

High-Performance Building by using Sustainable Materials

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Abstract-- Sustainability is one of the most impressive methods used in improving the building performance. The aim of this study is to indicate the impact of using sustainable materials on building performance. In this study, the use of unsuitable and non-sustainable materials is investigated in the building construction. The buildings used as a subject for the research are the student dormitory buildings in Eastern Mediterranean University in Famagusta, Northern Cyprus. The two case studies are Sanel Dormitory with low quality building materials and Longson Dormitory with high quality building materials. Furthermore, the other aspect is to investigate the influence of using sustainable materials on building performance.

Scientific evaluations show that 53 percent of the Longson Dormitory residences are satisfied with energy consumption; on the other hand, 11 percent of the Sanel Dormitory residents are satisfied with energy consumption with unsuitable building materials. In addition, Longson dormitory provides more thermal comfort, and acoustic comfort than Sanel Dormitory. Therefore, results show the importance of considering sustainability for improving building performance.

The research method is based on a comparison of the data collection, which was collected from case studies. Accordingly, the methods of data collection are based on observations, questionnaires and a relevant literature review. Finally, results show that sustainable building materials such as double skin façade, plasterboard walls and triple glaze windows can improve the building performance. Therefore, choosing the right and appropriate materials for the buildings is the best way to achieve sustainability in the Northern Cyprus construction industry.

Key words: Sustainability, Building Material, Building Performance

I. INTRODUCTION

Nowadays, considering the growth of the global population, the necessity for accommodation is also increasing. However, present mainstream building methods are non-sustainable, producing high amounts of CO₂ both during construction of the buildings and throughout their existence.

Sustainability is becoming a significant issue for developers with many of the exciting inventions in the field of industrial construction, regarding that sustainability is a possible solution in providing universal accommodation [6]. In other words, a sustainable building is the planning of creating structures and using processes that are ecologically responsible and resource-efficient through a construction's life-cycle from first step of project, building, maintenance, renewal, operation and deconstruction. This study develops and complements the classical construction design issues, which include budget, utility, long lasting, and comfort [5].

Sustainable constructions are also known for being high performance constructions. Hence, a proper selection of ecological sustainable construction materials is a simple and significant method for designers to integrate sustainable design codes in constructions. There are several ways of generating sustainability in the design of a construction likewise; there are variations of materials that can be utilized. An important aspect is to select materials appropriate for the local context. The advantage of using local building materials not only declines issues regarding transportation, but also results in positive economic and social impacts at the local level. Additionally, sustainable buildings encourage the usage of recycled materials [5]. This study, adopts both qualitative and quantitative methods to investigate the sustainability practices in the North Cyprus construction.

A. The research Problem

In the last decades, the use and development of sustainability has become an important issue in all fields, including the construction industry. Furthermore, this study has focused on investigating the construction and building performance of buildings constructed with the usage of sustainable materials.

One of the beneficial aspects of using sustainable materials in buildings is providing the proper environment for both the residents of the buildings and declining the risk of environment hazardous. This study aims as exploring a solution to solve an important issue regarding the North Cyprus construction industry. The problem that this study has focused on is:

- The use of inappropriate and non-sustainable materials in the North Cyprus construction.

In other words, the use of low quality materials in the construction will be investigated. In order to create suitable solutions for the two case studies in EMU campus, Famagusta, North Cyprus, it is essential to recognize the sustainable materials in the construction of building. However, the central of the problem is the absence of information concerning sustainability. Moreover, sustainability methods have already recognized to be valued on social and global. The aim of sustainability is to create human lifetime harmless, and decrease the risk of venture on environmental [5].

B. The research aim and objectives

The goal of this current research is to showcase the effect of using sustainable materials on construction performance. One of the objectives of this current study is to discover how designers can develop the construction performance by using sustainable materials. The central research question which this study purposes to answer is:

- How can utilized materials in buildings create suitable conditions in reaching sustainability for North Cyprus?

Consequently, the use of sustainable material is an essential issue in terms of improving the building performance. This study would result in a general idea of sustainability matters in building constructions, the utility and life cycles of these structures and the relationship among ecology and construction by benefiting from an in-depth comparison amongst two different types of building. The research will showcase how the correct materials for North Cyprus conditions can be selected in order to improve the performance of the buildings.

