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INTELLIGENT BUILDINGS WITH SUSTAINABLE ARCHITECTURE APPROACH

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Abstract. In the last decades buildings and the lifestyles within, have gone through significant changes. Thus nowadays, improvements in technology and its consequences, have had significant impacts on all aspects of human life. Intelligent Building Architecture emerged right after The Industrial revolution, and of course The Modernism; and it could be said that, existence of these kind of buildings is inevitable. There are various methods that could be employed for a building to meet the standards set for sustainable architecture, one of which is taking Intelligent Building Systems into service. Hence, this paper considers "Intelligent Buildings with sustainable architecture Approach". The research method used for this paper is the library research method; by reading books, articles, and journals, the concepts of computerizing, intelligent buildings, sustainable development and architecture are defined. The results of the studies and researches illustrate that proper use of intelligent systems for buildings, can reduce the cost of maintenance, increase efficiency, and energy saving, which, helps to achieve environmental, economic, social, and at last architectural sustainability.

Keywords: Intelligent Buildings, Sustainable Architecture, Computerizing.

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1. INTRODUCTION EXPRESSION ISSUE

Nowadays, intelligent use of information progress, in construction industry, is a determining factor in the evolution of great organizations, business world, and the human life. On the other hand, in today's advanced world, energy problems, and the diminution in the fossil fuels, are one of the biggest issues, which, can cause numerous problems. Given the undeniable role that buildings play in energy consumption and energy waste, the use of new technologies to reduce the consumption of non-renewable energies and save sustainable energy is a major issue that arises in sustainable architecture (Saatchi, 1391).

Intelligent buildings are seeking to create a perfect condition with optimum energy consumption, by employing the latest technologies. These systems monitor various parts of the building and create the right conditions, to provide concurrent services, which, can lead to, the optimization of energy consumption, improvement in efficiency, productivity of devices, value- added, and the facilities in the building. It is obvious that the initial investment used to implement the system, will be returned through the savings resulting from it. In this system the energy will be well spent, and besides protecting the energy produced, saving and efficiency are shown, as well. Control and access to this system by respective software, is easily possible by telephone and the Internet, from anywhere within the building and outside it (Niknami, Ebrahimi, 1386).

Rapid development and prevalence of information and communication technology, has led to emergence of a variety of different fields of using it in all aspects of human life. One of the advantages of this rapid growth of information technology is development of systems that can measure and estimate changes and then react to it. Progress in the field of change management of design practices can improve the physical environment. This development is more noticeable in the workplace. As a result, we are observing tremendous growth in the field of designing buildings that are known as intelligent buildings. In these buildings, the combination of information technology and communication systems, can provide convenience, security, and cause cost and energy saving (Saatchi, 1391).

This rapid development of new technologies, has introduced various fields to human life. By using the achievements of modern technology in residential complexes, office buildings, universities, hotels, and hospitals, a lot of advantages can be taken, by automation of buildings with the approach of sustainable architecture. Intelligent Buildings are a crucial necessity in energy management and also in confining environmental pollution. By implementing these projects, in addition to creating a diverse and beautiful environment, a reduction of energy consumption by 40 percent can be achieved. These buildings by installation of intelligent self-controlling systems such as: lighting, sound, cooling, and heating systems, can provide an environment that is integrally acting intelligent, and is in correlation with other spaces in the building, and can be activated or deactivated in any specified time. Actually, management and building automation systems, have the ability to control all the devices and equipment with modern information and communication technology applications for energy consumption management in integrated system; which, can control all the behavior inside and outside of the building to protect the building and its inhabitants from theft, fire, gas leak, and other incidents that are a result of human or non-human errors. (Kamarposhti, 1390)

According to the matters discussed, the importance of computerizing the buildings has stolen the attention of urban planners and architects through the entire world, thus, the relations between sustainable architecture and intelligent buildings will be vastly discussed.

2. RESEARCH METHOD

Research method used for this paper is Scientific-Revision (Library Research Method). Several sources are used to gather the needed information. Sources used, include: books, articles, scientific journals, and the Internet. The findings of this study can help city management, urban planners, urban designers, and eventually architects.

3. THEORY

3.1. Intelligent Building

Systems available in an intelligent building, provide an efficient and comfortable environment for its inhabitants. These systems are integrated in an intelligent building and put various equipment in communication and correlation with each other. With the help of this system, communications,

paperwork, and building control can be handled by intelligent management, through a comprehensive computer network. Any building that provides a responsive and effective environment, and the economic targets of that building can be achieved through that environment, is an intelligent building. Intelligent buildings combine and coordinate best ideas, materials, systems and technologies. These components combine, to achieve better performance in the building (Motiei, 1386). Some of the goals and benefits of

Computerizing the buildings are: 1. increased comfort and convenience for users, 2. Energy saving 3. Increased security and handling (Nikbakhsh, Abasgholiha & Mahmoudi, 1393).

