

**The Cost saving of using Limestone as a local material in Construction for  
lower height Buildings in Middle of Egypt.**

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**Abstract**

The sustainability awareness has developed to include many countries that contribute to sustainable environmental residential buildings, as environmental buildings, looking toward an innovative idea, integrated design and unique formation,

The research deals with the concepts of sustainability, their criteria, evaluation methods and their relationship to the local economy that to obtain the design of an existing sustainable environmental using local materials in each different environment at the lowest economic cost. Through the investigation study of natural construction materials in Egypt, it was found that natural limestone is one of the best environmentally friendly building material compared to other available building materials in terms of reducing thermal loads on the building, which leads to reducing energy consumption at the level of energy use and as local materials in construction, and achieved an economy building from survey study through the market of construction materials for housing , moreover using the limestone to improve the humanities skills and the opportunity of skilled workers .

The research concluded with positive results for the use of limestone in the construction of sustainable buildings dealt with an analytical study using the design builder environment program to analyse the differences between internal and external temperatures, to achieve the best thermal comfort inside the rooms through an applied model with achievable sustainability factors of economics and humanities.

**1- Theoretical investigation**

**Keywords**

Architecture Sustainability - local materials - limestone - thermal comfort – Economy housing

**1-1 Introduction**

Egypt vision 2030 started to develop most of the district in the country , the government houses is the major target to the new strategy vision to improve

the Egyptian life level ( Hayat Karemah ) and different levels of residential units

Sustainability has evolved in recent times to include sustainable development and its impact on the possibility of applying it to the environmental residential building.

The problem is the non-proliferation of sustainable residential buildings (medium height) using local and sustainable materials

The research assumed that the use of local materials in the design of residential buildings to become more sustainable, which results in achieving thermal comfort in the residential spaces

The research aiming to Achieve sustainable residential building design using local materials,

The research is to discuss the aiming and factors of sustainability with focusing in the natural materials to compare with the existing project using the proposed natural material of and its impact on thermal effect of normal different material the thermal effects on the building performance in the building .

### **1-2 Methodology**

The research follows the theoretical's investigation to extract the meaning of sustainability and its factor to follow and apply of the different projects in different locations, The research follows the definition of sustainability factors to apply it on the projects on new housing government strategy plan will be implemented in upper and middle Egypt.

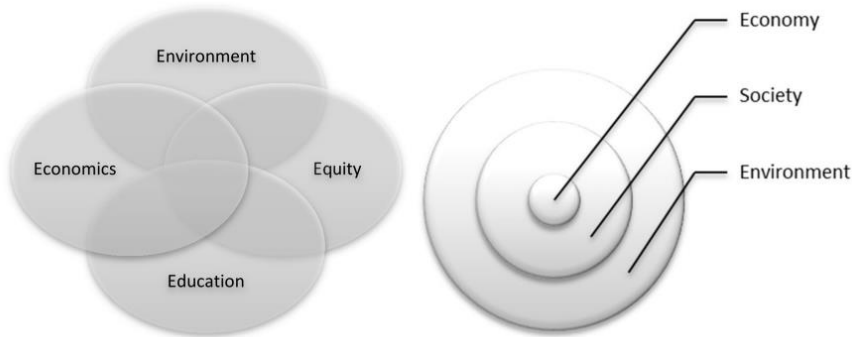
In addition the research implement the application study and analytical process to analysis the new houses and the application of sustainability factors of Environmental, Cost saving and humanity that to determine the applicable methodology to construct the new project with Limestone materials .

### **1-3 Factors and targets of Sustainability**

Sustainability is one of the disciplines of linking social sciences, architecture and construction, environmental and health sciences and integrating them with technology<sup>1</sup>. When we hear the word "sustainability using renewable energy sources, reducing carbon emissions, and protecting the environment, and we find that Islamic architecture used the concepts of green architecture and sustainability through environmental materials, mantles, domes, basements and internal spaces for buildings to maintain the best relationship of building with the nature around it.

