Establishment of Modern “Atrium” Buildings as a Model for Sustainable Energy Efficient Architecture

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Abstract

Introduction. Atrium communication spaces combine together separate functional spatial volumes to form a complete working structure. Covered communication spaces play a principal key role in improving and optimizing the bioenvironment for performing the fundamental human activities.

Analysis of the problems in the design of “atrium” building structures. Urban architectural spatial structures initially occur in regions with favorable climate – the Mediterranean Region. Climate conditions in the established public spaces - streets, squares, Agora did not differ significantly from the climate comfort in private living spaces. The same urban communicational model is applied later in areas where natural conditions are very unfavorable for performance of outdoor public functions - even impossible. The first covered public spaces are built in areas with extreme climatic characteristics. Communication atrium spaces develop progressively based on the following factors:

1. Historically determined urban structure of European cities with neighborhood block buildings.
3. Tendency to build a modern energy-efficient built environment.

Conclusion. With the building of the historically determined “atrium” area in Ancient Rome, the atrium space appears as a general spatial architectural element to overcome society’s dependence on external social and natural climate factors. Contemporary “atrium” communicational spaces are a sustainable spatial model for building a functional and energy efficient architectural environment.

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1. Introduction

Atrium communication spaces combine together separate functional spatial volumes to form a complete working structure. Covered communication spaces play a principal key role in improving and optimizing the bioenvironment for performing the fundamental human activities.

2. “Atrium” as the spatial unifying core in overall architectural composition of all large-area buildings and dense urban building structures

"Atrium" communication spaces not only unite in a comprehensive working structure separate functional spatial volume elements, but play a key role in improving and optimizing the bio environment for the execution of the basic human activities.

Ever since the "atrium" space was historically determined in Ancient Rome, the atrium is seen as a general spatial architectural element, which is meant to overcome society’s dependence on external natural climatic factors (Figure 1).

The big height of the atrium – 12/15 m retain heat only in the upper air layers, creating heat air ‘pillow’ equally useful in hot and cold weather.

The interior spaces of large-area building volumes are illuminated through an opening in the roof while using the reflected light from the water mirror, located in the middle of the atrium space.

Since the creation of the drainage system "compluvium" – "impluvium" a regulation of the humidity in the building volume is achieved.

The "atrium" space is an example of creating a model for sustainable energy efficient architecture.
3. Energy efficiency of contemporary “atrium” public buildings

The energy efficiency of atrium buildings is determined by the balance between the following factors determining the quality of the microclimate in the living environment.

3.1. Elements of energy efficient architecture

1. Natural lighting of the atrium buildings in minimizing heat loss;
2. Heating and cooling atrium buildings with minimal energy consumption and utilization of solar radiation;
3. Ventilation based on the natural convection of air flows;
4. Use of renewable energy sources complementary to conventional energy carriers.

3.2. Advantages of “atrium” buildings over traditional building structures in terms of their architectural and energy sustainability

1. Increase of natural lighting without increasing heat loss and overheating, which is characteristic of traditional building facilities;
2. Reduction of the heat losses by using double-glazing of the atrium as additional fencing;
3. Improvement of the heating and ventilation of the building through appropriate volumetric design solutions of the atrium space. Shape and orientation of the atrium space contribute to keeping inside the solar heat, or as a passive measure of overheating.

3.3. Factors that determine the initial parameters for the design of “atrium” buildings

Observing the energy expediency of construction of atrium buildings, we are confronted with two functional problems:

1. Protection from external adverse effects;
2. Economic expediency.

The level of comfort of the living environment depends on the energy loss of the facility. Losses are divided into expenses during the construction and operational costs.

Atrium buildings are strategic model to reduce energy losses and increase the comfort of the public built environment.

4. Regional, climatic and urban factors

4.1. Cities arise in areas with favourable climate – the Mediterranean. Climatic conditions in the created public spaces – streets, squares, agora – do not differ significantly from climate comfort in private living spaces

The same town-planning model is applied later in areas, where natural conditions are much more adverse for carrying out the public functions outdoors - even impossible.

Architect B. Fuller compares traditional town planning with the engine radiator with internal combustion - a huge surface divided in individual cells through which heat shall be conducted faster in space. It is a fact that
the first fully covered public spaces appear in areas with extreme climatic characteristics – Minneapolis, Atlanta, Houston (USA), and the Northern European Scandinavian countries.

Studies carried out in 1980 of Heysting and Rubens for glazed passages (covered streets), unequivocally prove the energy efficiency of "atrium" spaces. The glazed coatings of streets (passages) decrease by 57% heat loss in the buildings adjacent to them. The glass coatings allow penetration of natural solar radiation on the facades of buildings, streets and squares. In the same time, the heat loss from the surrounding structures is reduced. During the summer, months these coatings overshadow the internal walls while open air "hatches" ensure the necessary air exchange.

In the 80s is created the scientific model of "buffer" space (intermediate space) based on architectural practice - "arcades", "passages", "galleries", "atrium". The covered "intermediate" public space protects the enclosing structures of private building structures from the direct influence of the environment - sun, wind, rain.

