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GLAZED ATRIA AND PASSAGES

Glass using in roofs and canopies

The beginning of glass using in canopies is found at the end of 18th century in connection with new typological kind of building – commercial passage in Paris. The first passage mentioned in Paris was a Wood Passage at site of royal garden in Paris. This passage was built according to Victor Luis's project by duke Filip Orleans in the year 1790. Provisional wood structure with glazing was situated between low houses, which bordered Wood Passage from the lateral sides. The golden age of passages came with the development of new manufacturing technology of glass and iron. In the year 1798 one of the longest passages was built in Paris - the Cairo Passage named after Napoleon's victory in Cairo. Passages built in the later period took over morphological signs from palace houses, crossings in passages were often covered by great glass domes (Passage Colbert 1826).

Another new typological kind of buildings which used glass in roofing is glass-framed horticultural conservatory. Private orangeries and winter gardens became popular features on the country estates in Britain especially after about 1815, when industrially-produced iron framing became available. At the end of the nineteenth century the most of European cities could boast with great glass plant houses with plenty of exotic plants such as palms in their parks and botanical gardens. Palm House in Kew in Britain was built by Richard Turner in 1845-48 and is famous with sharply ribbed structure and elegance of design.

The development of railway in the nineteenth century roused the birth of another entirely new type of building - railway terminus. The new form of iron and glass shed was given to the new function of railway terminus, which contrasts with form of a head building designed as a palazzo or some other traditional architecture. The first example of railway terminus was Richard Turner and John Locke's Lime Street station in Liverpool (1849 - 50), then in London the King Cross station was built by Lewis Cubitt in 1854. King Cross was

roofed by 2 glazed arches spanning 32 metre and 244 metre of length. The largest spanning terminus structure in history was WH Barlow and RM Ordish's 75 metre wide St. Pancras built in 1868.

Finally there was the exhibition hall or exhibition pavilion represented by Joseph Paxton's Crystal Palace in London (1851) and Palais des Machines in Paris (1889), by Dutert as architect and Contamin, Pierron and Charton as engineers.

Crystal Palace set precedents for many characteristics of new architecture in the next fifty years. The form of building comprised a stepped hall 124,3 m wide in five main bays, the outer bays were built as a single-storey, the intermediate bays as two-storeys and the main central bay was built as three-storeys.

The success of Paxton's design laid in repetition of standard components and careful modular co-ordination, to ensure the successful on-site assembly of factory-made components. The two key dimensions were: the height of 7,3 metre required as an exhibitors bay, and the size of glass pane 1,25 metre.

After the middle of the nineteenth century, cast-iron columns and rough-iron rails used in conjunction with modular glazing, were the standard elements of prefabrication, which had become the new method in erection of the large market buildings, railway stations and industry objects.

GLAZED PASSAGES AND ATRIA

The topic of my thesis are glazed atria and passages, in next part of this work I will concentrate my attention only on these two typological types.

The birth (genesis) of passages as the new typological type can be exactly dated in 1790 in Paris and also their architectonic and functional characteristics can be easily defined. The passage as a new building type was described in Patent Books in Paris in 1786, which prescribed their width, height,

system of columns connected by arcades and required uniform portals.

In the point of the function, passage is a covered way or abbreviation, which protects (shields) pedestrians from external influences, bordered by arcades and providing upper (overhead) daylight.

Passages in Paris became immediately centre of social and commercial life, wanted and popular sites, where various shops, restaurants and coffee-houses were concentrated. The first half of the 19th century can be recorded as a golden age of passages. In the year 1840 more than 100 passages were built in Paris. Apart from commercial functions, passages were often sites, where bookshops together with printing offices were situated. In the next period the most of passages comprised libraries and reading rooms. The requirements of a new hygiene in the cities in Europe in the 19th century were the cause of installation of public washrooms and toilets in many passages.

Passages in European cities were often situated near the important buildings for example railway stations, theatres, opera houses. In passages were often installed last technical inventions - illumination by gas lamps, large size projecting screens, then after discovering of cinema - many cinemas were built as a component of passages in new multipurpose houses.

From 1853 to 1870 was in Paris realised Haussmann Plan, which changed the scale of urban space. Many narrow streets and middle-age blocks were destroyed to empty the space for new wide boulevards, erected according equiangular square grid. In the second half of 19th century the period of decadence of the passages is occurring in Paris, in other European cities the passages achieve success.

At the end of 19th century, in 1890 the passages are built in America, but the scale and style is different in comparison with European passages. First passages were in European cities built in middle-age private houses, (which existed thanks to tolerance of the owners) as the abbreviations across the blocks. The latest passages were built in new multipurpose houses - urban palaces, which contain also apartments, commercial spaces, offices, cinemas or theatres.

