

Intelligent Solutions in Buildings and their Impact on Elements of Architectural and Structural Design

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Abstract: *This Research focuses on the concepts of intelligent / brilliancy from several aspects in an attempt to access to intelligent solutions of various types. The problem and objectives of the research have been identified to include accessibility to interrelated design, structural solutions and buildings designed in a manner that respects the environment, and taking into account reduction of energy and resources consumption, as well as minimizing the effects of the construction and use on environment and also taking into consideration the existence of the technological excellence and development. The research includes of intelligence in general, its types and the concept of industrial intelligent as well as intelligent buildings and their importance and necessity. The questionnaire was randomly distributed (60 for) on a sample of engineers from different specializations in Khartoum state in order get a variety of different views. Results showed that, the concepts of intelligence is not adequately recognized, and this requires that the competent authorities give them a greater interest and attention as well as the knowledge of these concepts is not supported by study, experience and practice in the implementation. Also, before implementation, we must know all structural solutions that help the sustainability of the building and not exposing it to hazards*

Keywords: *Intelligent solution, Architectural design, Structural design*

I. Introduction

The environmental concept of the design seeks to contribute to regional and international efforts to reduce the negative effects resulting from the use of the conventional energy resources, and these issues are no longer a local or regional problem, but have become a global matter which needs concerted efforts to face the dangers that might occur in the future. It is estimated that round half of the energy consumed by human being is used inside buildings and this will reflect the enormous quantity of energy that could be saved if certain solutions are adopted in order to contribute to the reduction of the cooling, heating, air conditioning and lighting costs in buildings, in addition to finding aesthetic solutions that can add a beautiful and different architectural touch in buildings [1].

As the engineer is one of the most important persons who are responsible for drawing civilized facade of his country, if not the first one, he should develop engineering solutions to protect the environment in all its forms which are represented in open spaces between buildings and to increase the proportion of green spaces and beautiful environment reflected in the aesthetic appearance of the buildings as well as the cultural and moral level of society [1]. Furthermore, the different types of intelligent solutions were highlighted to include the design solutions which are divided into the sustainable development and its concepts and motivation to adopt its principles, the green architecture and its objectives and importance as a intelligent solution , Minimizing the cost of buildings as a intelligent solution, low-cost building material and modern construction techniques. It also includes the intelligent structural solutions that avoid damage that may affect buildings in future, with linking these construction solutions with design solutions [2]. The technological intelligent solutions related to technological buildings and the possibility of remotely controlling buildings and energy conservation inside the building etc. [3].

Then a study has been conducted on global building models and on each type of the aforesaid intelligent solutions such as London Tower for achieving sustainability concepts and reduction of cost, the Kingdom Tower in Riyadh which realized the concept of structural solutions and Khalifa Tower which includes simultaneously the structural and technological solutions, and addition to other models. At Sudan level a study has been conducted on Khartoum Communications Tower building for being the only building in Khartoum, which includes more than one type of intelligent solutions, that is in addition to a questionnaire to get the feedback from people about the smartness concepts and the extent of their knowledge about them, as well as their willingness to implement intelligent solutions in their buildings and homes. At last, one of the primary goals of this thesis is to draw attention to other types of intelligent solutions apart from the technological solutions, and to correct the prevailing belief that intelligent solutions are linked only to the technological aspects.

A. What is the definition of Intelligence?

Mind is of a purely humanitarian nature and its growth will be at different stages and is responsible for human excellence over the rest of living beings, but human beings are also different from each other's in their mental abilities. Among these capabilities, we find that intelligence is deemed to be a mental energy, mental return or related characteristic of mind that works actively and with understanding, depth and speed, and that's what makes us recognize it more and ask about its types, characteristics and the factors that are influencing it and its tests as well as the most important theories that explain it. In fact, intelligence is not confined or limited to a sole definition as some psychologists have tended to give it general and special definitions [4]:

- General Definition: It includes every type of knowledge whatever its origin whether from sensation, perception, crumbling, memory, imagination or understanding.
- Special definition: It look at the intelligence from two angles :
 - Scientific or direct intelligence as the ability to adapt solving new problems and surrounding circumstances.
 - The theoretical intelligence: the ability to adapt, understand and grasp different relations of similarity or variation.

B. Intelligent Buildings

These houses are almost do not need any conventional energy for heating or cooling where it gets its need of energy from sunlight, the earth and its inhabitants as well as it fulfills their daily requirements, even in their absence.

- Sustainable Development:

The sustainable development is the development that meets the needs of current generations without harming the ability of future generations to meet their own needs.

- Sustainable Architectural Design:

The most important principles of sustainable design is to reduce the use of energy and maintain the health of individuals.

- Green Buildings :

Green Buildings are those buildings that are designed, implemented and managed in a manner which puts the environment in mind first and which have less negative impact on the environment, as well as lessening their construction and operation.

II. Research Objectives

The main objectives of this research are summarized on the followings points:

- Accessing to design and construction solutions and their integration with each other.
- To design Buildings in a manner that will be friendly with the environment, taking into account reducing the consumption of energy and resources as well as minimizing the effects of construction and use on the environment.
- Non-negligence of the existence of technological excellence and development.
- Bolstering urban level and directing it towards modern scientific and technical methods.
- Working on finding smart solutions to reduce the cost and availability of beautiful buildings.
- Drawing attention to the virtually unbeknown smart solutions .
- Submission of a thesis that deals with the concepts of intelligence from a different perspective.