The buildings are able to respond to circumstances surrounding them, due to an artificial intelligence. Occupancy (presence) sensors, controlling all internal and external building systems, and commute as well, with an emphasis to boost the safety and welfare of residents, are all included. By employing various kinds of sensors in building automation systems, information such as temperature, pressure, humidity, air flow, and oxygen and carbon dioxide content, will permanently be available, and used in order to achieve the ideal conditions. Any building in compliance with mobile computer systems or with the ability of somehow taking control of the software and the hardware in their hands, is defined as an intelligent building (Niknami & Ebrahimi, 1389).

There are various definitions for intelligent buildings, a few of them will be mentioned: an intelligent building is a building that creates an appropriate and also cost saving environment, with optimized use of some basic elements including: structure, systems, services, and their interrelationships. The concept of intelligent building is a kind of seamless exchange of information among different parts of the building. The term "parts of the building" includes all of the components that play a role in building management. These parts are: mechanical and construction facilities, traffic and access control, security systems, management, lighting, maintenance, LAN, and energy management. Atkin (1988) defines an intelligent building as follows: “a building that knows what is happening inside it and outside it, and can decide the most effective way to create the right environment for users on time.” In this definition, in addition to the ability of receiving information as system inputs, and responding to the received information as system outputs, a time factor is also involved. According to the definition of intelligent buildings, presented by the “Energy Efficiency Coordinating Committee” in the United States, these buildings consist of a dynamic and cost saving environment, with the help of integrating major elements such as: systems, structures, services, and correlations between them. Actually it is an intelligent approach of architecture that suggests essential solutions for troubleshooting environmental issues, such as: optimum use of non-renewable energies, and functional use of controlling systems and materials. (Mahan, Ramezani, Veisipur & Khorshidi, 1393).

It should be noted that in a smart modern house, technology is used in order to reduce the risk of electrocution, to increase safety against theft and unauthorized people penetration into the home and security against incidents such as fire, and etc. and to summarize, it is designed in order to increase the safety, security and comfort for people (Jahanbakhsh, 1393). An intelligent building provides an efficient and convenient environment for its residents. These systems are integrated in intelligent buildings, and put various devices in relation and correlation with each other. With the help of this system the responsibilities of communication, paperwork and building control can be passed to intelligent management using a comprehensive computer network (

Motiei, 1386). To build an intelligent building, intelligent materials should be used, which, is a new term for materials that have the ability to understand and also process the circumstances surrounding them, and can respond properly. In other words, these materials are flexible and have the ability to change the shape, form, and color of inner energy, reversibly in response to physical or chemical impacts of environmental (Ritter, 2007).

3.2. Features and benefits of intelligent buildings

Intelligent buildings are equipped with communication facilities that are constantly reacting to the condition changes. In these buildings more efficient use of energy resources is taking place and the comfort and security of its residents are on a higher level. In an intelligent building these benefits are provided through automated control systems such as heating and cooling systems, air conditioning, firefighting, security systems and energy management and lighting. The other advantages of intelligent buildings can be low functional costs in the long run, shorter time for

construction, the ability of evaluation of the building, and more peace of mind and trust given to customers for living in these buildings. Intelligent buildings reduces all costs of repair and maintenance of devices by maximization the automated control, communication and management systems, and in General, with this system, electronic appliances can be remotely controlled from anywhere in the world (Motiei, 2007).

But the most important advantage of computerizing a building can be presented as follows:

1. To increase the welfare of the environment and the building by mechanizing it, 2. Reduction of energy consumption in the building with the optimum utilization of all kinds of energies and prevent the waste of non-renewable resources, 3. A significant reduction in the costs of building charges and maintaining of the building by using the intelligent method of maintenance and repair, 4. To increase the safety and security of the building using continuous surveillance systems and control on all existing systems such as video surveillance, traffic control, and anti-theft systems, fire alarms, and ..., 5. Optimal temperature control, using intelligent control systems of heating and cooling, 6. Lighting control using intelligent measurement and control system of the proper amount of brightness, 7. Remote monitoring and control of the building using various communication facilities (control systems through the Internet, mobile, phone, Wi-Fi,...) 8. The reduction of human resources associated with the repair and maintenance of the building and the prevention of secondary costs resulting from the lack of coordination of various groups, 9. The increase of the useful life of equipment used in the building by optimum and standard use of them (Hamouni, 1392)

Intelligent skin, forms different parts of intelligent buildings, and is referred to as the elements of a building, which forms the whole building. Design and implementation of such skin have the most controller potential of indoor spaces of the building. The controls are in the areas of lighting, heating, cooling, sound and ventilation (Wigginton, 2002).