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*Figure No (01) Factors of achieving sustainability*

**1-4 Materials factor impacts on Sustainable Building rating systems <sup>2</sup>**

<b>Sr.</b>	<b>Evaluation Criteria</b>	<b>Factor of sustainability strategy</b>	<b>LEED</b>	<b>BREEAM</b>	<b>GSAS</b>	<b>GRIHA</b>
<b>1</b>	<ul style="list-style-type: none"> <li>• Water management</li> <li>• Water Innovation</li> <li>• Water efficiency</li> </ul>	Environment	✓	✓	☒	☒
<b>2</b>	operations	Economic		✓	☒	
<b>3</b>	Local Material,	Economic and Environment	✓	✓	✓	✓
<b>4</b>	<ul style="list-style-type: none"> <li>• Health &amp; wellbeing</li> <li>• Indoor air Quality</li> </ul>	Human	✓	✓	✓	✓
<b>5</b>	Waste management	Environment	☒	✓	☒	☒
<b>6</b>	Energy atmosphere / Energy efficiency	Environment	☒	✓	☒	☒

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<b>7</b>	Land use & ecology / Site location	Environment	<input checked="" type="checkbox"/>	✓	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>8</b>	Transport Pollution ,	Environment	<input checked="" type="checkbox"/>	✓	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>9</b>	Cultural & Economic value	Environment - Human	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>10</b>	Urban connectivity	Environment and Human	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<b>11</b>	Performance monitoring and validation Innovation	Environment and Economic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

*Table No (01) The rate of using sustainable materials in evaluation systems*

In reference to aforementioned indicated table it shown that the importance of using a proper materials in the project an all the evaluation systems apply the material as a mandatory item to be followed .

### 1-5 Green Building Criteria and technique

Sr.	Factors of Criteria	Technique of implementation
1	Site and location <sup>3</sup>	<ol style="list-style-type: none"> <li>1. Select the proper location with utilities</li> <li>2. Optimizing the surrounding environmental resources</li> <li>3. Reuse and redeveloped the building</li> <li>4. Develop the layout to increase the green areas</li> <li>5. Provide public transportation, Metro, Buses, monorail</li> <li>6. Reduce thermal reflection from site orientation</li> </ol>
2	Energy efficiency	<ol style="list-style-type: none"> <li>1. Use renewable energy resources , photovoltaic , Wind turbine, Water hydraulic turbine <sup>4</sup>.</li> <li>2. Use smart electronic devices</li> </ol>

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		<ol style="list-style-type: none"> <li>3. Use Building management system for controlling the usage</li> <li>4. Use the smart technology of sanitary devices</li> </ol>
3	Reduce Water Consumption	<ol style="list-style-type: none"> <li>1. Smart devices <sup>5</sup></li> <li>2. Grey water reuse</li> <li>3. Black water treatment and recycling<sup>6</sup></li> </ol>
4	Waste Management and recycling	<ol style="list-style-type: none"> <li>1. Reuse waste material from other projects.</li> <li>2. Recycled waste materials from different projects</li> <li>3. Waste classification and controlling</li> <li>4. Reduce plastic materials</li> <li>5. Using Analytical materials</li> </ol>
5	Indoor air quality	<ol style="list-style-type: none"> <li>1. Provide natural ventilation inside the building</li> <li>2. Allow natural light for all spaces to reduce the energy consumption <sup>7</sup></li> <li>3- Indoor air quality monitoring using wireless sensor network</li> </ol>




*Table No ( 02 ) Green Building Criteria and implementation technique*

**2- Investigation and Analytical study  
2-1 Construction materials in Egypt**

Type of materials	Materials Name	Manufacturing requirements
<b>Natural</b>	Marble	Need Shaping , alignments
	Granite	Need Shaping , alignments

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	Limestone – Hashmi , Yellow	Need Shaping , alignments , sizing	
	Bazalt stone	Need Shaping , alignments , sizing	
<b>Commination between Natural and Industrial</b>	Red Bricks	Burning , shaping , Sizing	
	Red Blocks	Burning , shaping , Sizing	
	Cement Bricks	Extract the cement from stone , Industrial process , Mixing , Burn , shaping and sizing	
	Cement Blocks	Extract the cement from stone , Industrial process , Mixing , Burn , shaping and sizing	
<b>Artificial and Industrial</b>	Insulated white Blocks	Burning , Industrial process between foam and shaping and Sizing	
	Mix between Cement and Foam blocks	Burning , shaping and Sizing	
	Cement Board	Extract the cement from stone , Industrial process ,	