III. Methodology Of The Study

The methodology of this research has done on two aspects, the theoretical and practical studies. The theoretical studies includes the information / data that the researcher receives from sources and references in various languages and which are related to the theme of intelligence in buildings and solutions of design and construction, whereas the practical studies have included distribution of questionnaires on the selected sample of engineers from different specializations in Khartoum state from Sudan.

Axes of questionnaire questions:

- The first axis: It includes an introduction, definition of the project and its scientific purpose, as well as explaining the importance of the questionnaire in directing the research to a suitable direction.
- The second axis: It contains all questionnaire questions with answers that are placed in front of each paragraph so as to enable the Screened person to select the appropriate answer for each question of the questionnaire form, which is divided into six sections:
 - Section I: It includes personal information such as qualification, specialty, years of experience, nature of work etc..

- Section II: It contains the concepts of smart solutions and the extent of their knowledge about them.
- Section III: The questions revolve around the sustainable development as an intelligent solution.
- Section IV: The questions revolve around minimizing cost as one of smart solutions.
- Section V: This section questions were about construction solutions.
- Section VI: It deals with the technological solutions in buildings as intelligent solutions.

IV. Discussion Of The Results

• **Section I: Personal data**

The questionnaire results of section I (includes personal information such as qualification, specialty, years of experience, nature of work etc..) were shoed in the Fig. 1, Fig. 2, Fig. 3 & Fig. 4. A percentage of 66% of the targeted sample were holding high degrees (MSc & PhD), while 34% of the sample were holding bachelor degrees (BSc) have shown in Fig. 1. Fig.2 shows, the percentage of 71 % of the targeted sample were architects, 23% of them were civil engineers, while 6% were electrical engineers. Fig. 3 shows, a percentage 49 % of the engineers have less than five years' experience, 27% of them have experience of 5 – 10 years, 6 % of them have experience of 10 – 15 years, whereas 18 % have more than 15 years of experience. Fig. 4 shows, a percentage of 57 % of respondents were engineers, 20 % of them were consultant engineers, 6 %, were contractors and 17 % for other categories.

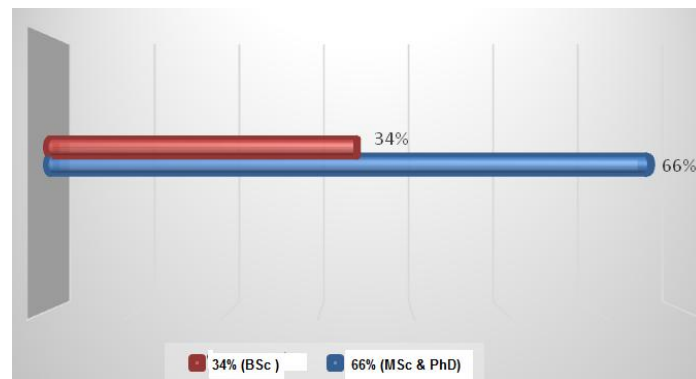


Fig. 1: Personal data (qualification)

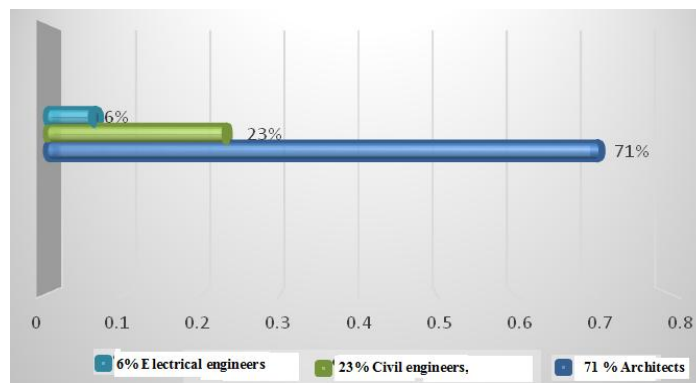


Fig. 2: Personal data (specialization)

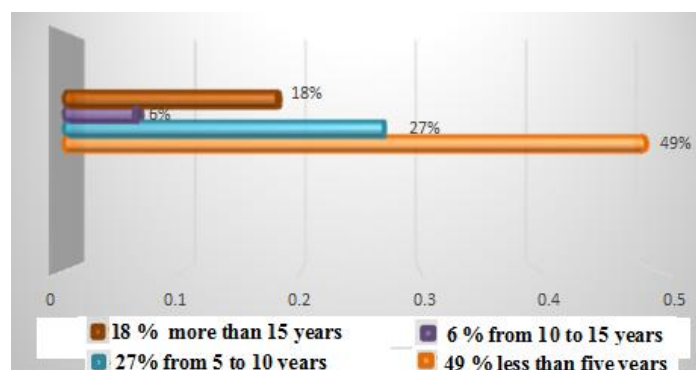


Fig. 3: Personal data (years of experience)

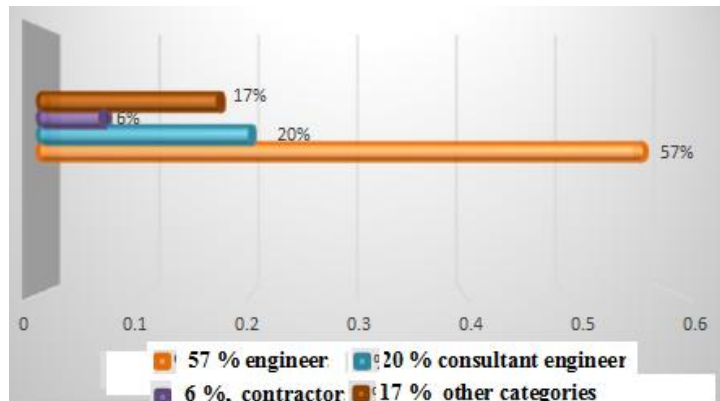


Fig. 4: Personal data (nature of work)

