Journal of Al Azhar University Engineering Sector

Vol. 12, No. 42, January, 2017, 145-154

ENVIROMENTAL APPROACH FOR FAÇADE CLADDING IN OFFICE BUILDINGS IN EGYPT

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ملخص
تهدف هذه الورقة إلى معرفة التأثير الحراري لاختيار الكسوة الخارجية للمباني الإدارية في مصر من اجل تحسين أداء الطاقة في المباني الإدارية من خلال اختيار نوع الكسوة الخارجية الأفضل بيئيا ومقارنتها بمعيار (ASHRAE) كما تم استخدام برنامج المحاكاة (Ecotect) للتحقق من أحمال السنوية للتبريد (تمثل أداء لطاقة) و لتسجيل الأداء الحراري وتم إجراء هذا البحث لمعرفة مدى التأثير الحراري للكسوة الخارجية على أحمال التبريد السنوي وخلصت إلى ان أداء الطاقة يمكن تعزيزه باستخدام كسوات خارجية ذات تأثير حراري منخفض و استخدام فجوة هواء بين الكسوة و الحائط و استخدام عزل حراري.

ABSTRACT

In dealing with the building as a thermal system, the correct choice of its parts and their relationships can be composed utilizing a frameworks approach. This can be accomplished by coupling an improvement method into the thermal performance of building right on time in the outline procedure. This requires planning the building all around as a thermal system in appropriate structure for the different methodologies.

The goal of this paper to assess the potential of façade cladding to save energy by studying it's thermal performance, summarizes the outcome of a simulation analysis to determine the inefficiency of envelope construction cladding in reducing energy consumption for office buildings in Egypt.

KEYWORDS: Energy Crisis, Egypt, Energy Consumption, Building envelope, Cladding, Office buildings, Thermal performance.

1. INTRODUCTION

The building envelope is the interface between the inside of the building and the open air environment, including the walls and roof. By standing as a thermal boundary, the building envelope assumes a vital part in directing the inside temperature and decides the amount of energy to preserve thermal comfort. (Iwaro .J, and Abrahams, M., 2014) [5]

Minimizing heat exchange through the building envelope is vital for diminishing the requirement for space heating and cooling.At chilly atmospheres, the building envelope can decrease amount of energy required for heating; at hot atmospheres, the building envelope can decrease amount of energy required for cooling. (Iwaro .J, and Abrahams, M., 2014) [5]

As indicated by the Köppen Climate Classification System Egypt lies in the hot climate area. The climate is hot and dry the greater part of the year, barring some stormy days in January and February, and some damp days amid a few months in the winter.

The facade's design in hot dry regions is anticipated to be in charge of up to 40% of the building's cooling loads. The expanding of constructing office buildings in Cairo on air conditioning systems shows the important role of the building envelope to achieve its function as a moderator leading to decrease the electricity consumption.

Office buildings in Cairo expend 5-7% of the total nationwide energy consumption. (Hamza, N.A., 2004) [4],Since mid 90s the office buildings sector in Egypt has been developing due to the urban and economic expansion concentrated in the Nile Delta.

Many new buildings were constructed without paying attention to ecological considerations at the early stage of design which has lead to a wide use of active air-conditioning to achieve thermal comfort and healthy indoor spaces. As a result, buildings' energy consumption has been increasing due to the requirements of cooling and electric lighting.

On the other hand most of these new buildings had been designed as glass boxes deprived of local architectural character or vernacular style (Nabih .A, Michel .M, Michel .S, Farag.A and Khalil.M, 2011) [6], Adopting the energy conscious approach from the earliest starting point force intuition is a more all encompassing methodology (Ahmed, A.A., 2015) [1].

1.1. Problem definition

Re-evaluate the potentials of façade cladding according to its thermal performance .

The choice of office buildings is generated from that office buildings suffer the negligence regarding the thermal performance; designers focus on the aesthetic aspects trying to please the client, paying no attention to the environmental issues ,the excessive cooling load is the common feature in office buildings that are located in desert environments.

And the large amount of energy consumed in the office spaces due to the cooling loads required during day time to achieve indoor thermal comfort which affect directly on the general energy loads consumed in the city.