Limestone factory  
production line  
Baniswif Asuit Desert  
Road<sup>8</sup> *Photo by  
researcher*

Burned Red bricks  
factory, Girza  
Alwasta, ,Baniswif<sup>9</sup>  
*Photo by researcher*

Cement bricks  
factory , Baniswif<sup>10</sup>

	Mixing , Burn , shaping and sizing
Gypsum board	Extract the cement from stone , Industrial process , Mixing , Burn , shaping and sizing

*Table No ( 03 ) Matrix of Construction materials in Egypts and the requirements of production*

**Limestone specification data sheet**

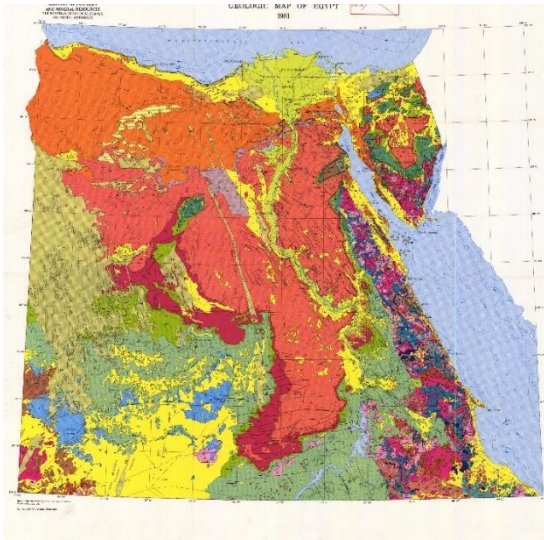
Limestone is an organic sedimentary rock made up of calcium carbonate and commonly composed of tiny fossils, shell fragments and other fossilized debris formed over millions of years. It is created when the calcium carbonate crystallizes out of solution in shallow seas,<sup>11</sup>

Limestone Other means of identification: Crushed Stone, Calcium Carbonate, Aggregate Relevant identified uses of the substance or mixture and uses advised against:

Limestone may be used in the manufacture of bricks, mortar, cement, concrete, plasters, paving materials, and other construction materials. Limestone aggregate may be distributed in bags, totes, and bulk shipments. No known recommended restrictions

**2-2 Limestone location map in Egypt**





*Figure No 2 , the Limestone location in Geotechnical maps of Egypt<sup>12</sup>*

Limestone with chert and minor clay beds from high cliffs and plateaux overlooking, The limestone is partly exposed along the Sin elkadabb scarp to Darb el-Arab'in , also exposed in the Kharga scraps and plateaux and in Farafra and Baharyya Desert ,<sup>13</sup>

Limestone is located in the western and central region of Egypt stationed in Beni Swif and Minya up to Fayoum and extends south below Minya, and Minya is characterized by the large number of quarries present, which depend on industries derived from the cracking of limestone and limestone bricks is one of the pictures of these industries



*Figure No (03 ) The Limestone location along with the West Asiut Cairo Arterial Road <sup>14</sup>*

## **2-3 Sustainable factors of Limestone materials**

### **2-3-1 The Economic impacts of using sustainable buildings**

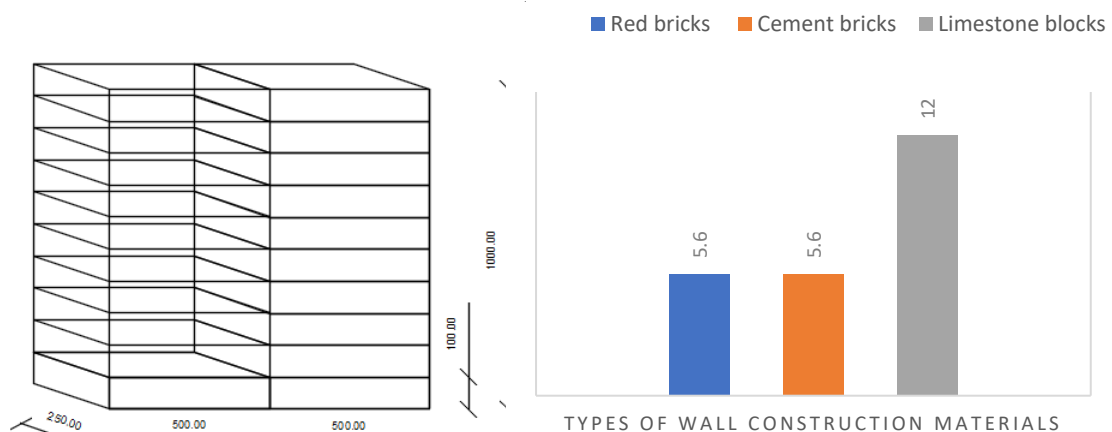


Building and construction operations affect several economic areas that make up the local environment through tools and future needs. The areas that directly affect the movement of building and construction are:

