

The evolution of the ceiling in architecture

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Abstract – *The evolution of the ceiling, vault, as an important element of forming the interior space of architectural buildings is highlighted. The form, structure, materials and aesthetic factors in the building history of mankind are analyzed. The changes in the formation of the ceiling, the principles of the application of polychrome (e.g. vaults) was discussed in detail. Examples of modern types of ceilings, such as geo-grating, ceilings made of red shoe laces, modern interpretation of the vault – stretch ceilings, etc., which today are extremely important for interior design of buildings, are given.*

Keywords – ceiling, vaults of the building, art aesthetics, interior design.

I. Introduction

From the beginning of their existence, the primitive men tried to protect himself from adverse weather conditions, other dangers, creating a comfortable environment, optimal for existence (Fig. 1). Thus, the fencing structures of the primitive dwellings, horizontal ceilings, primitive roofs had to protect dwellings from rain (Fig. 2).

The stand-beam system was preceded by the complicated structures of the overlay, and is based on the use of trunks of trees as the main building material.

So ceiling began to form – horizontal fencing of the building or structure that receives and transfers the load to the supporting walls or columns [1, 7].



Fig.1. Painting on the rock of the Paleolithic era [16]



Fig.2. Trypillian housing [16]

Despite the fact that stone blocks and bricks soon replaced wood, the stand-beam system remained the main principle of construction in the Ancient World – in the architecture of Ancient Egypt and Ancient Greece (Fig.3- 6). The painting on the ceilings of primitive dwellings originates from the Paleolithic Age (Fig.1). Ceilings of caves, flat horizontal wooden ceilings of the buildings with polychrome, fragments of the ceilings of Herculaneum buildings, Pompey, beams of Hypostyle hall of Egyptian temples with an illusion of a starry sky, bright polychrome of the Greek temples' gates – all of these topics require a separate study.

The situation changed only with the invention of the Roman concrete, when people started using it for the construction of the vaults. In architecture, this is the type of ceiling or covering space, limited by walls, beams or pillars – the structure that is formed by sloping surfaces (rectilinear or curvilinear).



Fig.3. Gery II Temple in Paestum [16]



Fig.4. Temple of Bel [16]



Fig.5. Treasury of Atreus, Mycenaea, Greece [16]



Fig.6. Treasury of Atreus, Mycenaea, Greece, interior [16]

Vaults allow to cover large areas without any columns in between and are used primarily in the round, polygonal or elliptical rooms. The structures of the vaults, that is, the arched-dome floor system, was the next step in the development of architecture. The development of science in our time allows us to calculate more complex curvilinear constructions [6].

II. The evolution of ceiling in architecture

The invention of arches and vaults, built of raw clay brick, was a great achievement. The oldest arches and vaults, are distributed around the Middle East and the Mediterranean (Fig. 4), and originate from the method of masonry with a nap (it is the name of the false vault). This method involves sequentially placing the rows of the bricks horizontally so that each upright row rises above the lower one. In the construction of one of the buildings in Tel-Razuk (Iraq), built around 2900 BC, there are elements that can be called transitional evolutionary forms: the vault, constructed using both the stepped and oblique masonry [1].

None of these vaults survived, but the construction of a cane strap that mounted vertically on the ground, bent and bundled at the top (it was the ceiling and the roof), was their prototype.

In ancient Egyptian drawings and in hieroglyphs, there are images of reeded vaults above the temples, huts in the form of boats and other buildings. This method of their construction has been preserved and is now used in southern Iraq, in a swampy area near the confluence of the Tigris and the Euphrates rivers, where the Arabs still build large vaulted cane buildings, the outer surface of which is clad with clay. This type of construction can be attributed, probably, to the transitional stage of the vault evolution.



