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Impact of Atrium on the Formation of a Sustainable Architecture

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ABSTRACT

After the energy crisis in the 70s, the sustainable era began in the world which was followed by the rise of three effective areas-social values, environmental resources and design skills- in the field of development. The concept of design skills and technical knowledge was redefined with respect to three major issues of energy, environment and ecology and it was studied through the sustainable development approach in the scale of city to buildings. Today, architecture, as a super system, has taken an important responsibility, because 50% of global energy consumption is spent or wasted in this area. In order to improve the quality of life in sustainable development, architecture should coordinate its elements - as smaller systems- with sustainable development goals in addition to reducing energy consumption and decreasing environmental pollution.

KEYWORDS: sustainable architecture, sustainable development, energy, Atrium

INTRODUCTION

Today, many scholars believe that the sustainable development is not possible without considering the energy consumption and human life environment. Therefore, human activities should be done in association with two issues, namely, environmental resources and design skills according to social values and strengthening human relations.

Accordingly, sustainable architecture is associated with environment, energy and ecology. In such architecture, interior space, as interconnected and integrated components, has its own independent identity; at the same time, it is coordinated with the building form in a holistic process and creates the features of a sustainable architecture. This architecture has the least negative impact on the environment and it has an ecological relationship with it. Therefore, the design of a sustainable architecture is a complex and at the same time programed process. The main goals of this architecture are:

1. Versatile and flexible actions
2. Possibility of maximum use of renewable energy
3. No adverse environmental effects on the living site
4. Designing according to climate
5. Using past experiences and human civilization.
6. Studying native forms in accordance with climate conditions.
7. Improving the quality of life and sense of participation among people.

Background

The purest and most original form of sustainable architecture can be seen in the primitive houses and traditional buildings. The formation of these buildings has been achieved on the basis of materials in the environment, human experience and direct perception of climate conditions and the maximum compatibility with it. Among the most efficient spaces in these buildings is the room with a fenestration in the ceiling or private courtyards (inner) which has existed in its various forms from the ancient Rome to the Far East, especially in Iran and now it is generally known as Atrium in public buildings. Modern architecture has created an extrovert-introvert architectural model through deepening the internal spaces and emphasizing on the transparence of outer surface; and wantedly or unwantedly, it required that the light be brought into the middle of the buildings. Thus, the atria provided the residents with the natural light and a space protected from the wind and rain. They facilitated the access and created beautiful tropical trees and green space. However, considering the comprehensive approach to the issue of sustainable architecture, how these spaces can meet the goals of this architecture?

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1. In order to answer to this question, we should examine and analyze the atrium from the various aspects of a sustainable architecture. These aspects include:
2. How does atrium act in creating a moderate microclimate, providing human welfare and establishing an ecological relationship with the environment?
3. How does atrium create social interactions in the context of a sustainable development, and what role does it play in the relationship between the building and the city?

With regard to the conducted researches on the design of various types of atrium and according to the climatic conditions of the area, various aspects of these spaces have been investigated. Generally, the atria are divided into five different categories, i.e. centralized, integrated, linear, attached, and enclosed, and they are usually introduced under the topic of greenhouses (Figure 1).

Atrium have also been considered in terms of the thermal buffer effect, possibility of energy savings, impact on comfort conditions in adjacent areas, glazing types, the amount of thermal storage and the amount of opaque surfaces inside it, effects of noise reduction or dispersion, the rate of natural lighting and the development of public spaces inside and outside the atrium.

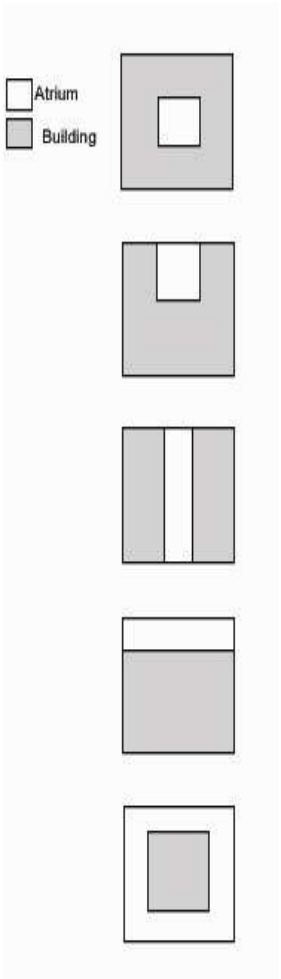

Figure 1. Types of Atrium from top to bottom: centralized, semi-enclosed, linear, attached

Assessment of Atrium performance in terms of saving and the ability of conserving energy

The creation of an atrium in a building, especially with the public and mixed use, could cause saving in four ways:

Atrium as a buffer space, in the form of thermal interface has normally a 15-18 ° C internal temperature. But the temperature of Atrium itself changes with fluctuations in ambient temperature and temporal delay. Adjacent areas to atrium are protected from the drastic changes in environment and this reduces the heat loss resulted from their transparent surfaces. The amount of savings depends on the internal temperature of the atrium, the atrium ventilation and airtighting, coefficients of thermal conductivity of its constituting elements, and amount of surfaces

insulation. It reduces the heating and cooling load of the building through pre-heating or pre-cooling the fresh air. If atrium enjoys heat storage surfaces and also if it is rotated towards the south, it passively uses the solar energy for heating in winter days and cooling in summer nights and consequently, reduces the use of energy. Energy saving in the spaces adjacent to the atrium reduces heating needs. Some atria reduce the heating needs of the building by their mediating affect. But this ability also depends on the internal heat of the atrium. This heat is associated with the following:

The ratio of the outer surface of atrium windows to the walls surface

The amount of heat passing through the wall separating the atrium form the main structure, which is usually determined by the ratio of internal windows surface to the entire wall surface.