- Environmental quality - Conservation of resources and raw materials - Energy conservation - Conservation of water resources - Site uses - Achieving integration and creativity

A. Bricks sizes saving cost in raw material and volume of walls

B. Size produce more productivity faster than the normal bricks , The labour can construct 1000 blocks per day and 3000 bricks per day , so the 1000 blocks will produce 12.5 m<sup>3</sup> but the 3000 bricks will produce 5.4 m<sup>3</sup> so the manpower will be reduced



*Figure No ( 04) Comparison between the Total m<sup>3</sup> for using the 1000 units of different bricks*

- C. To use the available resource reduce the transportation cost
- D. Using the natural material reduce the petrol for power in industrial burning methods for others
- E. Price and The economics factor in sustainable development is a major part to select the proper material in construction markets and effect on the project performance and project feasibility study moreover the discission making m upon that the following is comparing table of the price of limestone to the Normal blocks of Cement and Clay bricks.

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<b>LIMESTONE BLOCK SIZE<sup>15</sup></b>	<b>KG</b>	<b>Number PER PALLET</b>	<b>Number per m3</b>	<b>Number per m2</b>	<b>Price in market</b>
<b>600 x 150 x 300</b>	38kg	Per 1000	50	13	700
<b>600 x 150 x 150</b>	13kg	Per 1000	50	13	900

<b>Cement Blocks size</b>	<b>KG</b>	<b>Number PER PALLET</b>	<b>Number per m3</b>	<b>Number per m2</b>	<b>Price in Market</b>
<b>250 x 120 x 60</b>		48 Per 1000	50	13	800
<b>250 x 400 x 40</b>		Per 1000	50	13	1000

*Table No (04) The comparison of price for different of construction material*

**2-3-2 The Environmental Impacts for using Limestone in external and internal walls**

- A. Less Carbon emission comparing with the cement and red bricks
- B. Reduce using the industrial fuel for power in cement and burned bricks
- C. Minimum interaction with the chemicals
- D. Optimisation of natural interaction with wind and water

**2-3-3 The Human factors Impacts for using Limestone in construction walls**

Increase the Human skills workers from the society of middle of Egypt

Increase more additional factories of limestone production line

	<b>Factor</b>	<b>The impact</b>
<b>A</b>	<b>Cheeped material for lower economy building</b>	

**B** Create more opportunities for workers



**C** Develop the business and financial for small levels SMS



*Table No (05) Type Of Economics factors of using limestone in middle Of Egypt projects*

#### **4- Case Study of Government residential buildings , middle levels ( Housing of Society model )**

The social housing project is one of the most important projects led by the Ministry of Housing and Utilities and the New Communities Authority in implementation of Egypt's vision 2030 and new political trends with recommendations on the importance and need to get out of the valley land to new urban development axes, this project is among a number of projects under way and considers social housing the most numerous projects and implementation due to the large numbers of numbers for the target segment and the implementation of the economic model in cost and speed of implementation where it is implemented in the city of Beni Sweif Al , Jadida<sup>16</sup>

##### **4-1 Project Brief and information**

<b>Name of the Project</b>	<b>City</b>	<b>Number of Buildings</b>
----------------------------	-------------	----------------------------