1.2. Main goal

Enhancement and optimization of energy performance within office buildings in Cairo

Through selecting the best thermal performance façade cladding.

2. Research methodology

Experimental research will be used as a research methodology to investigate Annual cooling loads (representing energy performance). Environmental simulation software (Ecotect) will be used during this testing research to investigate the effect of types of façade cladding on annual cooling loads for two buildings one is bigger than the other to see the relation between the building envelope and its area.

2.1 Ecotect results validation

Ecotect Analysis follows various international standards for the different analyses it conducts. To be compliant with building regulations,

All the solar position, solar radiation and thermal load calculations conform to and are validated at Chartered Institution of Building Services Engineers- 'CIBSE TM33 (2006) which are Tests for Software Verification and Accreditation'. Solar access and rights-to-light calculations conform to the 'BRE Site Planning Handbook'. Ecotect Analysis's specific use of the admittance method is based on 'ISO 13791:2004 Thermal performance of buildings' and 'ISO 13792:2005 Thermal performance of buildings' as well as parts of 'ISO 13789:1999 Transmission heat loss coefficient - Calculation method'.

(http://www.buildingenergysoftwaretools.com/software/autodesk,)[8]

A survey showed that 64% of the engineers that responded to the survey used Autodesk EcotectTM as building performance simulation tool. The study also showed that EcotectTM was the mostly used program during conceptual phase and design development phase of the project. (Attia Shady, 2009) [2]

2.2. Setting

Two typical air-conditioned standard office buildings were selected for assessment based on a survey of the office buildings built in Maadi and the fifth's settlement in Cairo.
First Building comprises six floors with 4m height for each floor and a basement floor, Plan is rectangular (4100m2), core is centralized and the office space is open areas as shown at ***(Figure 1).*** Core details was simplified and set to be thermally adiabatic. Second building comprises five floors with 4m height for each floor, Plan consists of rectangular shape and half circle (2000m2), core is centralized and the office space is open area as shown at ***(Figure 2)***. Core details was simplified and set to be thermally adiabatic, second building is chosen to be smaller than the first building to recognize the impact of the envelop on a big and small plan areas.

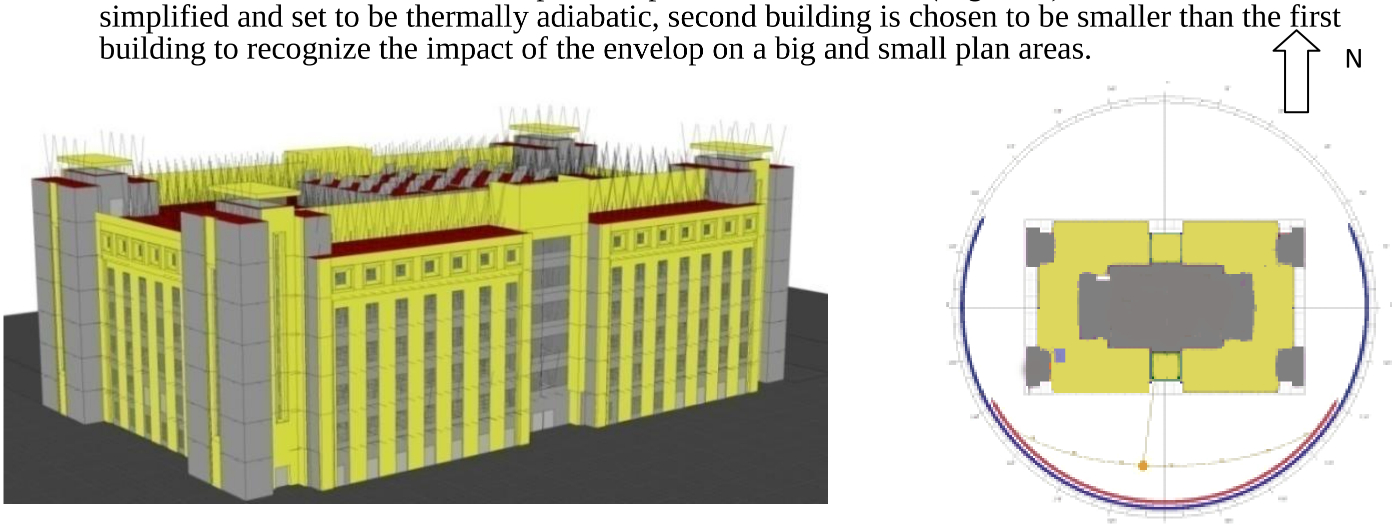


Figure (1) **Perspective for the first office building constructed in the ECOTECT simulation program & Typical mid floor plan**

