كلية الفنون الجميلة بالقاهرة
JAARS
مجلة الفنون والعمارة للدراسات البحثية
JOURNAL OF ART & ARCHITECTURE RESEARCH STUDIES
جامعة حلوان
HELWAN UNIVERSITY

IMPLEMENTING SUSTAINABILITY IN HISTORICAL BUILDING AS A WAY OF REUSING

CASE STUDY: SULTANA MALAK'S PALACE, HELIOPOLIS, EGYPT

تحقيق الاستدامة كطريقة إعادة استخدام للمباني الأثرية

دراسة حالة: قصر السلطانة ملك مصر الجديدة، مصر

Nisreen Abdeen [1], Shereen Khashaba [2], Engy Al-Ashqar [3]

Architecture, Engineering, Heliopolis University, Egypt (1)
Architecture, Engineering, CIC (Cairo Campus of Cape Breton University), Egypt (2)
Interior Architecture, Fine Arts, Helwan University, Egypt (3)

نسريين عابدين ١، شرين خشبة ٢، إنجي الأشقر ٣

العمارة - الهندسة – جامعة هليوبوليس للتنمية المستدامة، مصر (1)
العمارة - الهندسة – المعهد الكندي العالي لتكنولوجيا الهندسة و الإدارة، مصر (٢)
العمارة الداخلية – الفنون الجميلة – جامعة حلوان، مصر (٣)

nisreen.abdeen@hu.edu.eg [1], shereen_omar@cic-cairo.com [2], engy.elashqar@yahoo.com [3]

ABSTRACT

Each country is known by its architectural identity, so it is alarming when this identity is vanished, destroyed, reused inappropriately, or abandoned with no use. Egypt faces a great problem in efficiently reusing historical buildings. This paper aims to implement sustainability in historical buildings to cope with our requirements for healthy buildings, to preserve its aesthetic value, as well as being an expression of Egyptian sustainable identity. Regarding covid-19 pandemic, the paper's goal is to apply sustainable retrofits to historical buildings by utilizing passive ways, represented in using the double height ceiling, long windows, wind capture and to ventilate the building without using AC. The simulation uses the 'design builder' program as a software, for producing a methodology to implement sustainability in historical buildings.

KEYWORDS

Retrofitting; Sustainable Heritage; Aesthetic Value; Historical Buildings.

الملخص

تتميَز كل دولة بهويّة معمارية خاصة بها، لذلك فمن المُخيف أن تختفي هذه الهوية أو تُدمر أو يُعاد استخدامها بطريقة خاطئة أو يتم هجرها وتركها دون استخدام. تواجه مصر مُشكلة كبيرة في إعادة استخدام مبانيها التاريخية بفعالية وكفاءه تمكنها من الحفاظ على هويتها المعمارية المُميزة. لذلك يهدف البحث إلى تحقيق الاستدامة في مبانينا التاريخية، لمواكبة متطلباتنا من المباني الصحية المستدامة، والحفاظ على قيمتها الجمالية، فضلاً عن كونها راية لإظهار الهوية المصرية المستدامة. و مع ظهور أزمة كوفيد-١٩ , فإن تطبيق التحديث المُستدام للمباني التاريخية، باستخدام التقنيات السالبة مثل الأسقف مزدوجة الارتفاع، النوافذ الطويلة، و ملاقف الرياح ، لتهوية المبنى دون استخدام مكيفات هدف للبحث لتجنب انتشار الفيروس و خلق بيئة صحية جيدة التهوية. تمت محاكاة استهلاك الطاقة للمبنى حالة الدراسة (قصر السلطانة مَلك) باستخدام برنامج (design-builder) لحساب تأثير تطبيق سيناريوهات التعديل التحديثي ومن ثمَ عمل منهجية لتنفيذها.

الكلمات المفتاحية

التعديل التحديثي؛ التراث المستدام؛ القيمة الجمالية؛ المباني التاريخية

Copyright © 2020 | to JAARS

1. INTRODUCTION

The life span of historical buildings can extend for hundreds of years if they are well conserved, adapted and reused. This paper highlights the selection process of the most appropriate function for reusing historical buildings in a sustainable way. This process is done by choosing a suitable criterion in solving its environmental problems in a compatible way, in preserving its value thus adapting it to the degree of intervention in an economical way, posed on its infrastructure in a holistic way which comeback with great benefits for the community represented in new economic, cultural, and social values, and support local development (Della 2020). The reuse of historical buildings has been experiencing community criticism; there should be a continuous revision and adoption for sustainability (El-Sorady 2020).

The research discusses the sustainable adaptive reuse and general retrofit for historical buildings to upgrade the energy demand, to optimize the building envelope performance in a mutual compatible way (Dixon, T., Britnell, J. & Watson, G. B. 2014) according to climate change using dynamic computer simulation design builder program. Retrofitting is the refurbishment of buildings to improve their sustainability with regard to energy efficiency and carbon dioxide emissions, which improves the performance of the building while extending the building use over an extended period (Gleeson, 2011).

1.1 Research Problem

Unsuitable functions for reusing historical buildings result in extensive and negative effects on the building as a structure and its heritage value. It also may have a negative socio-economic impact on the surrounding areas. In addition, implementing sustainable adaptive reuse to these buildings is abandoned in existing facilities.

1.2 Research objective

The research aims to increase the energy performance, by surveying the existing building situation and how to upgrade it within low energy. Upon the research survey, the main constraints facing the morphology of the building were highlighted, by measuring the walls insulation, lighting systems (natural, and artificial), glazing, window frame, shutters, curtains, internal wall, ceiling alternatives, and natural ventilation impact on the indoor building thermal comfort and energy performance. Regarding to the crisis of covid-19, the research applies sustainable using passive techniques as the double height ceiling, long windows, and wind captures, to ventilate the building without using ACs. In addition, it defines the ideal solution phases for retrofitting strategy.

1.3 Importance of Research

In response to the new challenges and risks associated with development and implementation, innovative and adaptive strategies for historical buildings' adaptive reuse are required. Thus, implementing sustainability with regard to energy efficiency and carbon dioxide emissions to cope with our requirements of healthy buildings, preserving its aesthetic value while extending the building life span, provides huge environmental, economic and social benefits, as well as being a flag for showing the Egyptian sustainable and cultural identity.