C. The Research Methodology

The method of this current study is based on a comparison and evaluation of the data collection which was collected from two student dormitories; Longson dormitory A-block and Sanel dormitory. The Longson dormitory A-block was chosen due to it's high quality construction, and Sanel dormitory was selected due to it's low quality. These constructions are situated in the EMU, campus which is situated in Famagusta, North Cyprus. It is significant to note that the technique of data gathering in this research was a complex method which joint individual questionnaires (asked from 40 Students), observation, likewise a literature review linked to the subject in this study. This current study was planned to mixed quantitative and qualitative methods in order to find out the problems and also to formulate solutions for the chosen case study problems in the study. The quantitative information is created by the questionnaires, while the qualitative information is an outcome from literature review and observation the in this current study. The EXCEL software will be using to evaluate the information.

II. LITERATURE REVIEW

Sustainability is one of the crucial items used to develop the construction performance in terms of energy efficiency, durability, life-cycle performance, and occupant efficiency. Also, energy consumption, thermal comfort and thermal insulation are the other significant aspects of the building performance. So, the use of suitable materials has an effect on quality of environment, energy use, human health and the global economy. The use of sustainable material reduces harmful impact on future generation, and promotes environment quality, economic vitality, and social benefits [8].

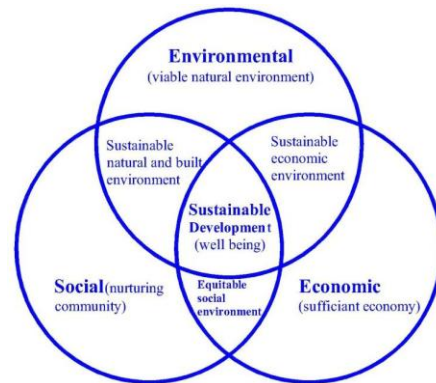


Figure 1. Three basics of Sustainable Development [8].

As mentioned above, sustainable buildings have several advantages, such as improving the building life cycle, and thermal comfort. Additionally, the effects of environment hazards may also decline with proper building construction and use of sustainable materials.

Most of the scientists are interested in developing “high-tech” construction materials by the up cycling of wastes from working activities. For example, much sustainable light steel can be reused of wastes and also save energy [2].

A. Examples of Sustainable Materials

A.1 Double Skin Façade

The facade has an important role in terms of its function as a shelter between indoor and outdoor environment. According to the importance of sustainability issues, facade as an essential component for use and integrating renewable energy[7].

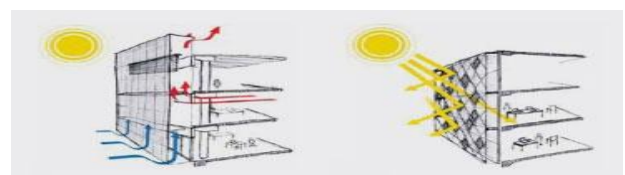


Fig. 2. Heat transfer and Airflow in double skin façade [4].

Double skin façade is the combination of two layers of airflows in the intermediate cavity which can be natural, artificial by the support of fans or electrical (Harris, 2004). Menzel (2012) discussed that one of the essential benefits of double skin façade is providing shading and increase of air temperature inside the cavity by solar radiation and a 25% decrease with natural air circulation. Double skin facade decreases heat loss when the air velocity inside the cavity is reduced (in comparison with the cases without intermediate placed blinds) which keeps the temperature warmer. In hot days, it increases heat next to the windows and openings which consequently improves thermal comfort of the residences.

A. 2 Plasterboard

Plasterboard is a panel prepared of gypsum plaster pressed between two thick sheets of paper. This panel can be used for the interior walls, panels, and ceilings. Using plasterboard building became extensive instead of traditional lath and plaster [1].



Fig. 3. Use of plasterboard sheet interior wall [1].

Since the mid-1980s, plasterboard walls sales in European country have increased by about 5% each year since the installation of this material is simple and rapid. To construct a core wall, for example, a frame is created, plasterboard is fixed to it, connections are occupied, and the wall is shaped. The process is clean, dry and simple when install in construction. Plasterboard can also be combined to insulation materials to create the so-called covered sheet in the building. These schemes can be simply install to the central wall of your building to generate thermal insulation and also to donate to the energy efficiency of the building. Plasterboard partitions and ceilings can be received in its cavity mineral wool to raise thermal comfort earning extreme performance in minimal space in the building. Therefore, ceilings, partitions, and linings become thermal insulated systems. The plasterboards keep the insulating material together with the air barrier, in preventing indoor humidity from getting in, or being stuck in the insulation [1].