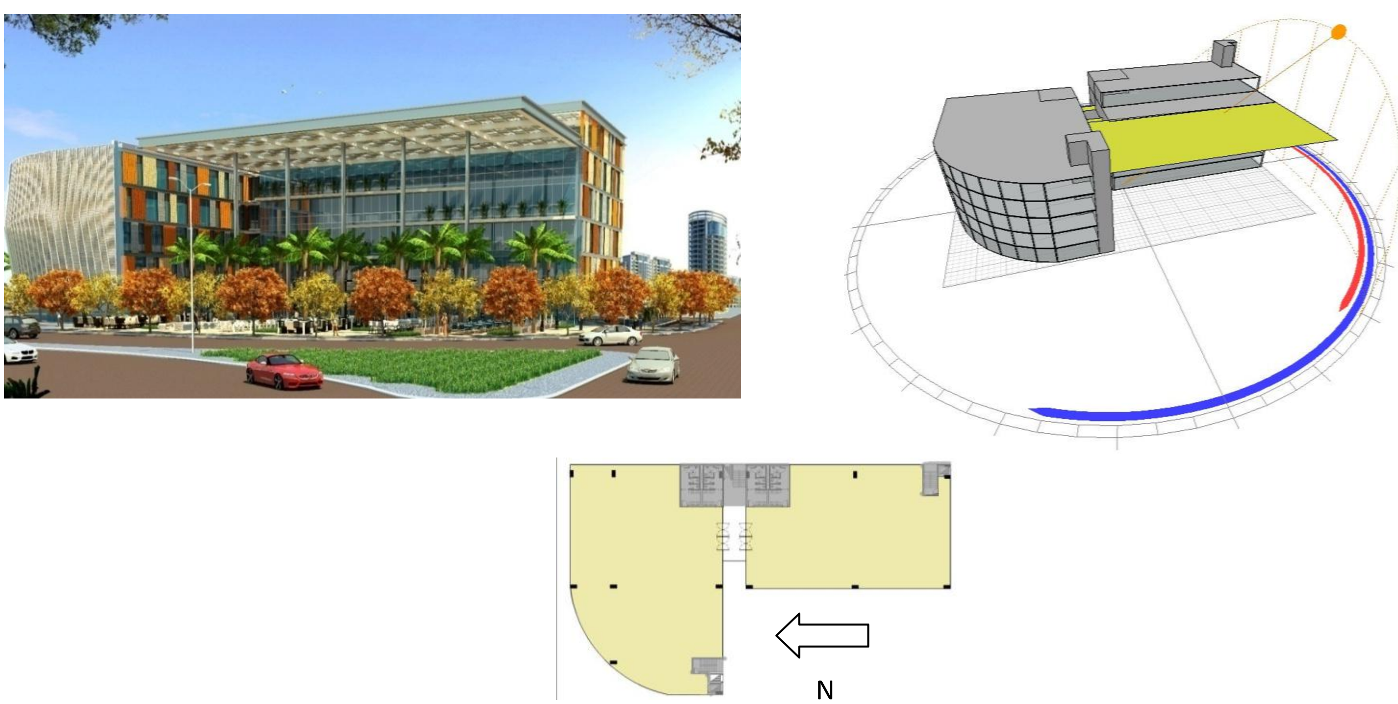


Figure (2) Perspective for the second office building constructed in the ECOTECT simulation program & Typical mid floor plan