Copyright © 2020 | to JAARS

1.4 Research Methodology

The research follows theoretical and application approaches as illustrated in Figure 2. It applies a quantitative method to implement sustainability using the design builder simulation tool to calculate the effect of the retrofit scenarios' application. Sultana Malak's palace was selected as a case study; it is luxurious by its inherited value and location, to preserve its identity by an effective transformation in usage, with preserving its aesthetic value through two main phases:

- **First phase:** surveying the existing situation of the palace, with flirtation of the weakness, and strengths by **SWOT** analysis.
- **Second phase:** solving the problems and weakness by redesigning it in sustainable way, maintaining its aesthetic value and identity.

Figure 1 Shows the SWOT analysis as a survey visual assessment tool (Source: The Authors).

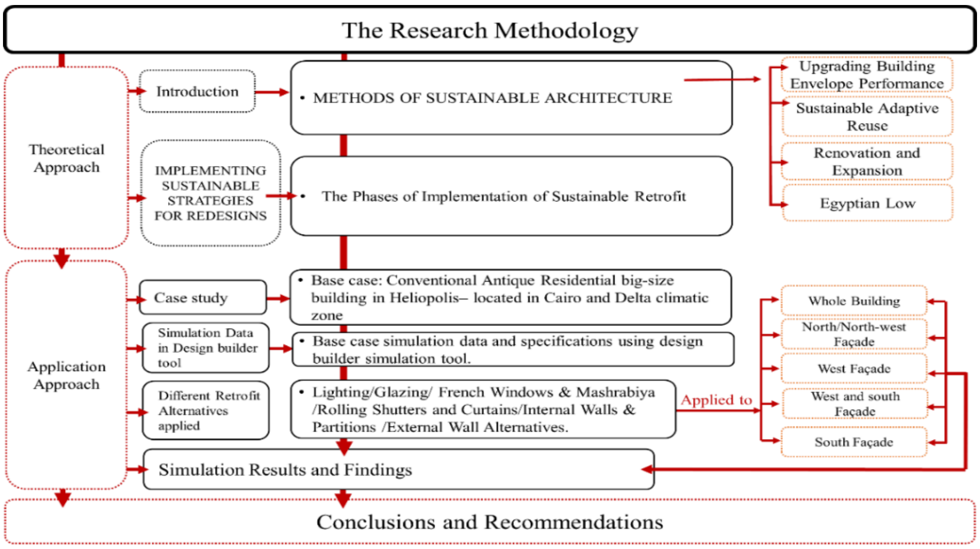


Figure 2 Methodology Diagram (Source: The Authors).

Copyright © 2020 | to JAARS

1.5 Theoretical Framework:

Upgrading Building Envelope Performance, the energy performance analysis was carried out according to the following evaluation methodology:

- analysis of the existing building structure;
- selection of possible interventions on building envelope;
- selection of the proper lighting systems
- Selection of the optimized solution by *SWOT* analysis and energy performance.
- Post-insulation of roof i.e. (expanded polystyrene sheets, polyurethane foam) up to 42% as an essential step in increasing the indoor energy effectiveness of existing building.
- Adding a wall insulation i.e. (Cavity Wall) this issue was not found critical since the external walls of considerable thickness and thermal mass leads to lower summer cooling demand.
- Preserve the historical value by maintaining the old wooden frames, installation of light reflection system between the glazing; shutters, curtain installation.
- Complete replacement of the window with the highest possible energy efficiency glass.
- Revival of historical building as a night landmark by adding external led lightings.

Phase 1 :problem formulation by S.W.O.T analysis
- Determines elements of the building which need retrofitting

Phase 2:an approach after setting the goal of retrofitting
- provide a base budget for the project.

Phase 3: evaluation of suitable techniques
- These include energy efficiency retrofit (e.g. solar retrofit, lighting retrofit, passive design), indoor quality retrofit (e.g. internal shading, top level sky lights under floor supply)

Phase 4: Implementation of retrofitting strategy
- meeting goals.

Phase 5: computer simulation Evaluation methods
- i.e. design builder

Phase 6: financial analysis of sustainable techaniques
- market performance and financial performance

Figure 3 shows the Chosen ideal solution phases for retrofit strategy. (Source: The Authors.).

Copyright © 2020 | to JAARS

2. METHODS OF SUSTAINABLE ARCHITECTURE

The effectiveness of buildings' function and comfort plays a great role in upgrading its indoor quality, based upon building's site, location, external envelope & orientation along the design processes, relevant to the international rating systems **USGBC LEED**. That is why, the most basic understanding of sustainable architecture strives *"to minimalize the consumed energy and resources for all phases of the building life-cycle – from there planning and construction through their use, **renovation**, and eventual demolition "* (Haroun, H., Bakr, A. & Hasan, A, 2019).

2.1 Upgrading Building Envelope Performance

The energy performance analysis was carried out according to the following evaluation methodology:

- analysis of the existing building structure;
- selection of possible interventions on building envelope;
- selection of the proper lighting systems
- Selection of the optimized solution by SWOT analysis and energy performance.
- Post-insulation of roof i.e. (expanded polystyrene sheets, polyurethane foam) up to 42% as an essential step in increasing the indoor energy effectiveness of existing building.
- Adding a wall insulation i.e. (Cavity Wall) this issue was not found critical since the external walls of considerable thickness and thermal mass leads to lower summer cooling demand.
- Preserve the historical value by maintaining the old wooden frames, installation of light reflection system between the glazing; shutters, curtain installation.
- Complete replacement of the window with the highest possible energy efficiency glass.
- Revival of historical building as a night landmark by adding external led lightings.

2.2 Sustainable Adaptive Reuse

New use ought to be compatible with heritage significance and involve the lowest changes to layout, setting and fabric. According to **ICOMOS** "*International Council on Monuments and Sites, 2010"* (Haroun, H., Bakr, A. & Hasan, A, 2019), the new use of a building and its compatibly with the heritage structure can be used as an indicator of success of adaptive reuse projects. Confirmed that the main focus in reusing is choosing the appropriate function, that constitutes a cultural property (Reda 2000).

2.3 Sustainable Renovation and Expansion of Buildings

The three pillars of sustainable development have to be achieved during the adaptive reusing process, they are: 1) environmental protection, 2) society and 3) safety and resistance.