**Economy  
Social  
housing<sup>17</sup>**

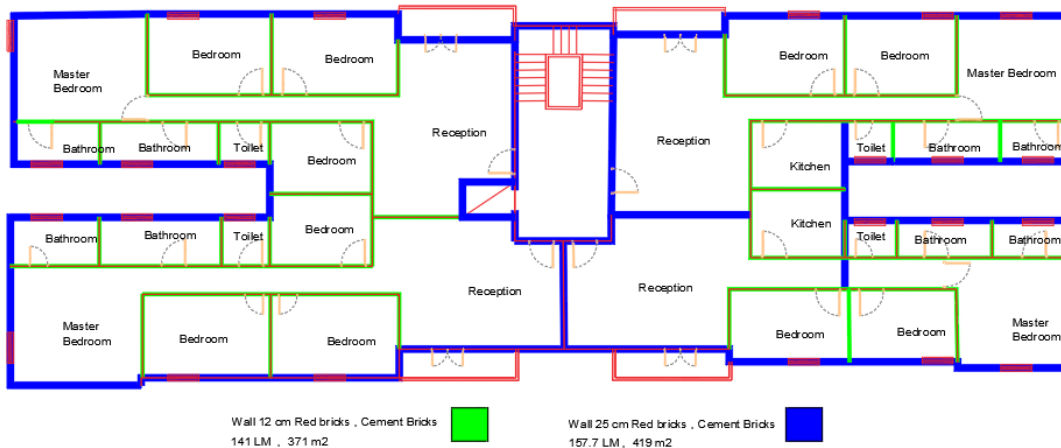
New  
Bani  
swif      221      5,304



New  
Al  
Menia      432      10,368



*Table No ( 06) Type and figure of Society housing , Economy type*

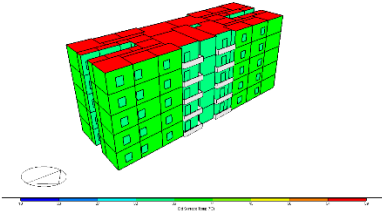
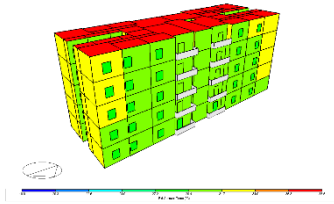
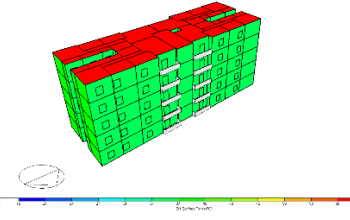
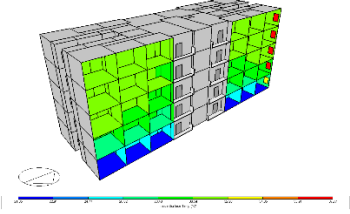
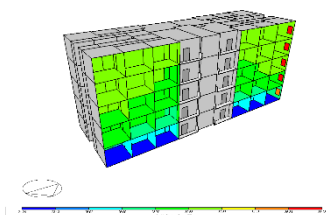
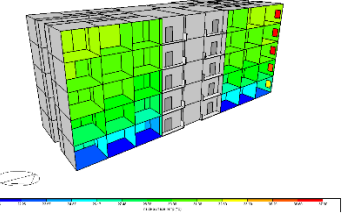