4.2. Economic factors for the application of indoor public spaces

The factors determining the economic efficiency of an architectural object is the balance between the expended material and energy resources during construction and reducing the operating costs of non-renewable energy sources. The main criterion is the time to recoup the initial investment, after which one would really begin to consider the economic impact of implementing "atriums" - covered public spaces.

The use of glazed public spaces - "gallery" or "atrium" - reduce the costs of heating or cooling the adjacent functional structures. "Buffer" space is a key component of the "passive" energy efficient architecture.

5. Construction factors to reduce energy costs through the use of the architectural model of the "atrium space"

(1) The application of covering public spaces - streets and squares, combines in a single volume entire urban structures - neighbourhoods. This construction process leads to a reduced external facade of the building volumetric surface that is exposed to direct impact of external climatic conditions. Smaller surface, less heat losses;

(2) The application of glazed atrium spaces reduces costs for heat insulation and waterproofing of internal facade walls;

(3) Energy efficiency of the "atrium" spaces is economically justified only when using unheated "buffer" areas. In many countries there has been introduced a normative basis for the use of unheated public spaces. It is normal in the cafeteria, located in glazed passage visitors to wear outdoor coats, but comfort of well-being is significantly better than in the open streets and squares;

(4) In cases where public activity requires optimal climatic conditions, the application of the atrium is energetically unjustified. In these cases, the atrium space has only an organizational function and an emotional aesthetic role;

(5) The use of patios – "atriums" for natural lighting of large-area buildings - inevitably leads to cost savings for the lighting of the working and residential spaces;

(6) Models of "buffer" spaces and their specific application in architectural practice.

In 1980, arch. Terry Farrell and eng. Rolf Lebens formulate the basic principles for the effective use of "glazed buffer" space.

- Solar energy is accumulated in the "atrium" space and is used for heating and natural ventilation.
- Intermediate "buffer" spaces are oriented north-south along the length of the building structure.
- The north side of the building is dug into a terrain sloping to the south or could be protected through a shaft and high vegetation.
- The east and west side of the facade are protected with open arcades (sunscreen devices).

Based on these principles are designed and constructed many innovative projects (Figure 2-8).

6. Shape and orientation of the "atrium" space

6.1. Location and orientation of the "atrium" space depending on the need for heating or cooling of the internal spaces inside the building volume

For all geographic latitudes, the sunlight enters from above and therefore "upper" lighting of the atrium area is the most appropriate.
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The use of solar energy for heating of buildings is the most effective when sunlight penetration occurs from above (through the glass roof covering), although there is a risk of overheating in the summer months for our geographic latitude (Bulgaria).

From constructional and operational perspective, sunscreen devices (blinds) are implemented and are much more effective when placed on a horizontal surface.
In areas with cool (cold) climate it is appropriate to use peripheral glazing on the south (towards the equator) in order to benefit from the rays of the sun inferior to azimuth.

Western and eastern glazed surfaces of atriums are recommended only when directed towards remarkable natural and architectural (urban) views or representative urban axes and squares.

6.2. Definition of the shape of the “atrium” space

Urban-determined environment and real parameters of the construction site – absolute dimensions and configuration:

- It is used in buildings with a great depth - more than 60 meters.
- The type of the covered glazed space is determined by the geometric dimensions of the site. Different configuration requires the use of different types "atrium" spaces.

7. Peripheral atrium spaces – “arcade”. Peripheral communication spaces

Figure 7. SANAA, 21st Century Museum of Contemporary Art, Kanazawa

Figure 8. SANAA, Rolex Learning Center

Figure 9. Parthenon, Athens/ St.Peter square, Rome/ Mondadori, Milano/ Beaubourg, Paris/ Cartier Foundation, Paris/ Olimpic Center, Athens
8. “Passing-through” atrium spaces – “passages”.
Linear communication spaces – “galleries”
Centripetal communication spaces

Figure 16. Passage ‘Petrovski’, Moscow

Figure 17. Architect Cesar Pelli, New York

Figure 18. Architect Massimiliano Fuksas, Milano

Figure 19: House of the Faun

Figure 20. Villa Rotonda by Palladio

Figure 21. Architect Helmut Jahn, City Hall in Chicago

Figure 22. Architect Atanas Vassilev, First Mall of Benghazi
The size of the built area and the need for natural lighting. With normal storey height lighting reaches a maximum of 6-7 m in depth of the premises without the use of reflective systems.

Constructional development of sites with small depth requires the use of simple basic forms of peripheral atrium structures. It is used the principle of "double enclosure" in order to reduce the costs for heating and ventilation ("Ove Arup").

In constructions with a big depth are used "closed" atrium spaces or "passing-through" passages. (Figure. 23, 24).

With the price of land in central urban areas increasing and with the development of building technologies there appears a new building type - "the skyscraper". In contemporary high-rise buildings are applied atrium spaces located on different levels in the building structure. In this way the pattern of "the black box", which defines isolated spaces on each floor, is broken.

Modern high-rise buildings are getting close to the futuristic models of the "Clusters" – urban structures, developing in height. (Figures 25, 26).

10. Conclusion

With the building of the historically determined "atrium" area in Ancient Rome, the atrium space appears as a general spatial architectural element to overcome society's dependence on external social and natural climate factors. Contemporary "atrium" communicational spaces are a sustainable spatial model for building a functional and energy efficient architectural environment.
References