Copyright © 2020 | to JAARS

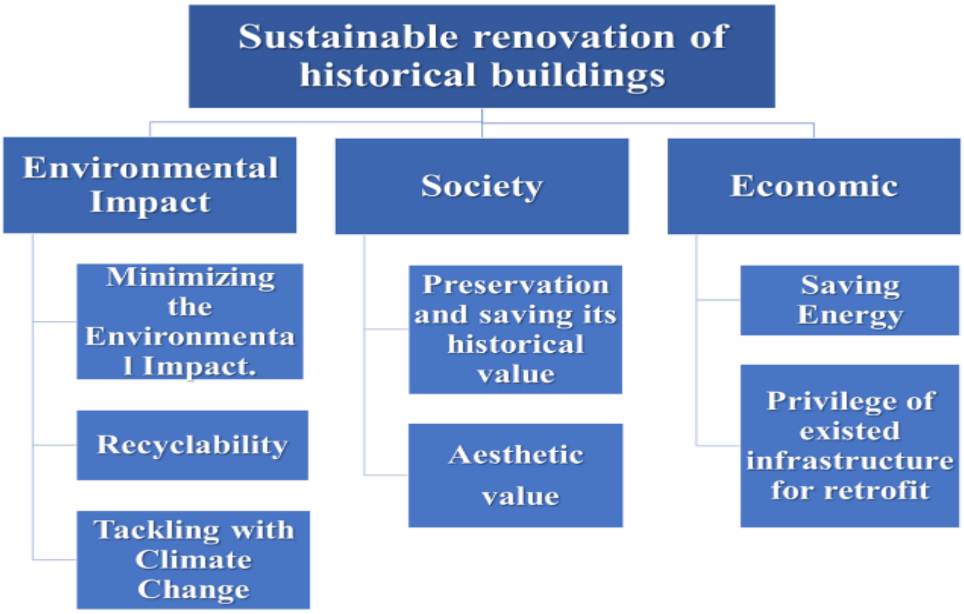


Figure 4, Sustainability indicators for the restoration of historical buildings (Source: The Authors.).

2.4 Egyptian Law

According to the executive regulations of the Antiquities Protection Law No. 117 of 1983 amended by Law No. 91 of 2018 issued by Ministerial Resolution No. 365 of 2018 issued by the Minister of Antiquities 11/27/2018 and published in Egyptian facts No. No. 275 of 7/12/2018. Now the Egyptian government is studding to publish the Egyptian code for reusing and Maintenance the antique buildings (Al-Ashqar, 2020).

3. IMPLEMENTING SUSTAINABLE STRATEGIES FOR REDESIGN

Implementing passive solar techniques allows the desirable winter sun into building during the winter and can keep the unwanted summer sun out, by correctly providing the shading on both the roof and the widows. This depends largely on building orientation and the widow to wall ratio (**WWR**), to make cross ventilation for cooling the building, to achieve the thermal comfort for the adaptive reuse of Sultana Malak's Palace. In order to cool the building in summer, it is necessary to have the building envelope insulated, to minimize the use of **AC** to reduce the energy consumption.

In the design phase, the annual building performance is evaluated using design builder simulation tool. The adequate interventions focused on the building envelope, HVAC systems, and lighting systems to reduce the energy consumption in a significant way. In addition, the fastest growing sources of energy demand is cooling the building. Where, the designed renovation takes place by installing modern techniques as an alternative solution for the damaged places for the existed palace that should meet the minimum energy performance requirements. The implementation of sustainable retrofits mingled in six main phases, as shown in (figure 3).

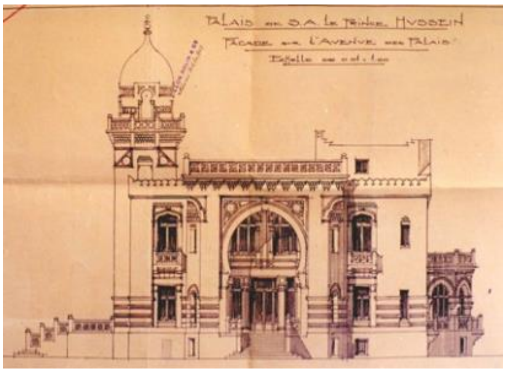
Copyright © 2020 | to JAARS

4. CASE STUDY: SULTANA MALAK’S PALACE

The researchers are took Sultana Malak’s palace as a case study ,as it is luxurious by its value and location, where it is located on a major street “El-Orouba Street “, having a good visual axis on Baron Empain Palace, and it is the frontage on the Historical buildings in El-Qrouba area. Therefore, it has a good effective impact on its urban context for upgrading its environmental sustainability conditions, to preserve its identity by an effective transformation in usage with preserving its aesthetic value. This palace has a historical and aesthetic value as follows:

- **Historical Value (Recorded):** the building is one of the most beautiful neighborhoods from khedivial era construction starts in 1909 until 1914, located in front of "*Baron Edward Empain Palace”* in Heliopolis, it was the residence of "*Sultan Hussein Kamel* “last sultan in Egypt (Dobrowolska, 2005).
- **Aesthetic Value:** the palace’s style is "*Eclectic*" Eclecticism style is one of the European architectural styles that have appeared in the buildings of Cairo in 13-14 A.H / 19-20A.D,which means the trend toward consolidation of various models and buildings in the previous civilizations and merge them and out in one building” (Enab, 2018). Its architecture style mixes between baroque and Islamic architecture (Neo-Mamluk / Mamluk Revival). The rooms' walls are decorated with oil human paintings and colorful panels(Abdelrhman 2016).

a) The main facade on the western side



b) The main facade on the south side facing Baron Edward Empain Palace by Alexandre Marcel who designed the Palace, Paris, April 25, 1908, (Volait, M., Solé, R. & Talmisānī, M, 2005) .

c) The main facade on the eastern side facing Al-Thawra Mosque (Source: The Authors).

d) The main facade on the north side.

Figure 5, The main facades (Source: The Authors).