2.3 Weather data of Cairo

The Weather data for Cairo is already used at Ecotect in line with the international weather for energy calculation (Egypt-Cairo_IWEC) file, using the weather tool and the solar tool, Egypt is

situated between latitude 31.33 ºN and 22 ºN and Longitude 26 & 35 ºE.,Elevation and it is average 74 m above Sea level.It consists mainly of desert (94% of Egypt land) except for Northern and Eastern coast and Nile valley.
Report of the Egyptian Meteorological Authority for the period from 1976 to 2005 obtained from Cairo airport station number 623660 indicates that the annual average temperature in Cairo is 22.4 ˚C with a maximum average temperature of 35.4 ˚C and minimum average temperature of 20 ˚C in the peak summer month (July) and a maximum average temperature of 18 ˚C and minimum average temperature of 10.2 ˚C in the peak winter month (January). The annual average relative humidity is 55% with a maximum monthly average of 61.7% in December and minimum monthly average of 45.5% in May.(Yassin ali , N Hamza,N and Theo Zaffagnini ,2013) [7]

3. Experiment design

Different cladding types were investigated for analyzing the thermal performance. Evaluating the results has been done according to two sequential phases.
Investigation was dedicated for testing ten cases as shown at ***table(4)*** -besides the base case- of ASHRAE Standard , as shown in ***table (1),*** and compare its impact on the annual cooling loads (kWh) inside the space.

3.1Stage one

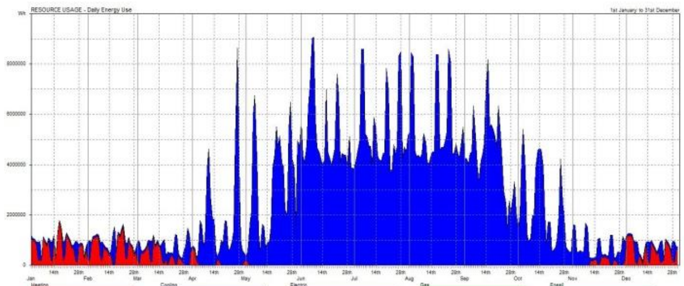
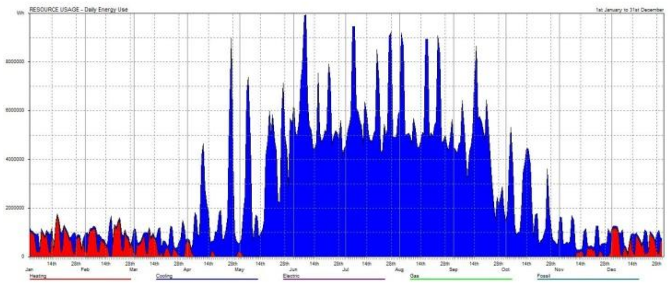
The choice of ASHRA standard to be the base line for the research is generated from it is the commonly referenced energy standard, which is referenced by building and energy codes in the majority of American states and Canadian provinces, And complying with our climate zone “Hot and Dry” (Graham Finch,2015) [3]
The results for the base case which will be comprised later with different cladding systems ,this base case according to Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 which mentioned that to compare the envelope of any building with the Results of the base model of ASHRAE standard it should be according to ASHRAE base case requirements of Appendix G in line with the Climate Zone 2B, “Hot and Dry”
at our case for nonresidential building walls above grade for wood frame and other material as shown at ***table (1),*** and fix all other materials for the base model of ASHRAE to be the same with deigned case ,then The baseline case model was first simulated with its actual orientation and was then again simulated after rotating the building by 90, 180 and 270 degrees.
The average of all 4 cases was considered as the baseline for comparing the energy consumption with the results of energy consumption for different façade cladding for two buildings.

Table 1 .

Opaque Elements		Nonresidential		Residential		Semi heated	
		Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs							
	Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.218	R-3.8 c.i.
	Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-6.0
	Attie and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.081	R-13.0
Walls, above-Grade							
	Mass	U-0.151[a]	R5.7 c.i.[a]	U-0.123	R-7.6 c.i.	U-0.580	NR
	Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-6.0
	Steel-Framed	U-0.124	R-13.0	U-0.064	R-13.0+ R-7.6 c.i.	U-0.124	R-13.0
	Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
Walls, Below-Grade							
	Below-Grade Wall	C-1-140	NR	C-1-140	NR	C-1-140	NR
Floors							
	Mass	U-0.107	R-6.3 c.i.	U-0.087	R-8.3 c.i.	U-0.322	NR
	Steel-Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.069	R-13.0
	Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0