The only disadvantage of intelligent buildings that is considered in early stages of implementation and installation, is the sizable initial costs, which, is two to four times more than the traditional method, and also installation and commissioning difficulties come to mind (Moghaddasi, Saleh and Salsali, 1393).

4. SUSTAINABLE ARCHITECTURE

Sustainable development is a development that meets and considers the needs of people with respect to the ability of future generations. (The World Commission on Environment and future development, 1981). Sustainable development that was introduced to scientific communities in the 70s, can be considered as a result of the logical growth of modern awareness to international environmental issues, and development, which, was influenced by environmental movements in the 60s, and emergence of some articles and books like the "limitation of growth", and also the first United Nations Conference on environment and development that was held in Stockholm in 1972. Sustainable development; is a qualitative development and the purpose of it, is to raise the quality of life for future generations. Sustainable development has profound themes in three areas: 1. Environmental Sustainability, 2. Economic Sustainability and 3. Social Sustainability (Kayoumarsi & Ahmadi, 1380). Therefore, today's sustainable buildings, shall be responsive to these three main elements of sustainable architecture.

According to Mahmoudi (1388) Sustainable Architecture considers the actual concepts of sustainability and sustainable development goals, to reduce energy waste and environmental pollution in architecture.

According to Mahmoudi (1388), the principles of sustainable architecture include: cognition of location, connection with nature, understanding of natural processes, knowledge and understanding of the environmental impacts and also understanding the people. On the other hand sustainable architecture, the same as the other architecture subjects, has its own principles, and any of which has its own strategies and also considers three steps: 1. Energy saving, 2. Designing to return to the environmental cycles, 3. Designing for people. Understanding and studying these measures, offers a greater understanding of the surrounding environment, to the architect.

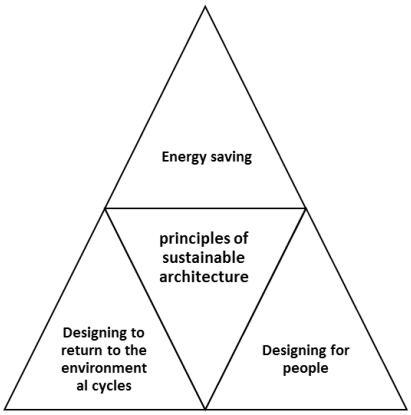

Figure 1. Principles of sustainable architecture

The goals of sustainable architecture consist of: caring about human life and saving it in both the present and the future, using materials that are sustainable and in harmony with their surrounding environment, in all the phases of production, using and even demolition, minimum use of fuel energies and maximum use of natural energies, the least possible damage to the environment, improve the human life and all living creatures physically and psychologically, and harmony with the natural environment. Thus the goals of sustainable architecture are based on the following categories: 1. Environmental, 2. Socio-cultural and 3. Economic (Gorji,1389).

Sustainable architecture is a concept raised from the definition of sustainable development, and is looking to provide convenience and security for its users, by employing computerized technology, and also keeping the wholesomeness and harmony of the environment, at the same time. Sustainability is a concept and a process that can be repeated constantly and be used again as a method. The method in which present and future needs will be satisfied with the help of renewable and sustainable behaviors over time (sustainable vision). Sustainable architecture recognizes that a material goes through what kind of changes in time, if it is destroyed? Or repaired? Sustainability means continuity, movement, and ultimately means the road map to development and storage. It maintains the things that are sustainable. The architecture can be

Used as a process, to stabilize the environment, along with the development of what needs to be sustainable. Sustainability will be achieved in a building when it can cope with the situation. According to Richard Rogers, "buildings are like birds, which cover their feathers in winter and adapt themselves to the new situation of environment and regulate their fuel accordingly". A building compared to other artifacts, has a relatively longer life, equipping or using it again will have a significant impact on sustainable development. A building, is a combined product of materials that are interacting mutually. Buildings have a significant impact on humans and the environment health. According to Frank Lloyd Wright, stability can guarantee the needs of present and future generations. Since the stability of the building is considered as a process, therefore achieving such conditions requires management and also taking the latest technologies into service (Mahmoudi, 1384)

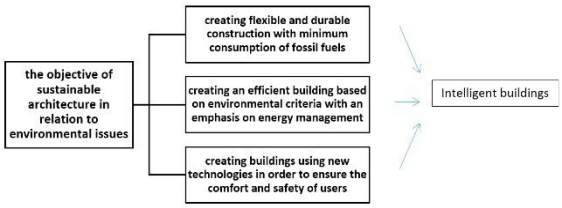

Figure 2. Objectives of sustainable architecture

The main objectives of sustainable architecture are, quality orientation, concentration on the future and focus on the environment (Mahmoudi, 1384).