Copyright © 2020 | to JAARS

4.1 Sultana Malak's Palace Descrubtion

The palace is composed of basement and two floors and has around forty rooms, surrounded by a garden and an iron fence. The features on the exterior include trefoil crenellations that run along the top part of the building. The main entrance portal has a triple arched passage. On either side of the main entrance is a tower-like structure (see Figure 5). One has the dome and the other is plain; unlike the rest of the building, it has a stepped cresting. Although the building possessed a Neo-Mamluk appearance on the outside, it was quite Europeanized on the interior (Marei 2012).

- **Basement:** The basement included the kitchen and food stores.
- **First floor:** Is occupied by the reception halls and formal guest rooms some halls there were gilded panels which had naturalistic scenes and human figures. Other halls had columns and painted ceilings with landscape figural. The adjacent hall had a marble statue of a woman and was also decorated with naturalistic scenery.
- **Second floor:** was most probably the private quarters of the house. The rooms there also had a European feel to them and were decorated with paintings and mirrors.
- **Stairs:** were decorated with a pierced balustrade pierced with arabesques.

Figure 5, Photo shows the building from outside (source: The Authors).

Figure 6, Photo the dome above the main entrance which will be used as a wind capture. (source: عبد الوهاب، إنجي ٢٠١٩).

Figure 7, shows how Alexandre Marcel mixed between New-Classism & Mamluk architecture by using decorative new-classical ceiling centered by Mamluk's dome and by shaping French windows through using Islamic Mamluk arch (source: The Authors).

Copyright © 2020 | to JAARS

Figure 8, Figure shows the different styles used in internal halls (Source: The Authors).

4.2 Unsuitable Reused Functions

It was occupied by a girls' public school in the 50s; this action affected the building badly; through implementing the school needs such as electricity supplies, ACs and dividing rooms by stopping doors (see Figures 9 & 10), now it is abandoned for re-using by a new function.

Figure 9, Figure shows the unsuitable way used for deleting in internal halls (Source: The Authors).

Figure 10, Figure shows the bad condition of the building after the unsuitable use & abandons (Source: The Authors).

Copyright © 2020 | to JAARS

5. THE ANALYTIC METHODOLOGY FOR RETROFITING IN HISTORICAL BUILDINGS

The Sultana Malak's Palace is a rich cultural archaeological building that has a rich value. Therefore, the government agency planned to convert it from a public school into a center for creative development for youth, to preserve its social value that reflects on its urban context.

5.1 Deep Energy Efficiency vs. Shallow Energy Retrofit

In our current study, the approach to retrofit the Historical building stock, by following a "shallow renovation" track that focuses on partial invisible refurbishments to preserve its cultural heritage value. Primarily on retrofits, that provide low risk on its value, to cope with our climate change. The research tends to choose renewable energy in cooling supply solutions to improve the indoor energy efficiency, and increase insulation. The decision-making on choosing the best function is to cope with its future investments. It is necessary to identify cost-effective pathways for remaining items as a cream "shallow refurbishment". On the other hand, "deep renovation as a carefully phased process" is a more promising strategy to reach long-term (2050) climate targets than "shallow renovation at high speed" (Lohse, 2017).

5.2 Appropriate Measures for Potential Energy Saving

The paper shows the impact of accurate energy utility after retrofits based upon research design builder variables data, to provide input to the process of determining proper goals to achieve the ideal building performance energy goal. Table 1 lists the necessary pre-retrofitting Historical building data.

Table 1 , necessary pre-retrofitting Historical building data

Type of information	Description / Example
energy usage	Specific consumption is assessed by an annual and long-term heating and cooling degree-days.
Baseline of performance data	Baseline is a whole survey for the existing building performance, by reviewing the building documentation, spot measurements.
Building usage data	Applying analytic survey for the building Usage design schedule before renovation, number of occupants, and activity level.
Design and as- built-drawings	Showing construction of existing walls, floors, and roofs. orientation, building elevations showing existing opening/fenestration characteristics, including materials, anticipated performance characteristics, sizes, numbers, and locations
Global and specific end energy usage	To depict the global and specific consumption, the sub- metering structure must be consistent and the data must be collected
Indoor building climate	Upgrading the indoor air temperature, ventilation rate, and relative humidity before the building renovation
Energy saving	saving of the load energy supply and major energy consumers need to be evaluated

Copyright © 2020 | to JAARS

5.3 The Morphology of The Façade

Increasing the self-shading using Mashrabiya panels to minimize solar heat gain of the sand stone used in the facade. According to the orientation, the optimal shading used to customize the inner wall thermal mass as a cooling process. Furthermore, the evaporative cooling method applied as an updated sustainable retrofit, to decrease the indoor temperature. So to upgrade the existing airflow using Mashrabias, and French windows to be opened upon the preferred sun angle.
Regarding the indoor airflow, the researchers suggest in their simulation to implement movable light partitions to be placed in the south facades as a double wall function, to condense the incoming air for cooling. The cross-ventilation system is applied using double height wind capture.

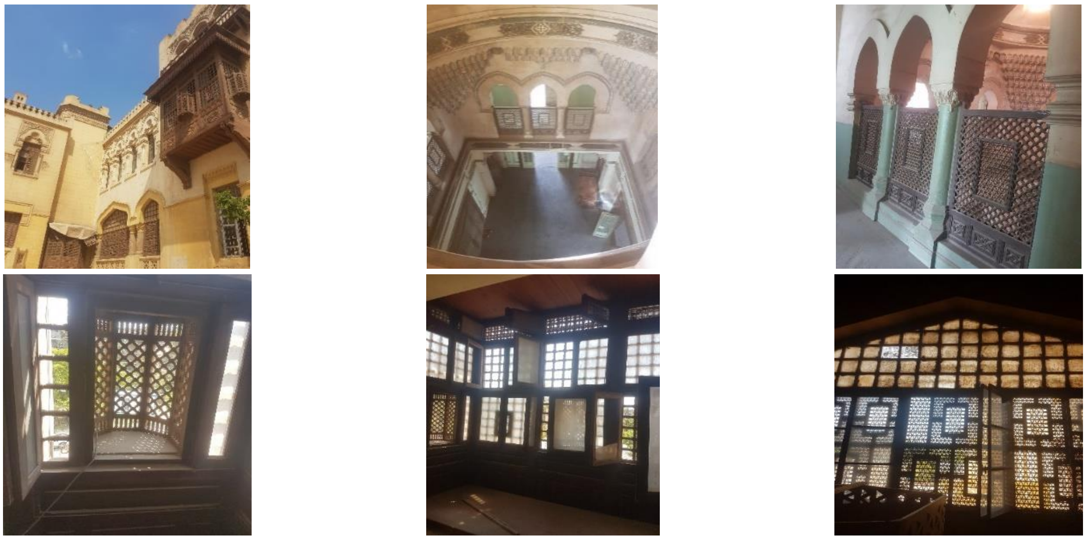


Figure 11, kinds of Mashrabiya used in facades & indoors to minimize the amount of sun radiation in summer and increase the cross ventilation *(Source: The Authors).*

5.4 Cautions for Internal Insulation Installation

There are many risks while installing internal insulation.