• **Section II: The extent of your awareness about intelligent solutions**

The questionnaire results of section 2 were presented in the Fig. 5, Fig. 6, Fig. 7 and Fig. 8. Fig. 5 shows that A large percentage of engineers (66%) believe that building techniques have become generally known, however, there are a significant percentage of them believe that these techniques are not adequately recognized, the matter that requires special attention in this aspect from the competent authorities. Fig. 6 presents that, 35 % indicated that the awareness of the concepts of smart solutions is insufficient, and efforts should be exerted to raise the level of awareness more. Knowledge of smart solutions - other than the technological solutions- quite a few one and it is necessary raise and draw attention of awareness to it and intensify knowledge of it , the matter that will allow us to have an erudite environment that helps in the dissemination of development in the country (Fig. 7). 62 % of the samples do not think that the construction and design solutions can be smart solutions. This shows that the majority of them believe that the smart solutions are represented in the technological solutions only (Fig. 8)

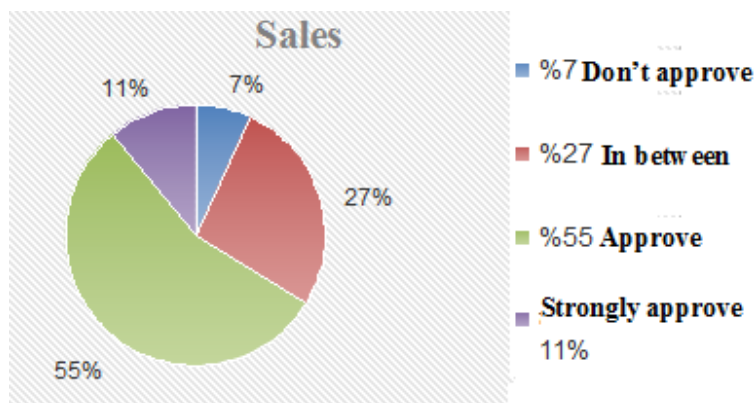


Fig. 5: Result of question - The smart buildings technologies has become used and recognizable?

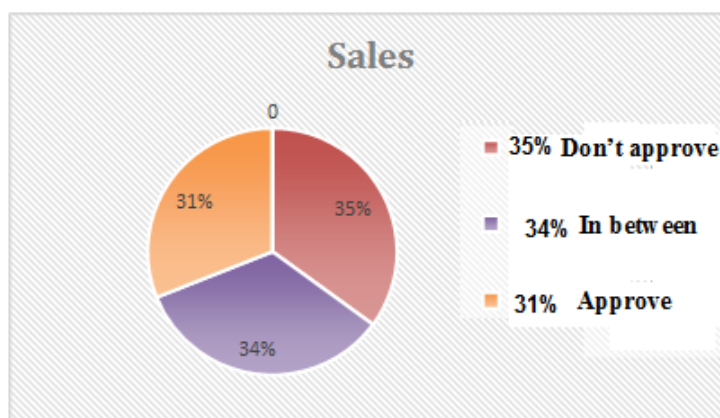


Fig. 6: Result of question - There is a very good awareness of the concepts of smart solutions?

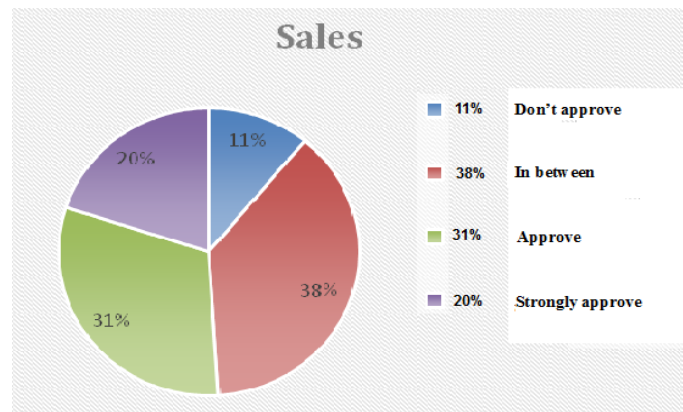


Fig. 7: Result of question - Do you think that smart solutions are limited to technological aspects only?

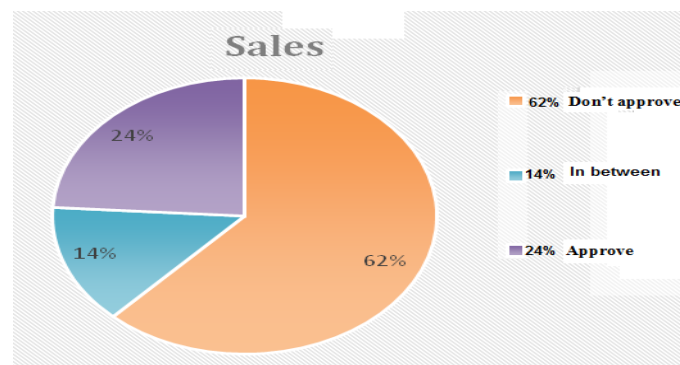


Fig. 8: Result of question - Do you think that the construction and design solutions can be considered as intelligent solutions?

From the above, we find that awareness of the concepts of smart solutions needs to be strengthened in such a better way as the results showed that these concepts are not adequately recognized the matter that requires the competent authorities to pay them more attention. It is found that the competent authorities do not throw adequate light on the concepts of intelligence and education courses on the concepts of intelligence should be intensified. Many people believe that smart solutions are limited to the technological side only, without paying attention to other solutions that give an intelligent building that agrees with the standards of optimal design, so awareness must be raised in order to get an intellectual environment conducive to the development of cities in a good manner. The results of study showed that a large number of people see that the optimized construction should be through the application of smart solutions, and consequently, they have a great desire to experience this kind of concepts, as well as the engineers tend to use these solutions in their designs.