*Figure No (06 ) Typical Plan of units for Society housing , Economy type*

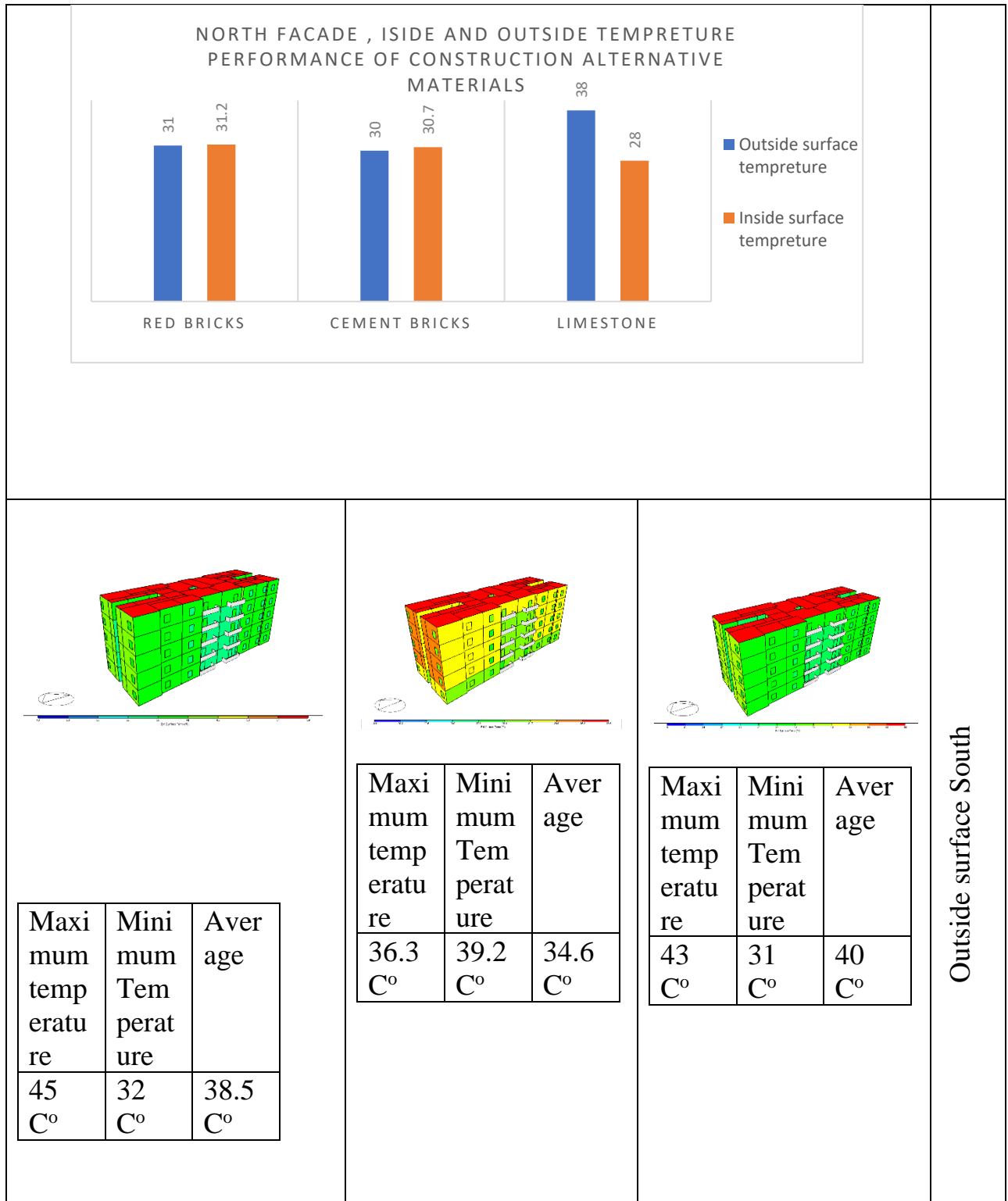
**4-2 Thermal impact of using Limestone comparing to other Alternative construction materials :** the structure and all finishes layer is fixed and the variance is type of walls materials only .