- Control the evaporate accumulated moisture affecting the outer walls.
- Preventing moisture from coming out of the pores wall material (stones, etc.).
- Avoiding the Disadvantage of insulation with some appropriate Finish material in inner space, as it decreases its existing area preventing the disappearance of the original materials from the inside.

5.5 Major Insulation Post External Wall Retrofit

The need to reduce energy consumption in Historical buildings undergo major rehabilitation in virtual environmental simulation for energy saving. The paper illustrates feasible retrofit scenarios as analytic way in creating its retrofit measures as base for its methodology, dealing with sustainable Historical buildings.

Copyright © 2020 | to JAARS

- The need to measure dynamic demand for building management is essential to extend the building's life span.
- Repurpose the building by sustainable improvement fitting its Historical value.
- Apply the national contemporary codes in the Historical building (e.g., fire protection).
- Improve existing thermal building mass comfort to increase the thermal resistance of opaque mass.

5.6 Passive Design Application

The existing circumstances facing the palace is having high moister in its outer walls which affects the indoor Humidity and temperature. The Mashrabiya panels are placed in the north, north west façades, that has a good orientation, which provides the building with cold air. On the other side the long French windows are placed in the south east, south west facades, that cause a great rise in temperature out of glass windows. The research plan is to implement wind capture, above the vertical circulation and domes, to capture the prevailing wind.

- **First Phase:** using the privilege of recessed masses in the arcades, as a shading area in south elevation, and increase airflow, by creating invisible vents to upgrade air circulation, using double height of vertical circulation stairs as a wind capture to provide cross ventilation. Therefore, the research applied two wind captures in the two vertical towers placed in the north, south-west facades, to condense the incoming air for cooling demand.
- **Second Phase:** building our solution upon choosing the best refurbishment coping with energy rehabilitation for energy supply system. The paper studies the passive energy techniques available to the thermal comfort for this zone. It can be applied in the existing atrium using its double height.

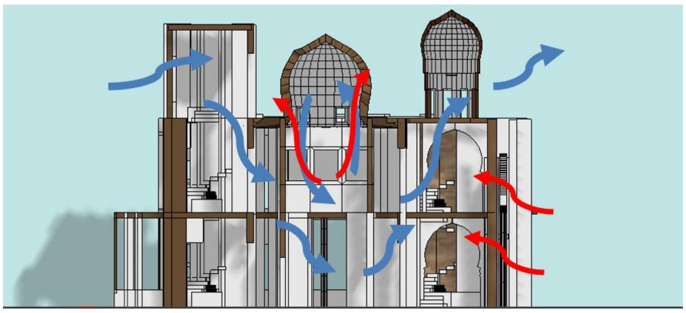


Figure 12, Section shows the cross ventilation after adding the wind captures. Air circulation concept within building (Source: The Authors).

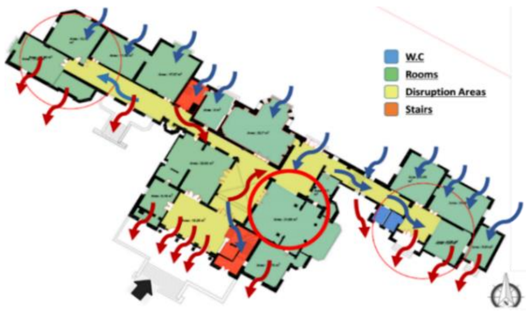


Figure 13, Plan shows the direction of in & the exhausted air (Source: The Authors).

To increase the environmental building performance, the researches use the wooden overhangs; Mashrabiya shatters as a good indicator for upgrading thermal comfort, airflow capture, using the perforated porous opening in an effective way, with maintaining its sustainable identity. The Mashrabiya has good sun altitude shading device to prevent high amount of solar radiation in

Copyright © 2020 | to JAARS

summer, but receives enough amount in winter. Sustainable Historical features have multiple impacts on its cultural value. For example, daylighting can contribute to the upgraded functional productivity. It can also reduce energy operating expenses costs. Therefore, the thermal comfort goal is to avoid glare problems. To upgrade the External wall insulation performance, the research study focused on the percentage of solid and void, to use the total area of windows to reduce heat radiation to let it more comfortable at workplaces.

6. SIMULATION SCENARIOS AND RESULTS

The Design Builder simulation tool is used to calculate the effect of the retrofit scenarios' application to the case study.

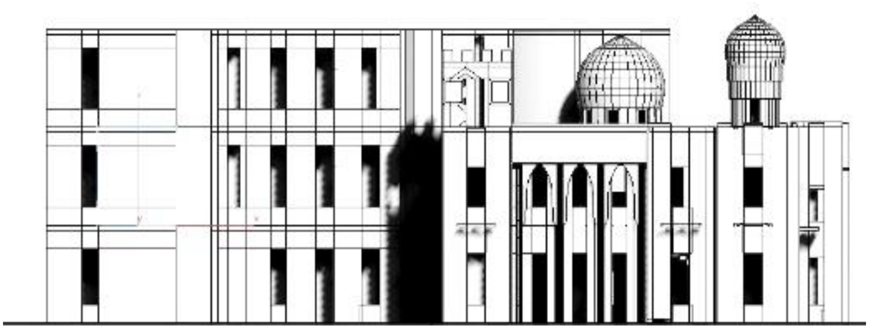


Figure 14, Model created for the simulation illustrating South-Western Elevation of the palace (Source: The Authors).