• **Section III: Sustainable development as an intelligent solution**

The questionnaire results of section III were presented in the Fig. 9, Fig. 10, Fig. 11 and Fig. 12. Fig. 9 shows that 94 % of the researched people believe that the concept of the sustainable development is very important in providing a healthy and suitable environment in the present and future. Fig. 10 shows that 77 % find that the use of sustainable development rationalizes consumption of energy and water. This means that the knowledge of the importance of sustainability is widely spread and known. About 62% of them take into account the requirements of the environment in their designs and put them in mind, while 21 % of them believe that this matter depends on the circumstances of the design (Fig. 11). Approximately 80% of them are finding that the green buildings give beautiful sight for buildings as well as them give psychological comfort and proper attractions (Fig. 12).

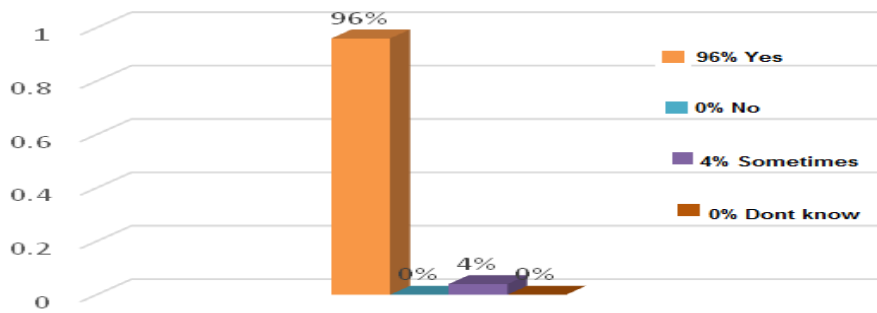


Fig. 9: Result of question - Do you know that sustainable development is significantly contributing to the preservation of the environment?

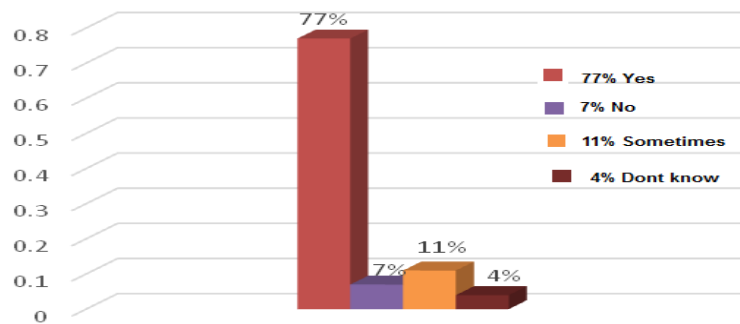


Fig. 10: Result of question - Do you know that sustainable development reduces the use of water and electricity?

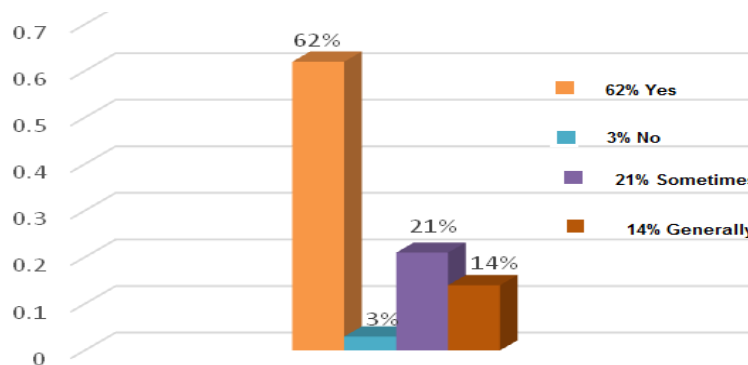


Fig. 11: Result of question - Do you take into account the environmental requirements in your design?

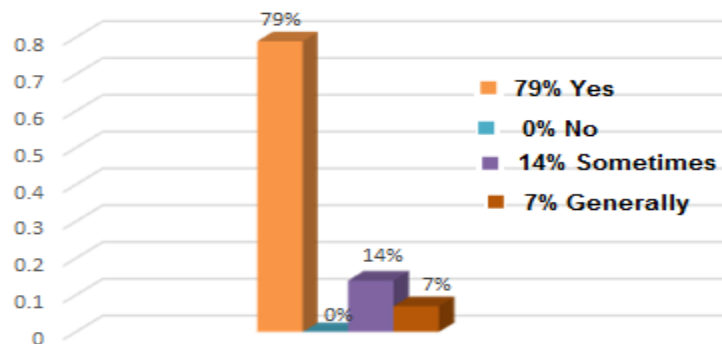


Fig. 12: Result of question - Do you think that the green building imparts a beautiful sight?

From section III, we find that there is awareness about the concepts of sustainability and green buildings, but this awareness needs to be strengthened in order to enhance the awareness about the importance

of sustainability. There is adequate awareness about the concept of sustainable development as a very important concept in providing a healthy and suitable environment in the present and future, as well as in rationalizing energy consumption. The majority of them think that the green and sustainable building adds beauty to the building and provides appropriate factors of attraction. Negligence in applying sustainability concepts at the moment is largely due to a lack of awareness of the owner, client or the architect about the importance of sustainability, as well as due to the high cost of implementation / execution.