A. 3 Triple-Glazed Windows

Triple glaze windows insulation layers is more than double and single glazing which increases the performance of triple glazing with these layers. The space of the layers of glazing

can be filled with air or special gasses. Triple glazing allows as much sunlight as single-glazed windows to enter, but can control heat gain much better than other glazing types [3].



Fig. 4. Triple-Glazed Window [6].

Triple glaze windows are known as a super-efficient window material used in buildings. Furthermore, three layers of triple glaze can block the heat gain and loss much better than single and double glaze windows. Between the layers of most double glaze windows are filled with Argon gas and between each layer of glass of triple glaze windows krypton is injected. Although Krypton is considered best insulator, it is an expensive gas [3].

III. FIELD STUDY

Longson dormitory A-block was selected as a suitable case study, while Sanel dormitory was selected as weak case study Both are located in EMU University, Famagusta, North Cyprus (Figure 5).



Figure 5. Case study site, (was taken by Google map 12 March 2014)

- Longson A Block Dormitory
- Sanel Dormitory

The reasons for selecting the two dormitories for the research are convenient access, and students' high capacity.

In addition, during observations it was found that some of the suitable building materials used in Longson dormitory include light steel for structure, double skin facade by plasterboard walls, triple-glazed windows, laminated wood floor surface, and timber roof.



Fig.6.Longson Dormitory (Photo by author in 20th of April, 2014)

Sanel dormitory has a concrete structure, thick single skin brick walls, double glazing glass as building materials are used. Both of these dormitories have approximately same student capacity, and building orientation.



Fig.7.Sanel Dormitory (Photo by author in 18th of April, 2014)

A. Personal Observations

During observations in Longson and Sanel dormitories it was found that the structure types and building materials are essential parts of the building construction industry. Therefore, the following results were obtained:



Figure 8. Longson Dormitory (Photo by author in 20th of April, 2014)

B. Result of Observations

B.1 Longson Dormitory A-Block

260 students currently live in Longson dormitory-A block.

Structure: light steel

Partition wall: Plasterboard

Earthquake-proof buildings are constructed by light steel technology. Walls are built with materials allowing sound and thermal insulation, also the plasterboard walls were used as partition systems, and rooms with laminated wood floor surface that has double skin facade.

In the Longsom dormitory, window frames are held by specific frames that avoid air penetration (Figure 8).



Figure.8.the window frame usage in Longson dormitory (Photo by author in 20th of April, 2014)

Triple-glazed windows have better insulation in Longson dormitory and its feature is that it reduces energy consumption and achieves thermal comfort (Figure 8).



Figure.9.Longson Dormitory (Photo by author in 20th of April 2014)

It was observed in Longson that the materials were used with low density and amorphous has been used as the material in facade to avoid heat transfer. However, in Sanel dormitory reducing heat transfer was not considered during insulation (Figure 9).



Figure 10. Interior space of longson dormitory A-bloke (Photo by author in 20th of April, 2014)



Figure 13. The window frame usage in Longson dormitory (Photo by author in 20th of April, 2014)

B.2 Sanel Dormitory

Capacity of Sanel dormitory: 237 students

Structure: Concrete

Partition wall: brick wall



Figure. 11. Sanel Dormitory (photo by author in 18th of April 2014)

Sanel dormitory consists of three blocks with three levels. The first two levels are for male students while the third floor is just for female students. Structure of Sanel dormitory is concrete and has single brick walls. It was observed that dormitory brick walls are thick and inappropriate, additionally it has single facade.



Figure. 12. Interior space of Sanel Dormitory (photo by author in 18th of April, 2014)

In Sanel dormitory, most of energy loss is resulted from inappropriate insulation, the high density of materials, and usage of single glazing without consideration to open specific lintels and frames (Figure.13).



Figure 14. Sanel Dormitory (photo by author in 18th of April, 2014)

Finally, in observations it was found that, the material in Sanel dormitory was chosen inappropriate and non-sustainable for Famagusta, North Cyprus conditions and the material of these buildings should be improved to increase the building performance.

IV. DATA EVALUATION AND RESULTS

A. Data Evaluation Methods

As mentioned above, mixed methods were used to collect data. The information required to answer the research question, and to achieve the goal and objective, so it is necessary to assess both with quantitative and qualitative methods. Quantitative data was collected by questionnaires, and qualitative data was collected via observations and literature review.