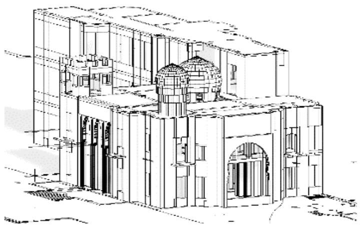


Figure 15, Model created for the simulation illustrating South west isometric view for the palace. *(Source: The Authors).*

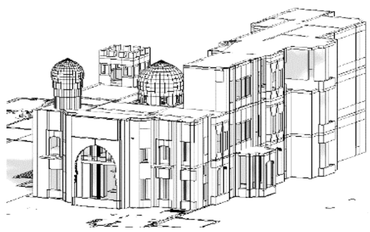


Figure 16, Model created for the simulation illustrating South East isometric view for the palace. *(Source: The Authors).*

Copyright © 2020 | to JAARS

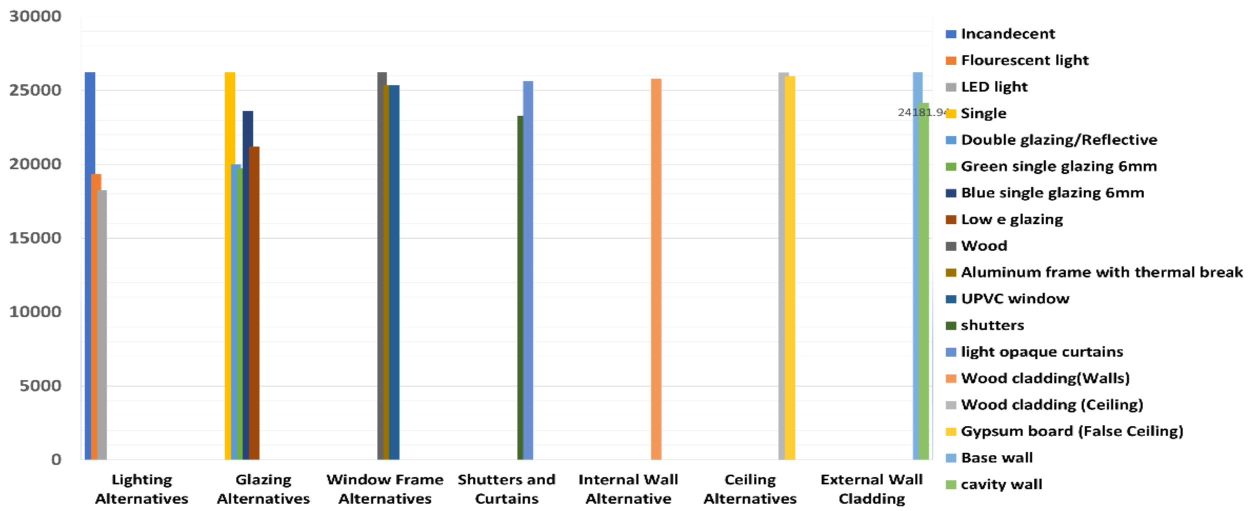
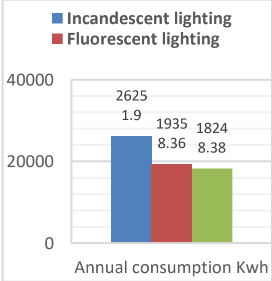
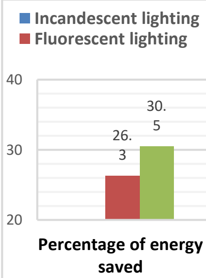
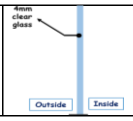
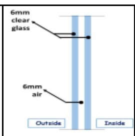
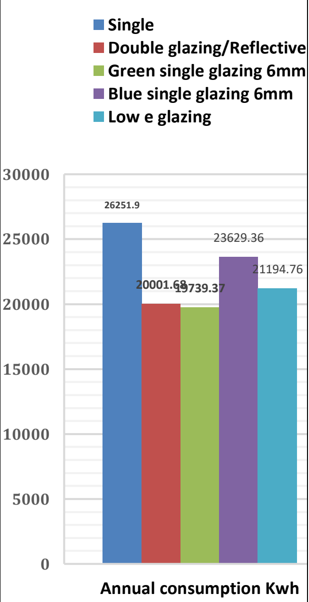
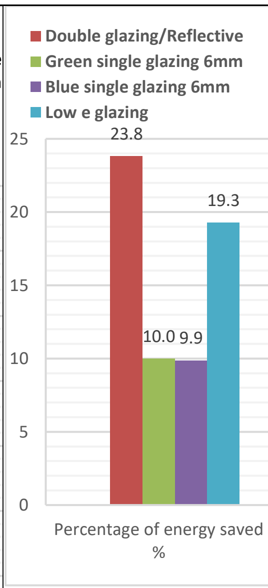
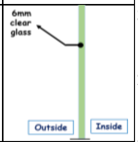
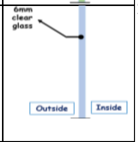
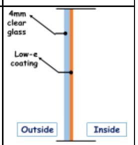
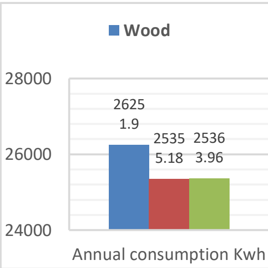
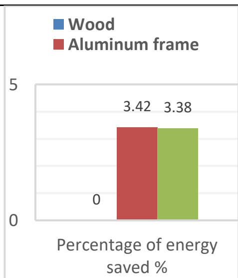


Figure 17, the Annual Energy Consumption (Kwh) for the different retrofit scenarios compared to the base case existing conditions. (Source: The Authors).

Table 2, Simulation scenarios and results (Source: The Authors).