GLAZED ATRIA

Atrium as a spatial element we can find in houses in ancient Greece and Rome, then as a part of dwellings in South Europe. It was a closed space from the lateral sides and opened to the sky.

Atrium as a glazed internal space was created in 1905 by Otto Wagner at the Post Office Savings Bank in Vienna. A two-storey hall with glazed roof and glazed walls on the second storey was situated between closed spaces of the post office and provided overhead and lateral light to the office. This type of space - glazed hall found using in post offices and banks at the beginning of 20th century and can be considered as a predecessor of large atria, which were built in the second half of 20th century. Using glazed roof in public building with one function, but not in tenement or not in passages crossings was a new moment and new spatial element in the evolution of modern architecture of 20th century. Thus monofunctional public buildings, hotels and administrative buildings were enriched by a large public space.

The 1950s brought a revival of the atrium initially in North America and than in Europe, what is connected with atria ability of saving energy. Glazed atrium as a space can be used in many types of buildings, banks, offices, apartment houses (tenements), post offices, hospitals, schools, hotels and department stores. Glazed atrium can be created in historical buildings with closed inner courtyard, which may be covered by glazed roof.

In the 19th century indoor climate in halls, passages, conservatories and other roof glazed spaces was maintained by passive means. With the development of air-conditioning many new-built atria were actively ventilated and wasted large quantity of energy. It was proved, that atria do not always reduce energy consumption, but may even increase it. In last years energy-saving potential of atria by passive means became again exploited. It is an incorrect assumption, that atrium which works well at one latitude will always work well at others.

Thermal energy

From the point of thermal energy, atria offer two main energy benefits. Heat losses from

the parent building via the wall separating heated building from atrium are reduced, and it causes that area of glazing on the wall can be increased and day lighting in neighbouring spaces can be improved. Secondly, the atrium offers possibility of providing pre-heated air for mechanical ventilation by windows and diminishes heat losses in parent building. The heat absorbed by massive elements (walls, flooring) during the day causes a greater temperature difference between the atrium and cool night air. In winter the heat emitted from walls and flooring is considered as heat gain. In the summer the air in atrium must be cooled by ventilation or by providing large openings at the ground level.

Ventilation

The last trend by ventilation design in atria in Europe, mainly in Germany is using natural ventilation. In this case the atrium must be provided by large openings at ground level and also openings in roof level. The atrium can be used to provide stack-effect for itself or for the parent building. The stack-effect in atria works well, when the average temperature of the air in the stack is greater than the external air temperature. The flow of air through the opening is roughly proportional to the area of the opening, the air change rate for the tall atria is less than for short atria, although the volumetric flow is greater.

Ventilation of the adjacent offices through atrium can be provided by simply opening windows. Make-up air for mechanical ventilation systems or for natural ventilation drawn through the atrium will collect heat on this way, that causes cooling of atrium in winter and overheating of the offices in summer.

The large atrium volume acts as reservoir of fresh air, refreshed by infiltration over 24 hour period and sometimes by help of vegetation.

Day lighting in atria

The atrium can make a very significant contribution to energy savings in the parent building by providing a source of natural light. Both electricity consumption and cooling loads can be reduced. Access of the daylight to the offices in the psychological point is very important. Usually offices or other spaces

requiring daylight receive light direct from the sky, in the case of the atrium the brightness of the sky is reduced by the absorption of the glass, by the support structure and by fractions of the fixed shading. The amount of the light from the sky in atrium depends on the shape of the atrium and on using high transmitting glass on the roof. The reflected light in the atrium depends on using of the highly reflected finishes on the atrium walls and floor. However as the building height increases the distribution of the daylight becomes more dependent on internal reflections.

Roof glazing

The optical properties of the glazing materials have an influence on the day lighting quality and lighting savings.

Transparent, clear glazing materials transmit the most of daylight and provide the most natural view on the sky. These materials admit the strong direct beams of sunlight to the atrium. Sunlight beams can be blocked, redirected or diffused by interior objects (shades, structural members). Translucent glazing materials diffuse the sunlight and do not allow a direct view of the sky.

To reduce condensation in atria the double glazing is recommended. The lower pane of the roof glazing must be laminated as safety glass. Glazing to adjacent spaces must have high light transmittance, if building and fire regulations permit, single glazing can be used.

Sunlight in atria

Sunlight in atria can cause glare, either directly or by reflection. In this case shading in atria is requested. Roof shading devices may be movable or fixed. Movable shading devices are flexible for seasonal or daily variations, fixed shading is cheaper.