Fig.7. The Roman Pantheon [16]



Fig.8. The Roman Pantheon, interior [16]



Fig.9. Colosseum, Rome [16]



Fig.10. The Arch of Constantine, Rome [16]



Fig.11. Three stone domes of the Taj Mahal [16]



Fig.12. Sophia Constantinople [16]



Fig.13. Taj Mahal, interior [16]



Fig.14. Sophia Constantinople, interior [16]



Fig.15. Blue Mosque, Istanbul, Turkey [16]



Fig.16. Blue Mosque, Istanbul, Turkey, interior [16]

sand – and it does not get solidified in the kiln, but in the sun, therefore, it is one of the cheapest building materials, and its production is more time-consuming than energy-consuming. In addition, raw brick is the most suitable material for arid areas, where during the day the air temperature varies widely, due to its low thermal conductivity. When the temperature exceeds to 32 °C on a sunny day, the temperature inside the room, built of raw materials is not higher than 27 °C. In a similar building, built of concrete, in which there are no air conditioners, temperature can exceed to 38 °C [5, 8].

Arches first appeared in the II millennium BC in the architecture of the Ancient East, in Ancient Mesopotamia in particular, where the construction of brick buildings has reached a high level. The arches in the architecture of Ancient Rome were also widespread and further used, both in small and in large, even monumental scales (e.g. bridges, aqueducts, triumphal arches, amphitheatres, caissons of temples, the dome of the Pantheon in Rome (Fig. 7, 8) – this is the evolution of the ceiling, the vaults of the interiors of buildings)

Yet the arch was invented not by the ancient Romans, and they did not first combine several arches to get the vaults.

At the time of the completion of the Coliseum, arches (Fig.9, 10) and vaults existed in the Middle East for about 3000 years [7].



Fig.17. Pisa's Cathedral [16]



Fig.18. Amiens Cathedral, France [16]



Fig. 19. Cathedral interior picture. Pisa's Cathedral [16]



Fig.20. Amiens Cathedral, France, interior [16]

After all, most builders in the Middle East abandoned the reed (which people only could gather in marshy areas) and began to use more reliable building material, sun-dried raw brick. Almost all arches that survived in the Middle East are constructed of raw brick or adobe. Even after the burnt brick appeared, the raw materials continued to be the main building material in the Middle East. Thus great vaulted palace complexes of the Middle East arose (Fig.11-16).

The reason for this is clear. The raw bricks are made of the most accessible components – clay, water, straw and

III. Arch – a precondition for the appearance of a vault

Arch (synonyms – bow, arches) (lat. arcus. – arc) – a curvilinear ceiling of a slit in a wall or a space between two supports (columns, pylons), which transfers the load to the basis.

The term is also used for any curved structure shaped like an arch. Arches can be used as a constructive architectural element, for example, above a doorway or gate, or as a decorative element.

The arch is one of the architectural decisions that have been long known to the mankind. Nature itself has created amazing beauty all around us – caves, cave entrances — they all have an arched shape. For people it's only left to observe a little bit and try to translate it into reality. Arches have always been an attribute of an ancient temples, palaces, houses of influential and rich people.

Different variations of arches were used at different times. For example, in the Romanesque style of architecture, the arch was sound and monumental (Fig.17, 19), in the Gothic version – pointed and elaborate (Fig.18, 20), it created the impression of a light temple. With the advancement of the technology of manufacturing monolithic reinforced concrete structures, arches began to be used as supporting bases. [11].

Even Gothic-shaped Florentine dome (Fig. 21, 23) is replaced by a hemisphere, round Renaissance dome (Fig. 22, 24, 25) is replaced by a dynamic baroque ellipse (Fig.26, 27), classical (Fig.29-30) and a semicircular vault is replaced by interesting paintings-deceptions. The Rococo style (Fig.28) brings the themes of Putty, Garlands, and the Modern era brings whole storylines.