• **Section IV: Minimization of cost as an intelligent solution**

The questionnaire results of section IV were presented in the Fig. 13, Fig. 14, Fig. 15 and Fig. 16. Fig. 13 shows that 48% of the sample believe that smart solutions are reducing the cost sometimes but not always, and this depends on the type of the intelligent solution, its flexibility and availability of material, while 40% of them say that they are working on reducing the cost in the long term, if not in the short term. Cost reduction has become a required element in designing buildings due to the increase of construction prices, and so it has become a requirement for each customer. Hence, he seeks to reduce the costs by any means whenever they provide safety and stability for his building, and so we have to enlighten him about these methods (Fig. 14). It is found that 63 % of engineers encourage using low-cost building materials and of less effect on the environment which at the same time have proved their effectiveness and durability, while 20 % of them believe that this will sometimes be according to the requirements of the project (Fig. 15). Minimization of cost is one of the most important goals sought by the client, but the problem arises in the lack of awareness of the landlord and his information about these options, which enable him to minimize the cost, so intensive efforts should be exerted to enlighten and inform the landlord about these options (Fig. 16).

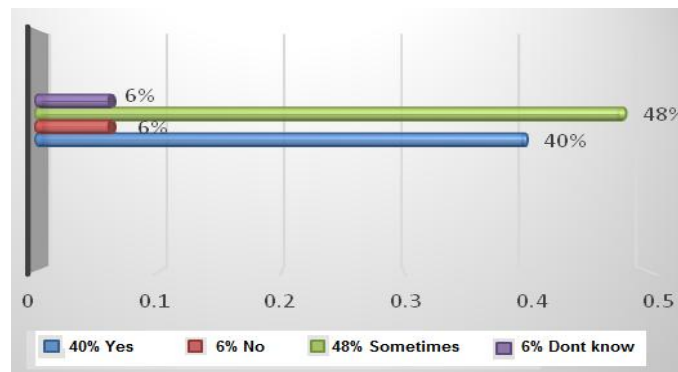


Fig. 13: Result of question - Does the use of smart solutions minimize the cost?

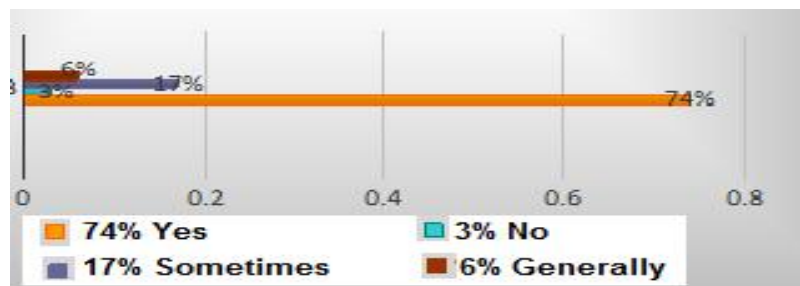


Fig. 14: Result of question - As a client, do you prefer using non-traditional methods in construction to minimize the cost?

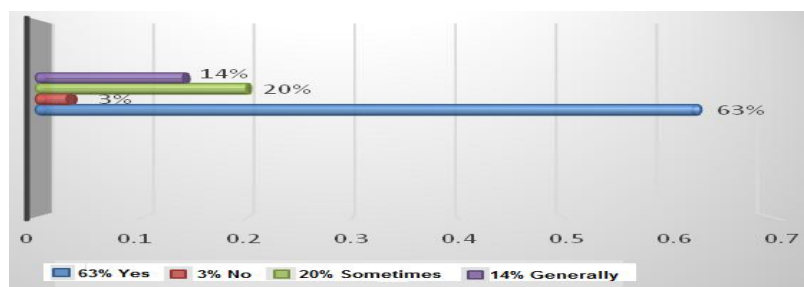


Fig. 15: Result of question - As an engineer, do you encourage the use of low-cost building materials in your design?

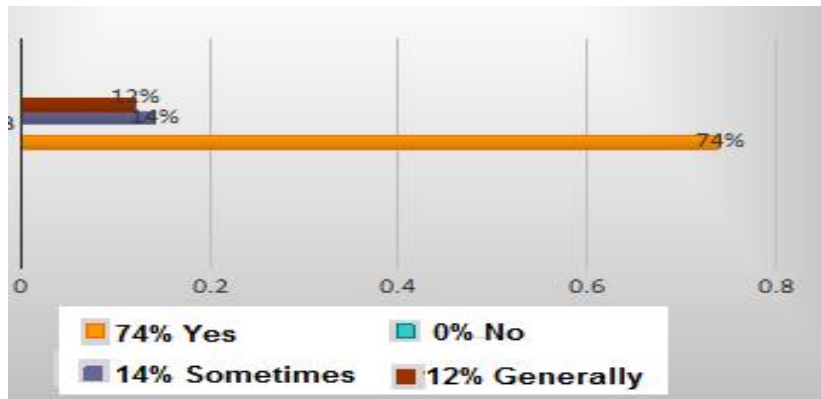


Fig. 16: Result of question - It is necessary to enlighten the landlord about the smart solutions that can reduce the cost of construction?

From section IV, we find that Smart solutions minimize the cost sometimes (and not always) are working on minimization of cost at least on the long run if not on short run. Customers or the landlords are willing to use unconventional methods in the construction. They are ready to try new solutions that lead minimization of the cost. A large proportion of Engineers encourage using low-cost building materials, which are of fewer effects on the environment and at the same time have proved their effectiveness and sustainability in buildings. Efforts must be intensified to enlighten the landlord about the different solutions that reduce the cost of his construction. To reach solutions of low-cost efforts of the landlord, architect and contractor must combine in the project.