3.1.1 Base case Experimentation design (building1)

Rotate the base model of the building by 90, 180 after applying the u value mentioned at ASHRAE/IESNA Standard shown at ***table (1)***.get the results of cooling and heating loads after rotate the building north, east , south and west as shown at figure (***3,4, 5,6)***

Figure(3,4) ECOTECT results for building 1 at direction north and east direction after applying cladding with U value according the Climate Zone 2B, "Hot and Dry" at ASHRAE standard

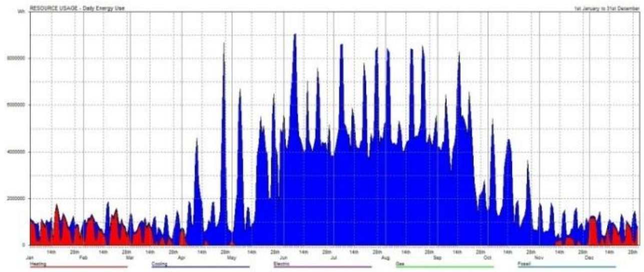
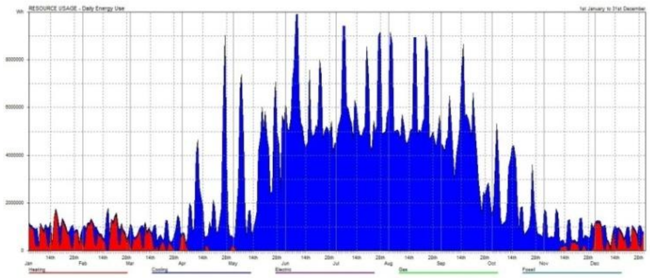



Figure (5,6) ECOTECT results for building 1 at direction south and west direction after applying cladding with U value according the Climate Zone 2B, "Hot and Dry" at ASHRAE standard

Table 2. Results of the base line model for building 1

BASELINE ENERGY MODEL SUMMARY FOR ALL YEAR	
ORIENTATION	**ENERGY CONSUMPTION (KWH)**
NORTH	**962787**
EAST	**1029208**
SOUTH	**973067**
WEST	**1035809**
AVERAGE	**925275.3973(cooling loads)+ 74942.998(heating loads)**

3.1.1.1 Results the base line model from ASHRAE standard) (studycase1)

The average of all 4 directions - as shown at ***table (2)***-was considered as the baseline for comparing the energy consumption with the results of energy consumption for the ten different façade cladding types for buildings ,The compression is between the cooling loads as the heating loads for base case is minor and less important and for the hot arid climate in Egypt the cooling loads consume most for our electricity.

3.1.2 Base case Experimentation design (building2)

Rotate the base model of the building by 90, 180 after applying the u value mentioned at ASHRAE/IESNA Standard shown at ***table (1)***.get the results of cooling and heating loads after rotate the building north, east , south and west as shown at figure (***7,8, 9,10)***

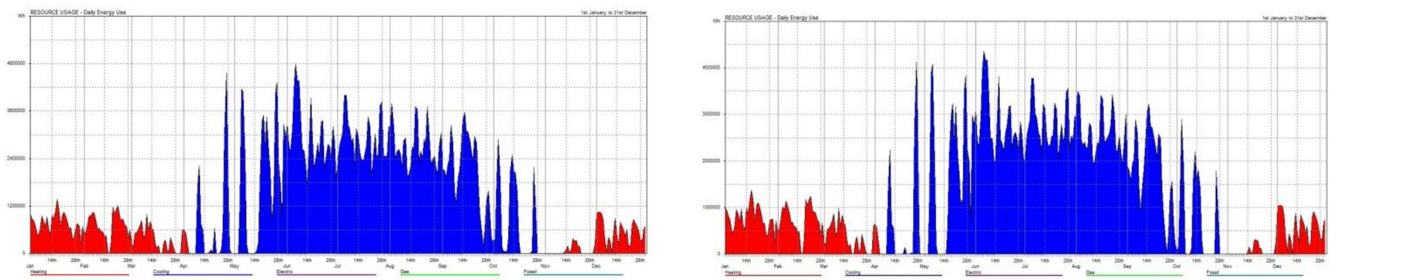


Figure (7,8) ECOTECT results for building 2 at direction north and east direction after applying cladding with U value according the Climate Zone 2B, "Hot and Dry" at ASHRAE standard