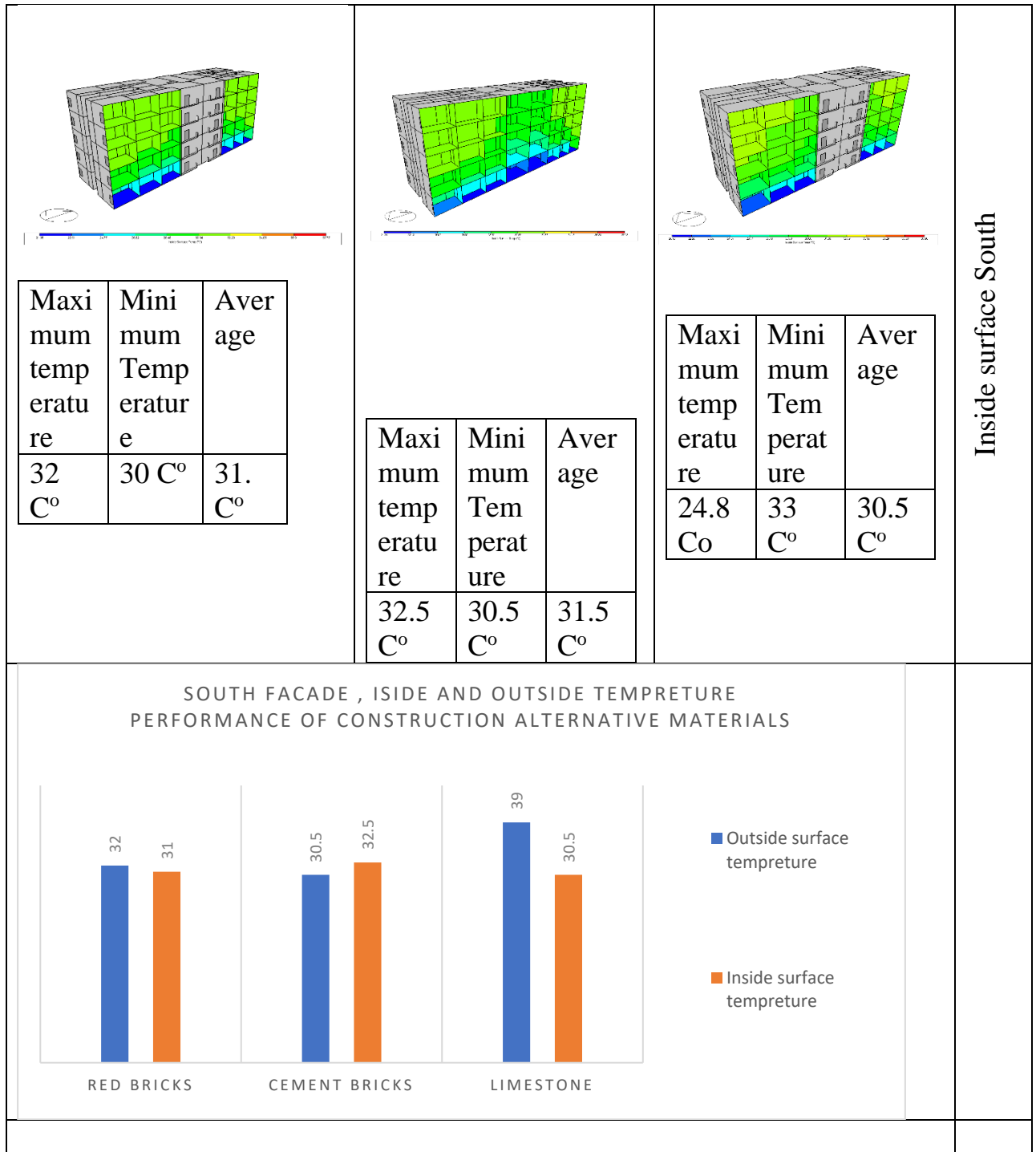
<b>Model , Temperature effects in, Almenia , Middle of Egypt , in Summer time , 27 July</b>	<b>Surf ace /</b>
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			<b>Façade</b>																		
<p>Red Brick size 250 x 120 x 60</p>  <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th>Maximum temperature</th> <th>Minimum Temperature</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">45 C°</td> <td style="text-align: center;">27 C°</td> <td style="text-align: center;">31 C°</td> </tr> </tbody> </table>	Maximum temperature	Minimum Temperature	Average	45 C°	27 C°	31 C°	<p>Cement Brick size 250 x 120 x 60</p>  <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th>Maximum temperature</th> <th>Minimum Temperature</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">34 C°</td> <td style="text-align: center;">27 C°</td> <td style="text-align: center;">30.5 C°</td> </tr> </tbody> </table>	Maximum temperature	Minimum Temperature	Average	34 C°	27 C°	30.5 C°	<p>Limestone 300 x 600 x 150</p>  <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th>Maximum temperature</th> <th>Minimum Temperature</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">43 C°</td> <td style="text-align: center;">34 C°</td> <td style="text-align: center;">38.5 C°</td> </tr> </tbody> </table>	Maximum temperature	Minimum Temperature	Average	43 C°	34 C°	38.5 C°	<b>Outside surface North</b>
Maximum temperature	Minimum Temperature	Average																			
45 C°	27 C°	31 C°																			
Maximum temperature	Minimum Temperature	Average																			
34 C°	27 C°	30.5 C°																			
Maximum temperature	Minimum Temperature	Average																			
43 C°	34 C°	38.5 C°																			
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Maximum temperature	Minimum Temperature	Average																			
32.2 C°	26.6 C°	31.2 C°																			
Maximum temperature	Minimum Temperature	Average																			
32.5 C°	26.9 C°	30.7 C°																			
Maximum temperature	Minimum Temperature	Average																			
31.8 C°	27.8 C°	28 C°																			