Simulation scenarios		Annual Energy Consumption (Kwh) Graphic illustration	Percentage of energy saved % Graphic illustration	Comment
Lighting system scenarios	Incandescent lighting (Base Case – before redesign) Fluorescent lighting LED lighting			Led Lighting alternative is the most efficient, compared to the base case.
	 *Figure 18 shows the lighting outs in the ceiling of the palace halls.*			• Internal lighting lamps (chandeliers) can be easily replaced by led lamps which are the most efficient and the lowest heat emitting. • To enhance the appearance of the interior decorative ceiling, walls, and different elements on the space, a well-designed lighting system must be added to each space according to its function. • The paper aim to install external Led lighting on the palace façades to upgrade its aesthetical virtual value at night to be taken as a landmark symbol for sustainable inherited buildings.
Glazi	Single 			The double glazing is the most efficient energy

Copyright © 2020 | to JAARS

	Double glazing/Reflective				saving, followed by the low-e glazing. On the other hand, blue single glazing is the least efficient.
	Green single glazing 6mm				
	Blue single glazing 6mm				
	Low-e glazing				
Window Frame	Wood (Base Case – before redesign)				Aluminum framed windows with thermal break can save up to 3.42%. With respect to inherited buildings its prohibited to replace any existing element to avoid using its inherited historical value.
	Aluminum frame with thermal break				
	UPVC window				

7. CONCLUSIONS AND RECOMMENDATIONS

Cultural heritage is a fundamental foundation for sustainable development as it is the link between population and culture needs for saving our nation identity and future generation vision. The paper highlights on reusing of historic buildings in sustainable way rather than constructing new buildings with no identity. Conservation aspects needed to be applied as a connected chain that reflects directly on environmental, social and economic impacts. Implementing sustainably in our valuable historic buildings is one of the most essential elements need by the culture to enhance the historical value for future generation. The paper suggested for other researches to apply analytic strategies to implement sustainability in historical buildings, by taking in consideration:

- Avoid constructing new buildings, and conserve the abandoned valuable buildings.
- Produce some guidelines to protect the environment of the historic heritage.
- Upgrade the using of natural resource to convert in renewable energy to self-sufficient sustainable rehabilitation of heritage resources.
- Sustainability depends on applying balance between human needs and natural environment in saving natural resource and converting it In Renewable energy in efficient way to fulfil the cultural and social requirements coping with nation identity.

Copyright © 2020 | to JAARS

Upon the analytic methodology for the case study, **Sustainable Rehabilitation Recommendations** in Egypt determines the appropriate re-use and renovation of inherited buildings to upgrade its function in applicable way to our daily requirements as follows:

- **Illumination:** using led lighting systems to enhance the illumination internally and externally, to be used as a sustainable landmark in our urban context, to save our national identity value.
- **Ventilation:** using wind capture to enhance natural ventilation by implementing vents in the vertical circulation for condensing the incoming air, as well as using domes in the distributing areas to cool the inner halls in the palace, using CFD simulation. The research makes use of the palace morphology in having environmental platform solutions to access the airflow in its backyard and front yard.
- **Glazing:** It is preferable to use double-glazing as it saves up to 23.8% of energy consumed.
- **Shading, wooden shutters (Mashrabiya), and internal curtains:** using the existed wooden overhangs as a passive solar solution to increase the percentage of shadow in the southern façade, adding to it wooden pergolas with the same perforated details to implement it in the palace front yard. Mashrabiya in the palace save up to 11.3% of the energy consumed, and applying internal light curtain can save up to 2.3 % of the energy consumed and avoid glare.
- **Window framing:** an optional alternative solution for upgrading the existing wooden frames is replacing it with an identical copy using Aluminum frame with thermal break, UPVC window frame, to enhance energy saving up to 3.4%, but according to inherited buildings it is prohibited to replace any existing element to avoid losing its inherited historical value. It can be reused in renovation in case this element is ruined or destroyed.
- **External Insulation:** the thermal mass of the existing sand stones helps to keep halls cool during the day and warm at night, but it can be upgraded in its performance as a transition element between outdoor and indoor conditions, by using a cavity wall as an insulator for halls that do not have art value to avoid losing its aesthetical inherited value. But it can be added to the damaged areas as a thermal hygrometric comfort. External insulators are used as an acoustic solution for external avoiding noise pollution.
- **Ceiling retrofit:** ceiling cladding materials i.e. wood or gypsum boards can be used only in renovating the damaged parts to save up to 0.2%.
- **Compatible infra structure:** For choosing the best alternative function for re-use as a quantitative assessment for saving its cultural value, beside enhancing the environmental performance, by surveying the following items:

Copyright © 2020 | to JAARS

- Compatibility
- Reversibility
- Degree of intervention
- Loading on infra structure
- Adaptation cost
- Economic benefit
- Accessibility

Assessing the positive aesthetic value to the street scape to enhance the pride of national identity in raising the level of awareness for inherited buildings, is to protect its heritage value, architectural value, economic performance, adaptation cost, social value and environmental impact.
Flexible movable light partitions can be used as subdivisions as an insulator for internal walls that can save up to 1.7% of energy instead of internal cladding to save its aesthetic inherited value.
The Building facades are the most common thing that has cultural value and therefore very often when refurbishing historical Building there is only one option to achieve better heat transfer coefficient – to insulate from the inside.
The paper purpose is to provide analytic hierarchy process for assessing the best alternative solution approach for the different values affecting the inherited buildings as a typology of indicators.

REFERENCES

Abdelrhman, Mohamed Ahmed. 2016. "Revival of Islamic Style in Architecture of Egypt in the Period between)1863-1920 A.D / 1288-1339A.H) Artificial and Archeological Study." Journal of Architecture, Arts & Humanistic Science, 1(2):1–26.

Gonzalo, R., Habermann, K. J., . (2006). Response to Extreme Conditions: School Complex in Ladakh. *Energy-Efficient Architecture Basis for Planning and Construction*, 93.

Agnieszka Dobrowolska & Jarosław Dobrowolski. (2006). *Heliopolis: Rebirth of the City of the Sun.* cairo: The American University in Cairo Press.

Ahmed K. (2012). Residents' socio-cultural dissatisfaction in the two stages of public housing in Cairo, Egypt: What has changed in the third 'current' one? *URBAN DESIGN International* (pp. Vol. 17, 3, 159–177). Macmillan Publishers.

Al-Ashqar, E. A. (2020). A SUGGESTED FRAMEWORK FOR RE-USING AN ANTIQUE VALUABLE BUILDING IN ADMINISTRATIVE USE: Case Study: Faculty of Fine Arts Cairo. *Journal of Art & Architecture Research Studies - JAARS, 1*(1), 66-82. Retrieved from http://jaars-fa.helwan.edu.e

Aste, N., Adhikari, R. & Buzzetti, M. (2012). Energy Retrofit of Historical Buildings: An Italian Case Study. *Journal of Green Building, 7*(4).