B. Data Evaluation Outcomes

The prepared questionnaire includes 14 questions; I tried to make general questions that are easy to answer for students who do not have knowledge regarding construction issues. In order to fulfill the goal I used the same questionnaire for

both dormitories residents in order to be able to compare the results. Half of the questionnaires were asked to Longson dormitory residents (20 Students), and the other questionnaires were given to Sanel dormitory residents (20 Students). Closed ended questions were chosen in instruction to ensure a comparison between answers. The following results obtained:

B.1 The Quality of Building Materials Used in the Dormitories

Below are the results that have been obtained from the answers to the following question:

How do you evaluate the quality of presentation of structural features with concerns to sense level in your accommodation?

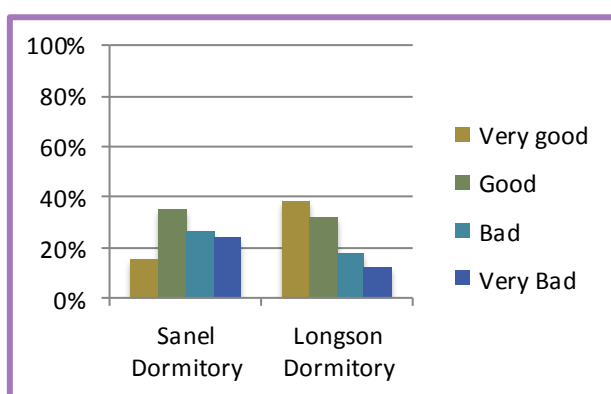


Figure.15. The quality of building materials in felid studies (drawn by author, 2014).

Quality of building materials is an important factor to make attractive spaces for residents. As you can see in Figure 15 the general level of satisfaction in Longson dormitory is 77 percent, however, just 30 percent of Sanel dormitory residents are satisfied with the quality of their dormitory building materials (Figure. 15).

Moreover, 24 percent of Sanel dormitory residents evaluated the quality of their dormitory building materials as 'very bad', but just 12 percent of Longson dormitory residents assessed the quality of materials 'very bad'. Against a 38 percent of Longson dormitory residents, only 15 percent of Sanel dormitory residents evaluated the materials quality as 'very good'(Figure.15).

B. 2 Energy Consumption Satisfactions

Below are the results that have been obtained from the answers to the following question:

Are you satisfied with your accommodation's energy consumption?

According to the literature review, reducing the energy consumption is the most important part in building performance. Therefore by reducing energy consumption the building performance can be developed. As you can see

in Figure 17 the amount of satisfaction with energy consumption in Sanel dormitory is just 11 percent. This means that 89 percent of residents in Sanel dormitory are unsatisfied with energy consumption (Figure .16).

This result is related to lack of consideration to use façade materials in the Sanel dormitory. In this building single glass windows and the thick single facades have been used. Therefore the materials used in this building are not suitable for North Cyprus climate conditions.

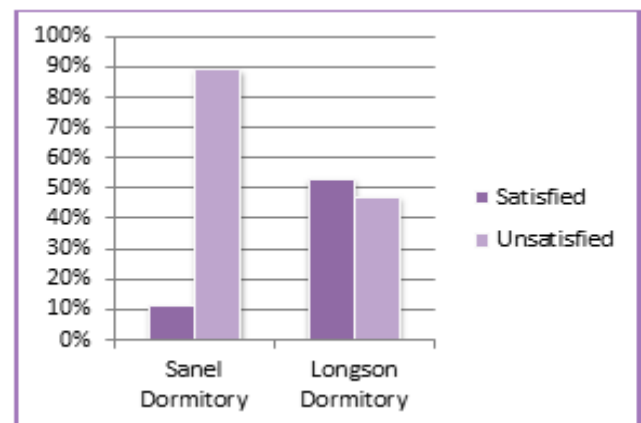


Figure.16. The energy consumption satisfaction in felid studies (drawn by author, 2014).

However, for Longson dormitory that has used double skin facade and triple-glazed windows, the amount of satisfaction with energy consumption is 53 percent, and 47 percent of Longson dormitory A blok are unsatisfied with this issue (Figure.16). To conclude, results show that sustainable materials such as double skin façade and triple glazed windows have the most important role to reduce energy consumption.