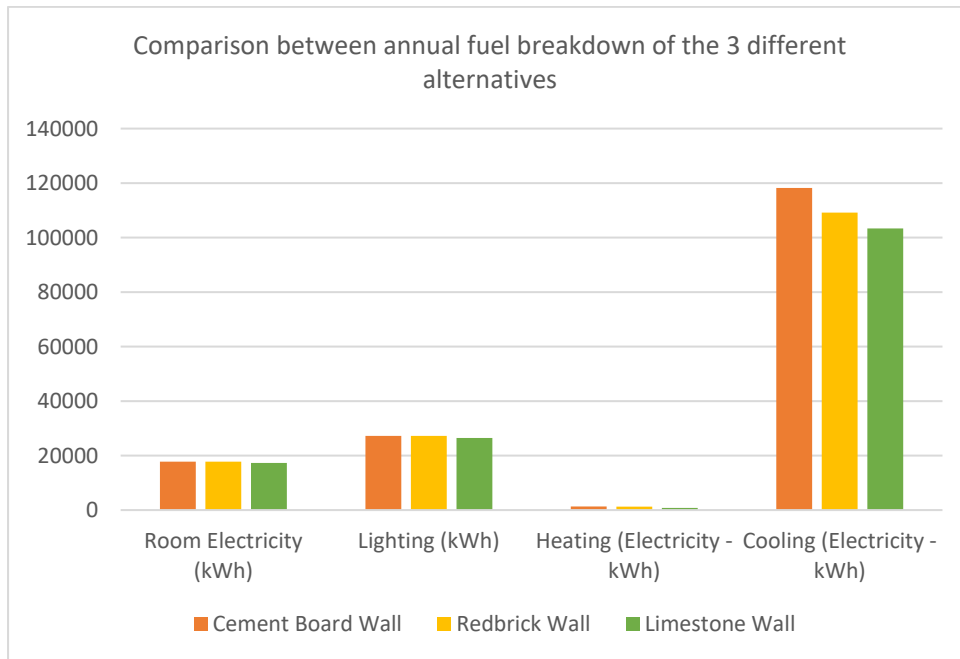
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**4-3 The annual energy Saving of cooling capacity for using Limestone**





	<b>Cement Board Wall</b>	<b>Redbrick Wall</b>	<b>Limestone Wall</b>
<b>Room Electricity (kWh)</b>	17797.16	17797.16	17272.79
<b>Lighting (kWh)</b>	27240.45	27240.45	26453.81
<b>Heating (Electricity - kWh)</b>	1336.215	1248.402	810.723
<b>Cooling (Electricity - kWh)</b>	118237.5	109145.3	103385.5

*Table No ( 07) Power consumption required by using different types of building material*

#### **4-4 Cost saving of using limestone in construction materials**

The difference in between Limestone and cement bricks is 400 KW

The Cost saving is : KW electricity is 2212.15 EP per Unit ( one Building )

Upon that the total of Energy saving of the project per City ( Menia ) project =  
 $432 + 221 = 653 \times 2212 = 1,444,436 \text{ EP / per year}$

## **5- Discussion**

There are many concerns and questions about the spread of limestone brick construction because there are some weaknesses represented in the following:

- A. Lack of water resistance
- B. Heavy of Weight
- C. Lack of empty bricks
- D. Concentration of factories in central Egypt and northern Upper Egypt

The above indicated item can be solved with the following technique

- A. Fix the skeleton of structure system
- B. Fix the finishes layer , Plaster and paint
- C. Increase the water resistance by adding water proofing

## **6- Conclusion :**

The research reached to confirm that limestone is one of the most important geological components and structures in the Egyptian territories and spread on the axis of the development of Upper Egypt in the western axis, the research reached the rooting of the craft of the limestone industry in the areas of north Upper Egypt and central Egypt.

The research concluded in showing the sustainability resulting from the use of limestone where it reduces the cost in construction and increases the employment opportunities for the community environment of the existing human force and increases the opportunities to invest in the development of the upper axis in central Egypt.

As the research indicated that the replacement of limestone brick blocks reduces thermal mobility and reduces the consumption value of electric power with an annual value of 1,444,436 EP , The research open the opportunities for discussion and more investigation to increase the performance of the Limestone resistance of water the weight in future to improve the sustainable factors

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- 17 [PowerPoint Presentation \(mhuc.gov.eg\)](http://mhuc.gov.eg)