Balamir, A. (2007). *Druk White Lotus School*. Retrieved from U.K. Aga Khan.

Darius Kalibatas, Jurgis Zagorskas, Ruta Skripkien ,Arunas Barvidas & Aivaras Jasiulevicius. (2014). Selection of Retrofit Measures for Historic Buildings. *The 9th International Conference "ENVIRONMENTAL ENGINEERING".* Vilnius, Lithuania.

Copyright © 2020 | to JAARS

Darius Kalibatas, Jurgis Zagorskas, Ruta Skripkien ,Arunas Barvidas & Aivaras Jasiulevicius. (2014). Selection of Retrofit Measures for Historic Buildings. . *The 9th International Conference "ENVIRONMENTAL ENGINEERING".* Vilnius, Lithuania.

Davidson F., Payne G. (1983). Urban Projects Manual. A guide to preparing upgrading and new development projects accessible to low income groups. *Liverpool University Press in association with Fairstead Press.*

Dixon, T., Britnell, J. & Watson, G. B. (2014). *'City-wide' or 'City-blind?' an analysis of emergent retrofit practices in the UK commercial property sector.* EPSRC Retrofit 2050. Retrieved from http://www.retrofit2050.org.uk/sites/default/files...

Dobrowolski, J. (2005). Heliopolis: Rebirth of the City of the Sun. In J. Dobrowolski, *Heliopolis: Rebirth of the City of the Sun.* The American University in Cairo Press.

Efthimiadou, T. T. (2017). A Sustainable Design Strategy for the Restoration of Historical Buildings. *International Conference on Sustainable Synergies from Buildings to the Urban Scale.* SBE16.

El Kafrawy A. (2012). *Housing policy and finance in Egypt:extending the reach of mortgage credit.* Thesis Submitted for The Degree of Doctor of Philosophy -School of Social & Political Sciences-College of Social Sciences-University of Glasgow.

Enab, M. (2018). ECLECTICISM STYLE IN ARCHITECTURE OF KHEDIVIAN CAIRO. *JOURNAL OF ISLAMIC ARCHITECTURE, 5*(2), 83-95. doi: http://dx.doi.org/10.18860/jia.v5i2.4747

Fleming, j.McGrown, R., D., Rose, J. (2002). *Arup Journal*, 16-18.

Gleeson, C. Y.-J. (2011). *European retrofit network: retrofitting evaluation methodology report.* School of Architecture and the Built Environment. London: University of Westminster.

Haroun, H., Bakr, A. & Hasan, A. (2019). Multi-criteria decision making for adaptive reuse of heritage buildings: Aziza Fahmy Palace. *Alexandria University Alexandria Engineering Journal*.

Hassan G. (2017). *Review And Re-Evaluation of The Successive Housing Policy in Egypt.* Retrieved from The Center for Planning and Architectural Studies (CPAS): https://www.cpas-egypt.com/

Hegazy I., Moustafa W. (2013). Toward revitalization of new towns in Egypt case study: Sixth of October. *International journal of sustainable built environment*.

L. Khodeir, D, Aly. & S, Tarek. (2016). Integrating HBIM (Heritage Building Information Modeling) Tools in the Application of Sustainable Retrofitting of Heritage Buildings in Egypt. *Procedia Environmental Sciences 34*, 258 – 270.

Limited, S. G. (2004). Oman seawater greenhouse project. *seawatergreenhouse*. Retrieved from http://www.seawatergreenhouse.com/oman.html

Lohse, R & Zhivov, A. (2017). *Deep Energy Retrofit Business Guide for Public Buildings.* New york: New Buildings Institute (NBI).

Menassa, C. (2011). Evaluating sustainable retrofits in existing buildings under uncertainty. *Evaluating sustainable retEnergy and Buildings, 43*(12), 3576-3583.

N. Aste, R. A. (2012). Energy Retrofit of Historical Buildings: An Italian Case Study. *Journal of Green Building, 7*(4).

Nadim W. (2010). *A Smart Future Housing in Egypt for all-a Challenge or an Opportunity?* Egypt: German Egyptian Research Fund.

New Urban Agenda. (2017). *United Nations Conference on Housing and Sustainable Urban Development (Habitat III).* Quito-Ecuador: United Nations.

Copyright © 2020 | to JAARS

New Urban Communities Authority. (2020). Retrieved from www.nuca.gov.eg/

Radwan, H. (2017, 2 30). *قصر السلطانة ملك الذى تحول إلى مدرسة مصر الجديدة الثانوية للبنات*. Retrieved from التربويون الجدد: http://neweducators-hananradwan.blogspot.com/2017/11/blog-post_552.html

Soliman A. (2009). Housing the Urban Poor in Egypt: a Critique of Present Policies. *International Journal of Urban and Regional Research*.

The World Bank. (1993). *Housing; Enabling markets to work.* Washington DC: The World Bank.

The World Bank. (2007). *Analysis of Housing Supply Mechanisms.* Egypt: The World Bank - Report no. 41180.

The World Bank. (2015). *Inclusive Housing Finance Program-Report about NSHP*. Egypt: The World Bank.

Tokede, O., Udawatta, N. & Luther, M. (2017). Retrofitting heritage office buildings in the UK: a case study. Built Environment Project and Asset Management. *Built Environment Project and Asset Management, 8*(1), 39-50. Retrieved from https://doi.org/10.1108/BEPAM-11-2016-0068

United Nations Development Programme. (2020). Retrieved 2020, from https://www.undp.org/

Volait, M., Solé, R. & Talmisānī, M. (2005). *Mémoires Héliopolitaines. Cairo, Egypt.* cairo: Al-Ahram Establishment.

Wakely P. (2014). Urban Public Housing Strategies in Developing Countries: whence and whither paradigms, policies, programmes and projects. *The Bartlett Development Planning Unit.* London: UCL.

الفتاح, ف. ع. (2020). *الشرق الأوسط*. Retrieved 2020, from https://aawsat.com/home/article/2171692/مصر-تستعد-لترميم-قصر-«السلطانة-ملك»-في-القاهرة

Copyright © 2020 | to JAARS