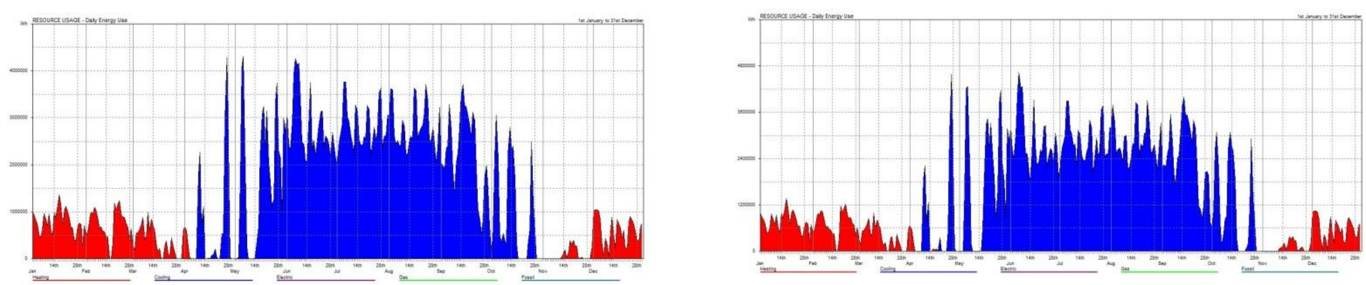


Figure (9,10) ECOTECT results for building 2 at direction south and west direction after applying cladding with U value according the Climate Zone 2B, "Hot and Dry" at ASHRAE standard.

3.1.1.1 Results the base line model from ASHRAE standard) (building2)

The average of all 4 directions - as shown at ***table (3)*** was considered as the baseline for comparing the energy consumption with the results of energy consumption for the ten different façade cladding types for two buildings.

Table 3. Results of the base line model for building 2

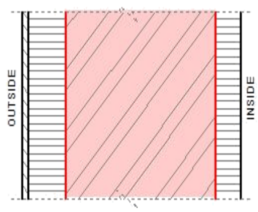
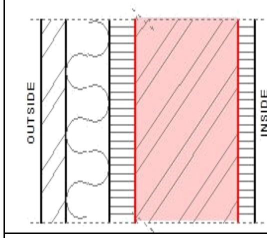
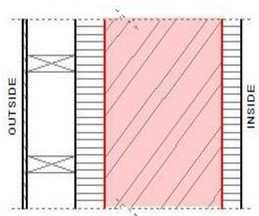
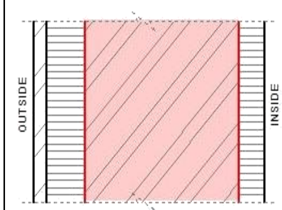
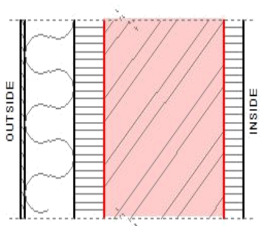
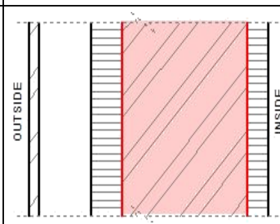
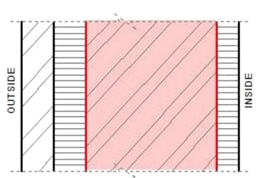
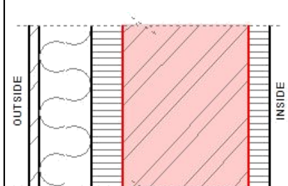
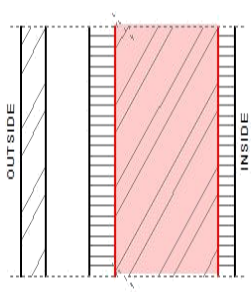
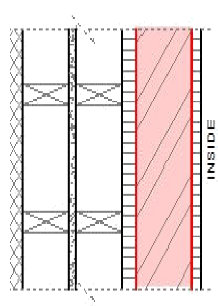
BASELINE ENERGY MODEL SUMMARY	
ORIENTATION	**(KWH)**
NORTH	**490162.8**
EAST	**463364.65**
SOUTH	**499502.59**
WEST	**517645.706**
AVERAGE	**414902.5508(cooling loads)+ 77766.39775(heating loads)**

3.2 Stage two

Comparison between results of total cooling loads for different cladding types with three cases (direct on the wall, using air gab and using insulation).