• **Section V: Structural solutions**

The questionnaire results of section IV were presented in the Fig. 17, Fig. 18, Fig. 19, Fig. 20, Fig. 21, Fig. 22, Fig. 23, Fig. 24 and Fig. 25. Fig. 17 shows that Errors in the design might be the cause for cracks and collapses of buildings. This assumption has been supported by 23% of persons, while 60 % of them see that this is not always a moratorium on the design, which may be a cause in some cases, while 17 % of them believe that design cannot be the cause of these cracks. There is no doubt that the error in estimating the loads may pose a danger to the building and this was supported by 40% of the subjects, but it is not necessarily to deem it as the main reason for always (Fig. 18). Execution errors pose a major threat to the buildings, and could lead to their downfall according to the opinions of 40 % of subjects, while 60 % of them believe that it depends on the details of the project. It is notable here that all the subjects deem it as a dangerous matter (Fig. 19). Fig.20 shows that We must take into account the surrounding environment during the design, as the design shape, manner of execution and other matters vary from one region to another according to their nature and the variation of environments, and this is the reason why we should pay attention to and take into account during the design to avoid causing danger to the building.

The results ranged (Fig. 21) from support and strong support on the need to take into account the wind loads during the design, especially in higher buildings. Approximately 80% of subjects believe that it is necessary to put the earthquake loads in mind during the design in order to avoid natural disasters that may lead to mass destruction in buildings and cities, so it is easier and good to protect buildings from the beginning before earthquakes occur (Fig. 22). There are many structural solutions (Fig. 23) that increase the effectiveness of the building and allow it to face the difficult natural conditions that surround the buildings, and minimize a lot of maintenance costs in the future. We must draw attention to them. It is necessary to undergo soil examination (Fig. 24) on the plot allocated for the construction of the building so as to know its load ability in order to avoid any problems during execution as per the views of 94 % of the subjects. Different breaks have a great role in the stability of the building and its sustainability, as well as they prevent occurrence of cracks that could lead to its collapse as 94 % of the subjects believe (Fig. 25)

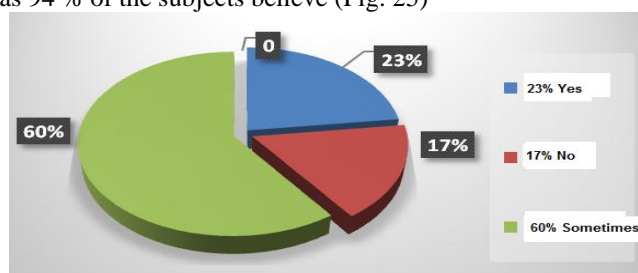


Fig. 17: Result of question - The causes of cracks and collapses of buildings are: Errors in the design?

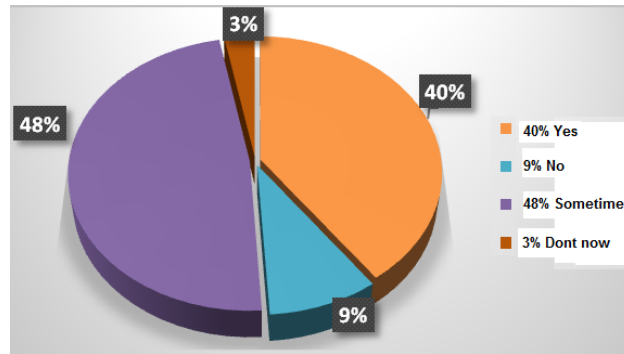


Fig. 18: Result of question - The causes of cracks and collapses of buildings are: Miscalculation of building payloads?

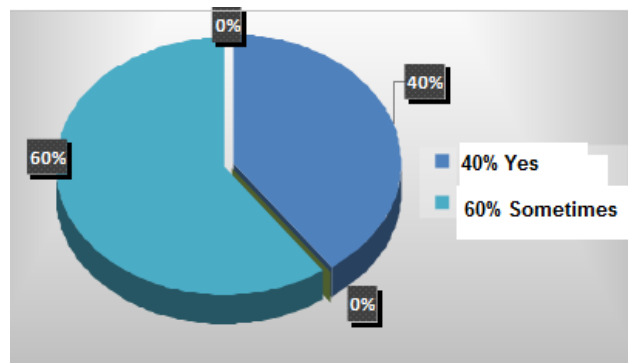


Fig. 19: Result of question - The causes of cracks and collapses of buildings are: Errors in execution?

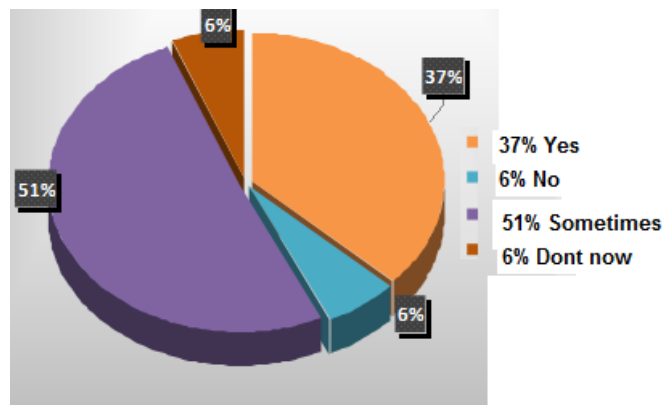


Fig. 20: Result of question - The causes of cracks and collapses of buildings are: Using the same system without taking into account the surrounding environment?

