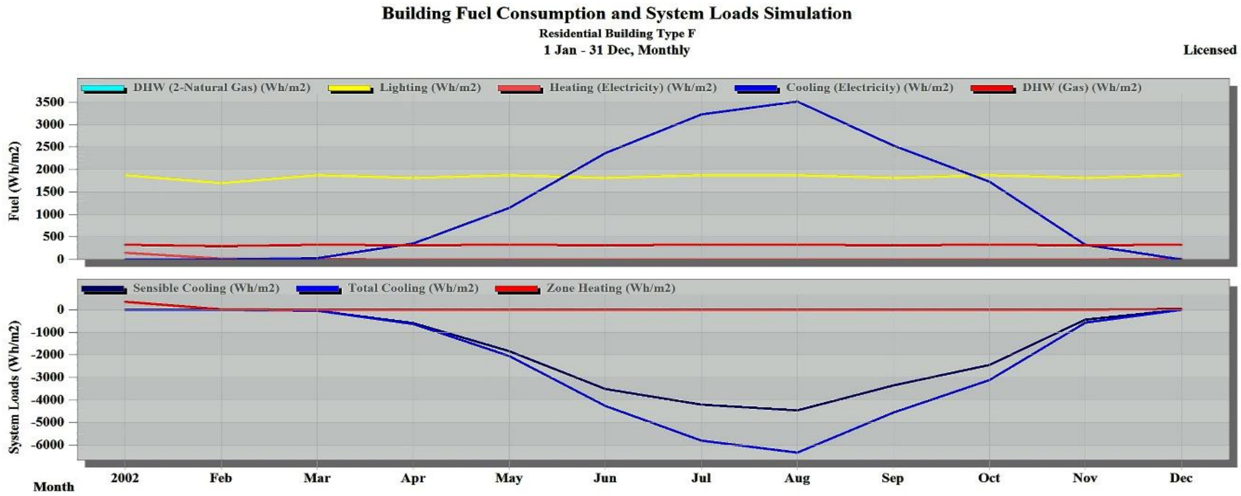
Building Type (D)



Building Type (E)



Building Type (F)



تحسين كفاءة الطاقة في المباني السكنية بإستخدام الطوب المعزول حرارياً

دراسة حالة في القاهرة – مصر

الملخص

يحظى استخدام الطوب المعزول حرارياً إهتماماً متزايداً في الآونة الأخيرة خاصة في البلاد الحارة - حيث تصل درجات الحرارة إلى مستويات عالية - نتيجة لتوصيلها الحراري المنخفض الذي يؤدي إلى إنخفاض كبير في كمية الطاقة اللازمة لتشغيل أنظمة التدفئة والتهوية وتبريد الهواء وتأثيراتها السلبية على البيئة المحيطة.

تتناول الورقة البحثية دراسة إمكانيات إستخدام الطوب المعزول حرارياً في أغلفة المباني في القاهرة - مصر لتحسين أداء المبنى بالكامل مع الحفاظ على البيئة. تمت تلك الدراسة بإجراء مقارنة تحليلية لنتائج محاكاة مبنى سكني نموذجي إفتراضي يقع في القاهرة – مصر بإستخدام برنامج محاكاة أداء المبنى (Design Builder Software Ltd - V. 7.0.0.116 - Educational Version) وبتطبيق ستة نماذج مختلفة من أغلفة المباني على المبنى ، أربعة نماذج تعتمد على أنواع تقليدية من الطوب في الحوائط الخارجية ، النموذج الخامس يعتمد على الطوب الرملي الخفيف ، ويعتمد النموذج السادس على الطوب المعزول حرارياً وذلك لإستنتاج تأثير إستخدام الطوب المعزول حرارياً على الأداء الحراري للمبنى وبالتالي إستهلاك الطاقة .

خلصت نتائج المقارنة التحليلية لأداء المبنى إلى تأثر المبنى بإنتقال كمية كبيرة من الحرارة من وإلى الفراغات الداخلية للمبنى خلال الحوائط الخارجية لنماذج المباني التي تستخدم الأنواع التقليدية من الطوب والتي يجب معالجتها لتحسين الأداء الحراري للمبنى؛ وباستخدام الطوب المعزول حرارياً لاحظت الدراسة إنخفاضًا كبيراً في الإنتقال الحراري من وإلى المبنى بنسبة تتراوح بين ٤١,٦١٪ إلى ٦٥,٠٨٪ مما أدى إلى تخفيض إستهلاك الطاقة في المبنى بنسبة تتراوح بين ٤,٢٧٪ إلى ١٣,٣٢٪.

وبناءاً عليه أثبتت الدراسة أن إستخدام الطوب المعزول حرارياً في أغلفة المبانى يعزز الأداء الحراري للمبنى بشكل كبير وبالتالي يخفض من إستهلاك الطاقة وما يتبعها من تكاليف التشغيل وإنبعاثات ثاني أكسيد الكربون والتلوث البيئي وغيرها من التأثيرات السلبية على البيئة المحيطة.

الكلمات الرئيسية: الأداء الحراري، كفاءة الطاقة، أغلفة المباني، أعمال المباني، الطوب المعزول حرارياً.