Buildings with central or linear atria have better buffering effect on adjacent spaces. On the contrary, semi-enclosed atria create the buffering effect only for a part of the building and add to the beauty of construction. The buffering capability of the attached or enclosed type is potentially high. But they should receive warmer air than the others.

When the glasses are inclined, the rate of heat loss is higher than that of the vertical one, and when the level of walls toward the sun within the atrium increases, heating needs decrease up to 25% and no changes are made in the internal condition of the building. So, the heat absorption in the atrium will be a function of the building ventilation.

The atria will have temperature increase in summer, and this increase in temperature can be reduced with appropriate methods. These methods may include, for example, using a wind catcher, shading of surfaces by trees or suspended plates, or sunshades attached to the atrium structure, ventilation and using thermal mass and radiative cooling.

Energy efficiency and other aspects depend largely on the choice of glazing size in the atrium, because it affects the amount of daylight penetration, thermal loads and thermal stratification. In the case of the BIC building, the atrium functions as a greenhouse in winter and warm air from the atrium is drawn during the daytime to heat the adjacent spaces. The roof glazing transmits approximately 60% of incident solar radiation. The heat loss harness in the atrium through glazing is in accordance with the needs and insulation of the atrium surfaces is done. All spaces are arranged around the atrium and this has made it a functional and visual center. Meanwhile, time, in addition to having the thermal buffering effect on adjacent spaces, it has created a moderate micro-climate in an arid desert environment for human residence (Figure 2).

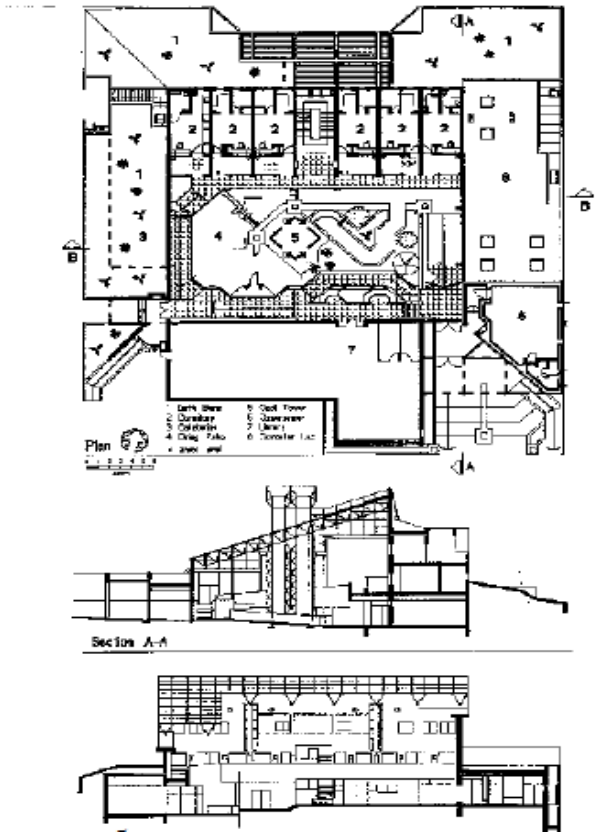

Figure 2. A natural tower cooling in desert conditions

During the winter, all openings are closed and the air inside is heated by the sunlight on floor and walls surfaces so that the floor temperature is 5-15 °C higher than the temperature outside. In winter, the normal temperature during the day is usually 20-25 degrees in the Atrium and it is reduced to 12-15 °C during the night. The difference between highest and lowest temperature in the atrium is 5 °C. Atrium makes more heat in top floors, i.e. the room attached to the top of the atrium has a temperature of 16 degrees; while the unrelated room has had a temperature change from 8 to 18 degrees through ambient temperature fluctuations. Calculations show that only a small amount of energy is needed to create thermal comfort conditions in rooms adjacent to the atrium.

Role of atrium in the development of moderate micro-climate and ecological communication with the environment

Many existing buildings such as offices, hotels, hospitals, and supermarkets benefit from atrium features. The importance of this space is completely clear at least in cold and very warm and tropical climates. In these buildings, atrium not only provides light and fresh air for the functioning, but it is also a space for seating, playing and making dialogue. Below the glass ceiling, many people can do daily activities in unfavorable seasons. In Canada and in the cities of Toronto and Montreal, the atria and underpasses have been very well received. The creation of such conditions in atrium is possible only through controlling it in terms of environment and ecology. This acceptance emphasizes the necessity of designing these spaces in areas with unfavorable weather conditions.