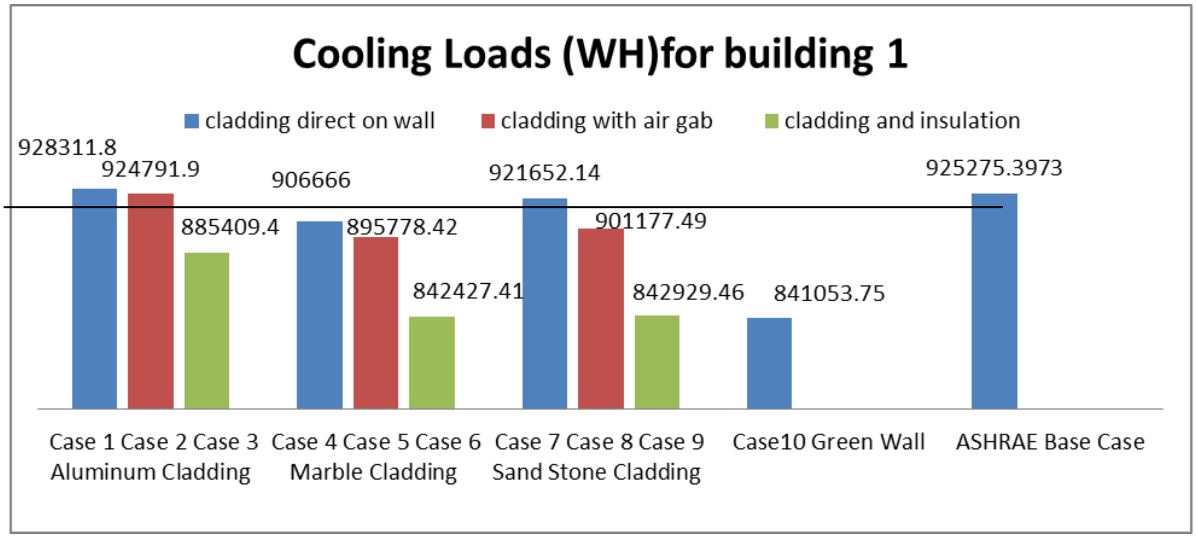
Table (4) shows the layers of façade cladding and among these types green wall was to test if using it at hot arid climate will make such different at reducing energy requirements for cooling as paper published by Juri Yoshimi[1] and Hasim Altan at School of Architecture, The University of Sheffield which green walls remarkably reduced electricity at Tokyo, Japan.

Table 4.