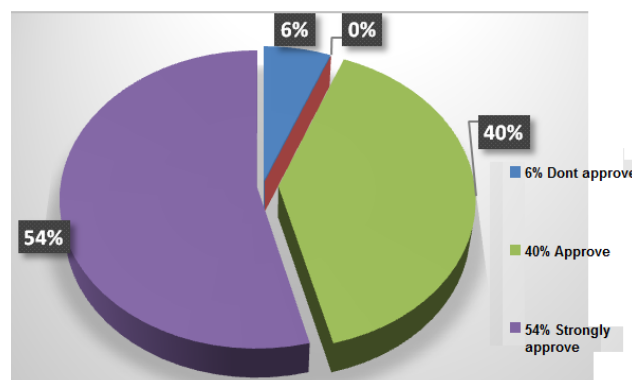


Fig. 21: Result of question - The causes of cracks and collapses of buildings are: Wind loads must be put in mind when you design?

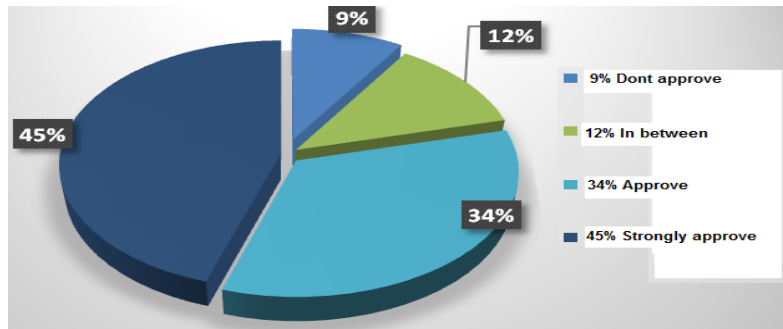


Fig. 22: Result of question - The causes of cracks and collapses of buildings are: Loads of earthquakes must be put in mind when you design?

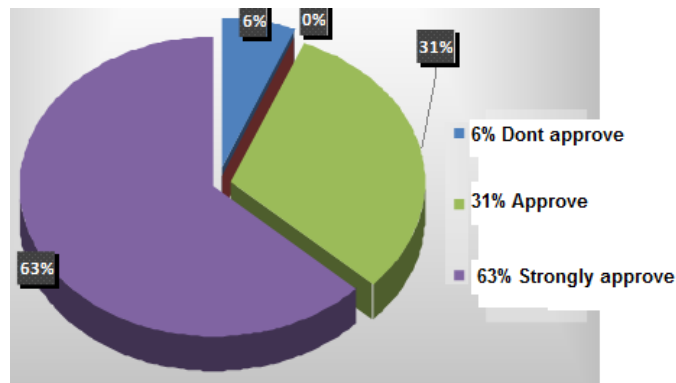


Fig. 23: Result of question - The causes of cracks and collapses of buildings are: Structural solutions may increase the effectiveness of the building and its ability to resist environmental conditions.

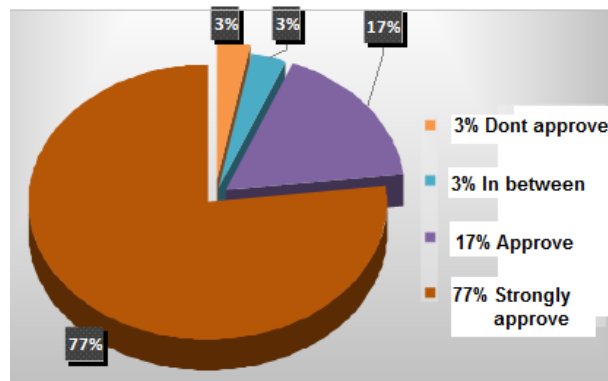


Fig. 24: Result of question - It is necessary to undergo soil examination on the plot allocated for the construction of the building before the execution of construction

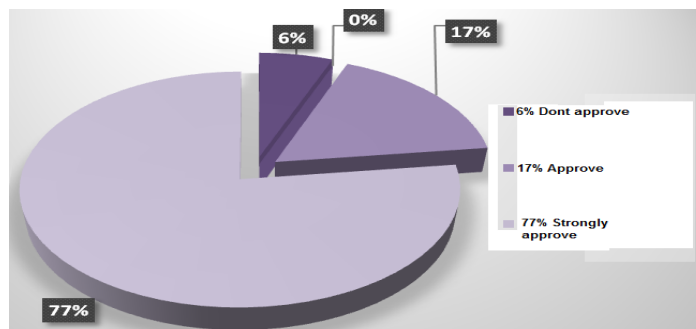


Fig. 25: Result of question - We must put breaks (for expansion - fall – etc..) in mind when we design

From section V, we find that errors in design as well as miscalculation payloads may be the cause of some cases of cracks in buildings, but that does not happen always. Execution errors pose a major threat to

buildings, and could lead to its downfall, so execution must be done according to the set specifications and by proper and allowed ways, and after conducting all the necessary tests. Environment plays a great role in the design shape and manner of its implementation, so we must take into account the surrounding environment during design process. Wind and earthquakes loads must be put in mind during the design, especially for higher buildings in order to avoid any collapses in buildings when exposed to natural conditions. Necessary examinations and tests on the soil must be done to determine its loading ability, and we must also put different breaks / separators in mind when during design and implementation.

• **Section VI: Technological Solutions**

The questionnaire results of section V were presented in the Fig. 26, Fig. 27, Fig. 28 and Fig. 29. Fig. 26 presented that, the technological aspect is certainly one of the aspects of smart solutions, but it does not represent all their concepts as most of the people think that a building can be considered as an intelligent building only if it contains technological solutions, and this misconception became clear in the answers of the subjects which ranged between agreement and disagreement. Fig. 27 presented that, the answers ranged between agreement and disagreement and the largest percentage (42%) agree that building automation should be considered as an intelligent building. Electromagnetic cells operate on a self-generating power to the building, thus saving the consumption of the building. The initial cost may be high, for being a new technology, but they save a lot in future term (Fig. 28). A percentage of 83% of the engineers believe that the use of technological solutions in buildings contributes to creating optimal design that conforms to the requirements of the environment (Fig. 29).