The main objective of sustainable architecture is also improving the quality of human life. Thus has the least damaging impact and the most appropriate influence on the environment. Sustainability in a space structure reflects the basic sustainability of the building over time. From the perspective of international research organizations (ITCP), principles of sustainable architecture include: reduced energy consumption, designing to return to the cycle of life, and protecting the environment.

5. COMPUTERIZING AND SUSTAINABLE ARCHITECTURE

According to the subjects discussed, and also the definition of intelligent buildings, there are some actions that can be applied in intelligent building system in order to lead the buildings towards the sustainable architecture, and create a sustainable condition in the building, these actions are as follows:

1. Reduce the temperature in the heating system when buildings are empty of inhabitants, 2. Set the internal temperature at the optimum temperature, 3. Intelligent lighting system and the savings gained

from it, 4. Intelligent Systems for canopies and curtains, 5. Intelligent Systems for water consumption, and 6. Computerizing the powerhouse system (Gorji, 1389).

Also with regard to the discussed subjects, the relationship between intelligent buildings and sustainable architecture can be noted as the following:

A) The useful life of a building with continuous and constant maintenance and care will be greatly increased. Also, according to the intelligent management in these buildings; this time period is increased and as a result, replacement of facilities, devices and …, and destruction of the building and also pollution of the environment will decrease.

B) Energy saving and avoiding the consumption of non-renewable energies is the most important advantage that relates intelligent buildings to sustainable architecture.

C) Less water consumption and as a result preventing water waste and pollution of the environment and etc.

D) Respecting and paying attention to human needs and designing for him, is the most important principle of sustainable architecture. Intelligent buildings also act accordingly. They respect human and seek to find and satisfy his needs. In fact, it could be said that the intelligent buildings and sustainable buildings are not different from each other, and can be the basis for the formation of the sustainable architecture and development (Amini and Mehravan, 1393).

6. CASE STUDY

Two of the most successful examples in the field of intelligent buildings with sustainable architecture approach will be discussed in the following:

6.1. German parliament building (Reichstag)

"Norman Foster" is one of the well-known contemporary architects and famous for high-tech architecture. His plan for the reconstruction of the Reichstag (German parliament) in Berlin in 1993, was announced as the winner. In his design, Foster suggested a glass dome to replace the damaged dome of the parliament (in World War II).

Figure 3. Intelligent panels of the German Parliament

German parliament building is an obvious example of intelligent buildings under sustainable architecture approach. The building is an example of using smart windows combined with solar panels. The new dome is interesting from several aspects. First a spiraling ramp on the inside of the dome, leading visitors up to a rooftop terrace with the most amazing view across central Berlin, and also placing them symbolically above the heads of their political representatives.

At night, the dome enlightens through the chamber below, and shines as a radiant dome, it is, which is a symbol of power and ability of democratic process in the federal Germany. In summer, natural ventilation of the Board of Representatives happens through the glass dome. In winter, hot air climbing from the chamber to the space under the dome is recycled and reused. Finally, mirrors in the center of the dome, directs natural sunlight and public's image (the origin of Parliament power) into the chamber of representatives. (Ghobadian, 1389).

Figure 4. The dome of the German Parliament

Other significant cases that have been considered in the design of the reconstruction of the building are as follows:

1. Photovoltaic solar panel with a total area of 300 square meters on the south roof of the building to supply power, 2. Smart windows for ventilation, 3. Using renewable fuel (biogas) to produce electricity without pollution, which prevents spreading 94% of the produced carbon dioxide, 4. Designing a curtain, controlled by computer, right under the glass dome to prevent direct sunlight and its reflection into the chamber below, 5. Saving the extra heat in different parts of the building in a natural reservoir that provides hot water for heating, 6. Saving cold water in the bottom layers of the ground to provide cooling in summer (Ghobadian, 1389).