Plants can grow in the atrium, because they are as passive objects; they utilize solar radiation for their growth and don't reflect or radiate it. Plants create a suitable environment for the human by absorbing carbon dioxide from the space, producing oxygen, absorbing water vapor and particles from space by their leaves and shading. When the mean radiant temperature (MRT) is high in the environment, the temperature of the environment will rise according to the following equation:

$T_{env} = 1 / 3DBT + 2 / 3MRT$

Where DBT is dry-bulb temperature and T_{env} is the temperature of the environment. The trees in the atrium reduce this amount by creating shades. The relative effect of trees on temperature conditions of a sample atrium can be shown by drawing psychrometric charts.

Role of Atrium in sustainable architecture through creating internal public spaces

The geometric feature of atrium causes that we consider it as an integrated space. In such a space, beside the ease of access and movement inside the building, the presence of people with be along with mediation, concentration, feeling of solidarity and interaction. When Frank Lloyd Wright designed the Larkin Administration Building, he sought the respect for human values which was to be manifested in the workplace. Although his design was used in flat areas and undesirable arrangement of urban elements, including offices and workshops, he tried to turn the workplace into an internal space so that while preserving company's hierarchy, the members work together and seriously. Creating skylight with atrium space under them, he sought to form a glorious space in which life, work, and art develop alongside each other. Perhaps this feeling was the reason why employees used to stick around for a while when the work was finished.

Atrium is one of the pleasant spaces which students use for conferences and displaying their works informally. Such a space is very suitable for leisure time, friendly conversation and meetings regardless of weather conditions and street noise, along with services such as restaurants and cafes and the use of trees and fountains. Accordingly, atrium makes possible close relationships among people. In educational spaces, it encourages the learning continuation outside the restricted and scheduled classrooms and promotes human activities alongside the social interactions. The public nature of atrium is a context for manifestation of folk art such as music, painting, or setting up festivals and exchanging ideas. Among the famous atrium buildings are the Max Planck Institute in Dresden, Germany and the Hertfordshire College in which the most important aim of using the atrium design was to create a unified identity among scientists and students (Figure 3). Designers used atrium to encourage a sense of synergy and collectivism. Atrium brought together all public spaces, including rooms, laboratories and offices and it has been symbolically placed in the center of the building.

Figure 3. Presence of humans in the atrium -interaction, learning and convergence in the North Hertfordshire College and employees in the Larkin Building

Role of Atrium in the creation of relationship between building and city in the framework of a sustainable architecture

One of the new objectives of architects in the design or development of buildings is the possibility of creating a new relationship between the space within the building and urban space. This will make a convergent relationship between the people inside and the community outside the building. Among these programs is converting museums into public spaces. The atria play the key role in this transformation. By designing the atrium spaces next to museums or roofing the urban squares adjacent to museums, the public spaces would be drawn into museums. This relationship is doubled when the atrium connects the old and new buildings. In this case, the atrium space functions as an interface by establishing the vital relationship between the two buildings and also emphasizes on the old building. The ramp and stair movement within floors starts through this space and it is made possible to create a sense of three-dimensional space. Although the rate of direct airflow and lighting received from the windows of buildings is reduced compared to before through creating the atrium space between the two buildings, the proper and uniform distribution of temperature, humidity and ventilation in all rooms overlooking the atrium will result in public satisfaction. The relationship of politicians, planners, scientists and students with the society is among its achievements. For example, the main purpose of designing a new laboratory at the University of Georgetown was creating a close relationship between scientists and people. By designing a restaurant in the atrium and turning it into the public space, people have the possibility of meeting the scientists.

In another example, LSE New Academic Building designed by Nicholas Grimshaw, the atrium is a central space to which are connected all entry paths and it is a key place for finding directions, the visual connection throughout the building and visitors reception center. The design of this building which is based on the active and passive development of space in the form of a linear sequence has the feature of being dynamically connected to active areas such as atrium and the square in front of the building. The place where visual connections are formed and public movements are intertwined is the same place where the public and social space is centered. This is

exactly where you can understand the life of a building and actively participate in it. The atrium is an internal plaza which is terraced and a more private space for café and the seating for the people is placed next to it.

Conclusion

The lack of flexibility of modern buildings in the twentieth century to environmental conditions and reliance on the use of technology and non-renewable energy for providing the heating and cooling needs, have caused serious problems for the life on planet earth and the cycles in the ecosystem. In this respect, changing the attitude towards human activities and development in order to control and compensate for the losses incurred in all areas, coordinately and sustainably, is emphasized by planners, policy-makers and international organizations. Thereupon, the approach of architecture design in a sustainable development and unity of building components as a system related to the environment is very important. In this regard, the atrium, the central skylight, as one of the best and most identity-giving spaces used in the past, especially in modern architecture, can be considered and used as a symbol of sustainable architecture beyond the role of providing lighting and internal access.

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