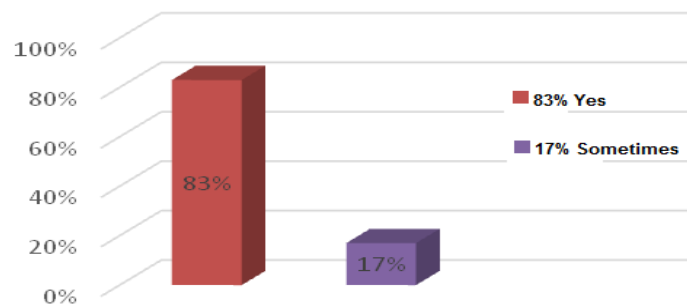


Fig. 26: Result of question - The technological aspects represent all the concepts of smart solutions?

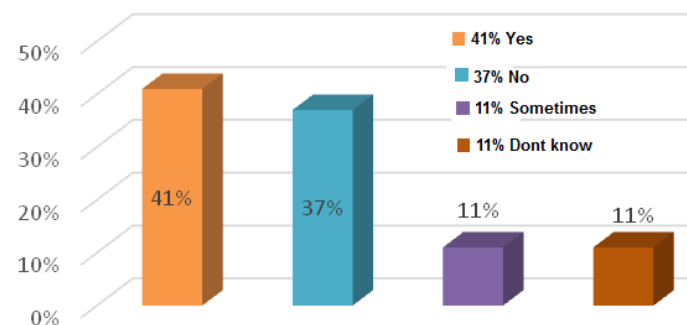


Fig. 27: Result of question - From your point of view the building must automated first in order to consider it as an intelligent building?

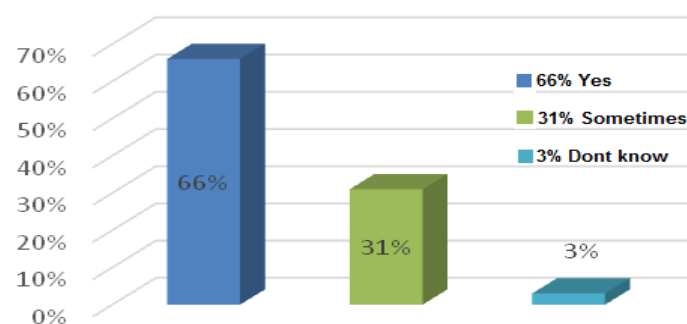


Fig. 28: Result of question - When we install the cells of cellar energy in the building, they save a lot of cost?

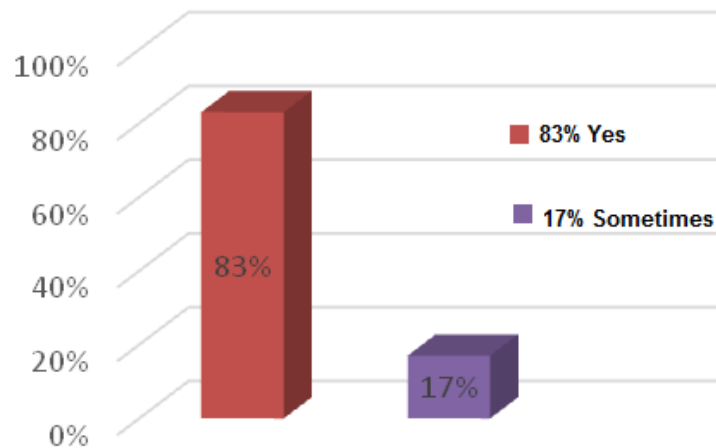


Fig. 29: Result of question - As an engineer, do you encourage the use of technological solutions in the design?

From section VI, we find that most people think that a building can not be regarded as an intelligent building unless it contains technological solutions, and that the building automation must be done in order to consider it as an intelligent building. Power generation cells operate on a self-generating energy for buildings and consequently work on saving energy consumption in buildings. Engineers encourage the use of technological solutions in buildings as they contribute to finding the optimal design that conforms to the requirements of the environment. We must go to the sustainable sources of energy that do not dry up, and build whole cities that rely on electro-cellar cells for power generation.

V. Conclusion

By analyzing the results of the questionnaire, the results of the study are summarized as follows: -

- There is a need in some cases to explain some terminologies which are meant by the various intelligence concepts, as well as there is a confusion between the concept of intelligence and the concept of sustainability.
- There are not enough scientific researches on the issue of intelligence in all its aspects, they are either focus on the technological side only, or just focus on the concepts of sustainability etc.. So there is a considerable need for scientific researches that address all the different aspects of intelligence concepts.
- The scientific courses that interpret the concepts of intelligence, as well as university curricula, need to intensify and highlight these concepts further.
- Negligence to apply sustainability concepts at the moment is largely due to a lack of awareness of the owner, client or the architect of the importance of sustainability, as well as due to the high cost of implementation.
- There is a desire from the client or the owner to use new solutions and different techniques to reduce the cost, but they lack sufficient experience and knowledge that allows him to take such a step.
- There is also a desire among engineers to use smart solutions in their designs if they are given the right opportunity.
- People deal with technological solutions as representing all the concepts of intelligence, and without their existence the building is not considered as intelligent building.

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