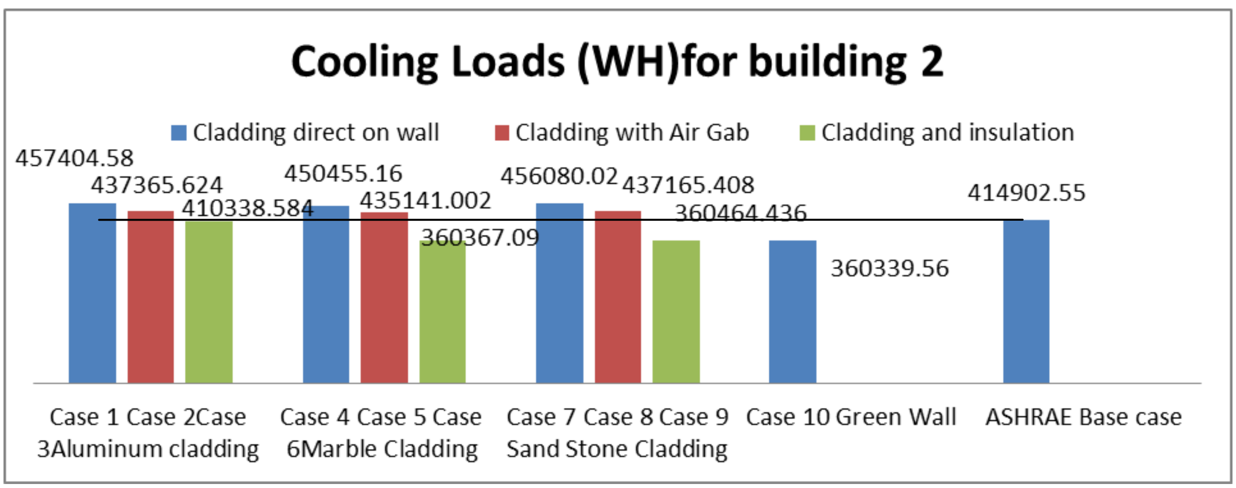
Cladding	Layer name , thickness(mm)	Cladding	Layer name , thickness(mm)
 Case 1	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Aluminum cladding 5mm	 Case 6	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Insulation 50mm Marble cladding 30mm
 Case 2	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Air Gab 50mm Aluminum cladding 5mm	 Case 7	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Sandstone cladding 10mm
 Case 3	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Insulation 50mm Aluminum cladding 5mm	 Case 8	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Air Gab 50 mm Sandstone cladding 10mm
 Case 4	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Marble cladding 30mm	 Case 9	Plaster 20 mm Egyptian brick 120mm Plaster 30 mm Insulation 50mm Sandstone cladding 10mm
 Case 5	Plaster 20 mm Egyptian brick 120mmm Plaster 30 mm Air Gab 50 mm Marble cladding 30mm	 Case 10	(Green Wall) Plaster 20 mm Egyptian brick 120mmm Plaster 30 mm Air Gab 100 mm Soft Wood 15mm Air Gab 100 mm Leaves

3.3 Thermal energy analysis

After sitting the two buildings at the original direction as it was designed, these are the results of the cooling loads for all year for all previous material mentioned before at ***Table (4)*** and compared with the base case of the two building at the (ASHRAE) as mentioned at ***Table (2)***for building 1 and ***Table (3)*** for building 2.



(Fig. 7) **comparison between all three materials thermal performance by showing cooling loads for building 1**



(Figure 8) **comparison between all three materials thermal performance by showing cooling loads for building 2**

RESULTS

A case study was implemented and the following results were found for two medium sized building located in Cairo-Egypt. The simulation results shows that whatever the material is the thermal performance improves with using air gab and better results when using insulation. After comparing the results for energy consumption for different façade cladding with the base the baseline case model there was several results.

- Worth thermal performance material among the three materials is aluminum cladding although it is the most useable façade cladding material in office building in Egypt.
- Aluminum cladding which is putted direct on wall is the only material that above ASHRAE base case at building 1.
- All cladding which are putted directly on the wall or use air gab are all above ASHRAE base case at building 2.
- Green Wall the best thermal performance among the four materials and it reduce energy of annual cooling loads by around (44222 Wh) at building 1 as shown ***figure(7)*** and (54563Wh) for building 2 as shown ***figure(8)*** .
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4. Conclusion and Recommendations

4.1. Conclusion

- It is concluded that using natural stones is better for thermal performance.
- Aluminum cladding which is putted direct on wall is not an environmental choice as a façade cladding.
- The area of the building is so important to determine the impact of the envelope on the energy consumption at the building, as at building 1 the is larger than building 2 which made (case 1)Aluminum cladding which is putted direct on wall is the only material that above ASHRAE base case Although All cladding which are putted directly on the wall or use air gab are that above ASHRAE base case at building 2 so, as the area of the building is smaller the impact of façade cladding material is more effective.
- Using green wall made a huge impact in reducing the cooling loads at hot dry climate.

4.2. Recommendations

- Designers should consider important issue for choosing the right façade cladding.
- If the designer determined to use aluminum cladding he should some previous studies about composite layers on the wall like using air gab and insulation to reach a value accepted at the ASHRAE standard.
- studying the impact of different types of green walls on consumption of energy , Start using green walls at the new projects

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[8]http://www.buildingenergysoftwaretools.com/software/autodesk, access (2016)