Figure 5. German Parliament

6.2. Commerzbank office tower Frankfurt

Commerzbank building in 1992, was designed by Norman Foster with the approach of sustainable architecture. The building has 53 floors, and is the first office tower in the world with ecological characteristics. This building used new concepts about the nature of the workplace and new ideas about ecological models and workplace paradigms. The most important feature of this project, is concentration on lighting and natural ventilation, which, is an upside of intelligent management system used in the building. In this building, all individual offices are lit with daylight and are capable of opening and closing windows automatically. According to this situation, controlling the inside characteristics with regard to the outside climate condition will become possible, and leads to energy saving by 50% compared to other typical office buildings. In most times of the year, natural ventilation can be a solution to maintaining a pleasant indoor climate. If air conditioning systems were to be deployed outside, natural aeration and cooling can cause energy savings and provide the necessary comfort (Wigginton, 2002).

Figure 6. The Commerzbank tower

The plan for the tower is triangular and in the corners there are different offices. The center of the tower also has a central open atrium with a height equal to the height of the tower. At different levels for each of the three towers, there is a spiral garden with the height equal to height of four floors, surrounding the building. As a result, only two sides of every story of the tower is dedicated to administrative offices. Socially and visually, the gardens are at the focal point of the offices. In addition, they lead natural light and fresh air into the open atrium. The atrium-like chimneys, have the responsibility of ventilation of the offices (Wigginton, 2002). Existing garden spaces on different floors enhance the natural and humane aspect of the workplace and gives a sense of transparency and brightness to the building from the outside.

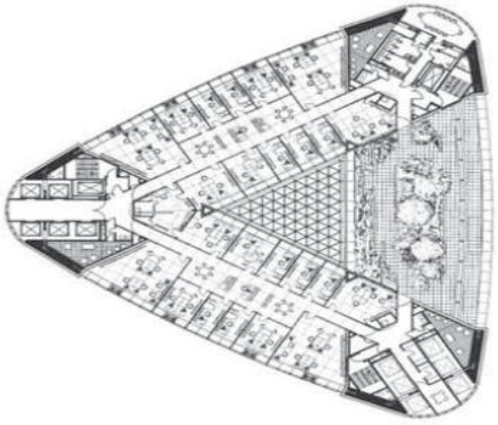

Figure 7. Plan of Commerzbank tower, use of lighting and natural ventilation

Front surface mounting system, includes a space between the two layers of glass fragments insulating shell, inside and outside shell is simple and provides

conditioning facilities and thus protect the building against climate change. On the other hand air enters into the empty space, through the seams embedded in the outer skin. Natural ventilation takes place in offices by panels, which can be opened and closed manually or mechanical. Of course when weather conditions make it impossible to use natural air conditioning, mechanical ventilation system envisaged by the plan will fail, and generally in the winter, the heating subsystem is used with thermostats control. The tower has changed the skyline of Frankfurt on display but at the same time, has maintained its relationship with low-lying tissue of the town. The tower is the center of a city block and is raised high in the sky, adjacent to the main Commerzbank building. Due to the successive reconstructions and restorations, the nature and scale of traditional buildings adjacent to the tower has been preserved. The ground floor of the tower consists of a shop, a parking lot, apartments, and the bank's main hall, which has created a strong relationship with the surrounding environment.

Figure 8. The Commerzbank office tower

7. CONCLUSIONS

The goal of this paper is to dissect intelligent buildings from the point of view of the sustainable architecture approach. The results of this survey illustrate that an intelligent building, is a building with the ability of responding to its users' needs, based on the processed information imported by numerous inputs. Factor of responding in the specified time is crucial. The goals achieved by building an intelligent building, cover almost every aspect of human life. High efficiency, energy saving, entertainment, convenience, cost saving, and increasing the useful life of the building, are all achievements of building an intelligent building. Thus, appropriate use of intelligent buildings leads to cost saving, better maintenance of buildings, and also increasing efficiency, and energy saving. An intelligent building is a building that, provides a dynamic and cost saving environment, by integrating 4 major elements: systems, structure, services, management, and the correlations between them. This integration leads to an increase in the design life of the building, better efficiency, and better use of energies, which, helps to achieve environmental, economic, social, and at last architectural sustainability.

Nowadays' intelligent buildings increase the efficiency, and security, and prevent energy losses. This system is applicable to both old and modern buildings. The elderly and the physically impaired can easily access the facilities. Also, according to the matters discussed before, there are legitimate reasons, not only for buyers, but also for the constructors, for using these intelligent systems. Taking communication and information technology into service, can lead to optimum use of the building, and energy saving, which, in conclusion leads into construction of sustainable buildings. Also, as described in the 5th edition of country's development plan, "achieving advanced technologies, consideration of advanced standards to secure buildings, fortification of structures, and exertion of regional and national indexes of sustainability, should be operated". Thus the act of computerizing with the help of the building's information model in both design and construction phases, gives the possibility of constructing the perfect, fault-free, and sustainable buildings.

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