There are two main categories of shading :

- Diffusing shading which intercepts direct sunlight and creates a bright diffuse sky.
- Redirectional shading which consists of reflectors, mirrors, prismatic and hydrographical structures.

Sunlight diffusing can be achieved by using fabrics. They can be designed as horizontal shades, or they may follow the slope of the roofing. Light directing elements such as

mirrors or reflectors are fixed shades and reduce the light-admitting area. Prismatic structures are very expensive and cause that the direct view through glass to the sky is not possible.

Heating in atria

In spite of the success of a non-heated atrium, there are many examples of legitimated needs for heated or partially heated atria. It can set, when the space of atria is used as a temporary meeting area, reception area, exhibition or cafe. Heating in atria must be projected purposefully, to avoid large energy costs and without negating the principles of the atrium climate.

The main rules which will reduce the need for heating are:

1. Free heat gains as solar gains stored in massive elements, exhaust warm air from parent building must be used as much as possible.
2. Movable shading devices can be used as insulation during the night.
3. Warm air heating is not recommended, because heat is moving from the occupants to the high level.
4. Heat must be applied to the occupants or plants by using directional radiant sources or under floor heating.
5. The choice of plants for atrium is very important. In atrium the plants must tolerate low temperatures, because they occupy the building 24 hours a day.

Structure and support system of roofing

Roofing in atria and passages is created in both cases by overhead glazing. The glass roof consists of support structure and of the plain of glazing. The support structure can be created by grid trusses laid on support walls in certain modular step. Grid trusses are made mainly from steel, sometimes from wood. Seldom reinforced concrete trusses are used. By spanning of the large areas without columns the space grid structure may be used. The support structure is usually situated under the plain of glazing, so the glazing is laid on support structure. In some cases the glazing is hung on support structure by steel cables, the structure is over the glazing.

The support structure should not diminish the area of glazing. Ian Ritchie Architects suggest that the structural silhouette should cover no more than 15 per cent of the field of view by looking perpendicularly through glazing. [1]

According to Peter Rice and Hugh Dutton's book *Structural Glass* [1], the overall roof system by glass canopy must be rigorously divided into a hierarchy of three separate layers based on structural logic. The first layer is created by large-diameter members carrying heavy loads over a long span. The second layer is presented (represented) by the slender members supporting small well-defined segments of canopy. The third separated layer is a glass shell with its support points. The main reason of the consequent separating of the layers is the requirement not to carry over the movement from the support system to the plane of the glazing. While in the support system the movement rises in the plain, the glass shell must be purposed to carry over the movement in three dimensions (in the plane of glazing and also perpendicular to this plane).

Comparing atria and passages

The atrium or hall is the space which is closed and has usually only one entrance and is accessed only for certain set of people. The atrium can be described as type of space, which is closed from the sides and glazed in upper level and is a component of some type of building with definite function. The atrium is put into a one-function building with the aim of the revival the space.

The passage is opened for wide public and has minimum two or more entrances. It is typological type, which is connected with commercial function.

While in atria built in last 20 years, the great stress was laid on energy saving, in commercial passages these principles cannot be applied. Commercial spaces have no demands on daylighting; ventilation by windows is impossible and also is not sufficient in the point of air exchange and fire safety. Commercial spaces and passages connected with them must be air conditioned, if the overhead glazing is used, the glass must be translucent, but not transparent.

Conclusion

The aim of my thesis is to concentrate the knowledge and experiences of the realisations of atria and passages in the world and in our country. In my thesis I want determine the main principles of proposing and projecting of the atria and passages for students of architecture. The principles will contain requirements laid on proposing these spaces by Slovak Technical Norms.

Ecological aspect

The central Europe has passed through very hot periods but also very rainy periods in summer months in the last years. During these periods the two last erected commercial centres with covered passages Polus City Center and Aupark in Bratislava were the most wanted spaces for shopping, culture and fitness. Many people gave priority to make shopping in air-conditioned covered spaces than in usual shops accessed from hot or rainy street.

In connection with global warming of the atmosphere these spaces could probably be the solution of the new climatic situation and also challenge for architects, planners and investors.

References:

1. Vandenberg M.: Glass Canopies, Academy Editions a division of John Wiley & Sons, Great Britain 1997
2. Wiggington, M.: Glass in Architecture, Paidon Press Ltd, London 1996
3. Brožová, M.: Pasáže – prchavý sen o městském ráji, p. 38 – 40, Architekt 2/99
4. Hart, S.: A Brilliant Shell Game at the British Museum, p. 149 – 154, Architectural Record 03.01