B. 3 Thermal Satisfaction

Below are the results that have been obtained from the answers to the following question:

Are you satisfied with the Thermal comfort in your dormitory?

Thermal comfort is an important issue to improve building performance and provide satisfaction for building residents. The results for this question are as follows:

The 64 percent of Longson Dormitory residents are satisfied with thermal comfort, however on the opposite side the number of satisfaction in Sanel dormitory is just 28 percent (Figure.17).

Also, while the amount of unsatisfied residents in terms of thermal comfort of Sanel dormitory is 72 percent, however in the Longson dormitory A block just 36 percent of residents are unsatisfied with thermal comfort.

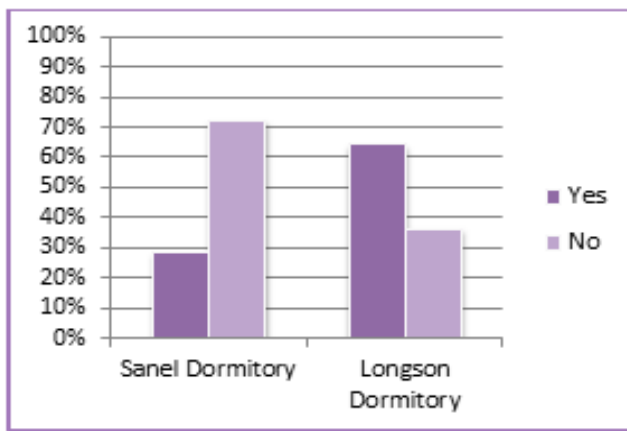


Figure.17. The the evaluation of thermal comfort (in felid studies drawn by author, 2014).

B.4 Acoustic Satisfaction

Below are the results that have been obtained from the answers to the following question:

Are you satisfied with your accommodation's acoustic level?

Sound comfort has a significant role in the performance of buildings. The plasterboard as a sustainable material for creating partitions and walls has suitable potential to use acoustic insulation, which results in achievement to high-performance building.

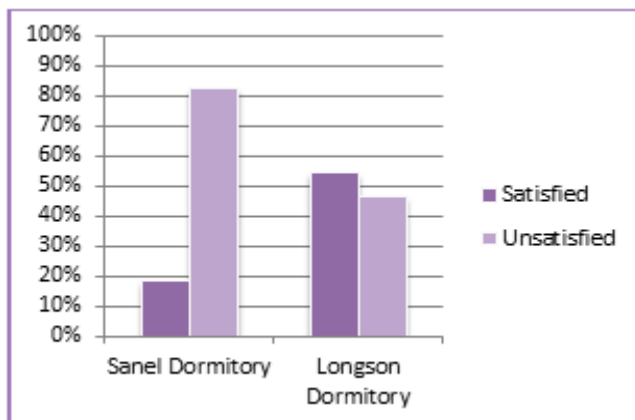


Figure.18. The evaluation of acoustic comfort (in felid studies drawn by author, 2014).

The 54 percent of Longson Dormitory residents are satisfied with the acoustic, while the just 18 percent of Sanel Dormitory residents are satisfied. Therefore, the amount of dissatisfaction for Sanel dormitory residents with acoustic comfort is 82 percent, however the amount for Longson A block dormitory residents is 46 percent (Figure.18).

Accordingly, the plaster board wall is a suitable material to use as partition walls in buildings.

V. CONCLUSION

In this research, the main results show the significance of suitable materials in order to improve building performance. By comparing the data collection outcomes show that the building performance is a comprehensive issue used to identify and set comfort and energy efficiency in a building. According to the literature review the energy consumption, thermal comfort and acoustic comfort are the important aspects of building performance. Therefore, by consideration to choose suitable material high performance buildings can be created.

The results show that 53 percent of Longson Dormitory residents are satisfied with the energy consumption while just 11 percent of Sanel Dormitory residents are satisfied with energy consumption. Also 54 percent of Longson Dormitory A-blok residents are satisfied with acoustic comfort, while the amount of satisfaction Sanel dormitory residents is 18 percent. Moreover, 64 percent of Longson Dormitory A-block residents are satisfied with thermal comfort, on the other hand the level of satisfaction of Sanel dormitory residents is 28 percent.

In conclusion, the research showed the importance of building materials on building performance. The scope of this study was to improve the awareness of architects about sustainable materials. Therefore, it is necessary for all architects and investors to be aware and to consider about the benefits of sustainable materials to create buildings with high-performance.

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