Fig.21. Dome of the Florentine's Cathedral, Florence [17]



Fig.22. Dome of the St. Peter's Cathedral, Vatican [17]



Fig.23. The Florentine's Cathedral, Florence, interior [17]



Fig.24. The St. Peter's Cathedral, Vatican, interior [17]



Fig.25. San Lorenzo Church [17]



Fig.26. A dynamic baroque ellipse, dome of church [16]

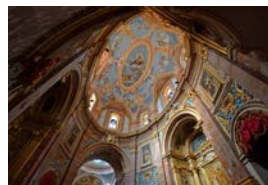


Fig.27. The Carmelite Church in Mdina in Malta [16]



Fig.28. Interior of the Rococo style church [17]



Fig.29. St Paul's Cathedral Church of St Paul the Apostle, London [16]

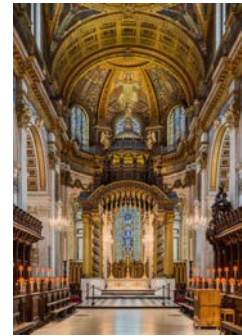


Fig.30. St Paul's Cathedral Church of St Paul the Apostle, London, interior [16]

IV. The vault as a constructive and decorative element of architecture

The vault became a key architectural element back in the Roman period. In its simple form, it consists of two parallel walls, which gradually leaned towards each other, joining at the top of the centre with a central key stone. The vaults were a necessary part of the various large basilicas of the classical architecture (Fig. 31). They flourished in the cathedrals of the Middle Ages, which did not seem to obey the power of earthly gravitation [2, 6].

Unlike a single vault of the basilica, the enormous space of the Gothic cathedral is being covered by a complex network of vaults (Fig.32).

Semi-cylindrical (Fig.35, 36), concave arch is the oldest and the main one. It appeared in the IX. B.C.

The semi-cylindrical vaults are built on the basis of a wooden frame form work, which is taken apart right after the arch's highest point is finished [2].

The buttress has been developed as constructions that convey the weight of the vault to the ground in buildings that did not have massive walls. In the most refined Gothic architecture, the buttresses could even be located separately from the main building. These "flying buttresses" are shown in the Cologne Cathedral (Fig.33, 34).

The shape of these vaults is different: from a simple cross to a complex system of the primary and secondary ribs. One of the most complicated Gothic vaults is the stellar vault (Fig.37). The ribs are in the form of stars, performing mainly decorative function, and are used as an adjunct to design. Together they form a mesh pattern of the vault [1, 3].



Fig.31. Basilica of Sant'Andrea-Mantua [16]



Fig.32. Winchester's Cathedral, England [16]



Fig.39. St. Stephen's Cathedral, Vienna [17]



Fig.40. The main nave of the cathedral in Lincoln [16]



Fig.33. Milan's Cathedral, Italy [16]



Fig. 34. Interior of the Milan Duomo [16]



Fig.35. Alhambra: ruined decorative semi-cylindrical vault [16]



Fig.36. Church of Santa Maria del Naranjo, Spain



Fig.37. Star-shaped vault, Lincoln's Cathedral, England [16]

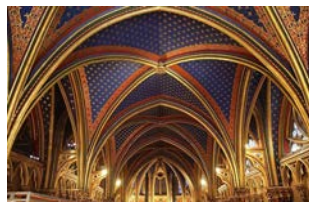


Fig.38. Cruciform vault, Church of Saint-Chapelle, France [16]

The intersections of the ribs, especially located in the center vault section, are often decorated with protruding cast-stone, covered with a beautiful carving.

Stone ribs supported the masonry located between them. Also this place was adorned with the jewellery of the vault.

One of the later variants of the Gothic vault, with pendants, which seem like they hang in the air, but is actually a continuation of the stone vaults of the castle (Fig.39, 40).

When two cylindrical vaults intersect at right angles, they form the protrusions, or ribs, as in the Swedish church of the XI century. In other cases, where these ribs are supported by the stone supports, a cross-vault is formed (Fig.38) [6].

V. Beauty with accuracy up to a millimeter (artistic aesthetics of the ceiling)

The painting on ceilings originate from the Paleolithic era. Rock paintings of various animals, plants and natural phenomena still remain untouched (Fig.1). A huge number of pictures of an extraordinary beauty on the ceilings of buildings were found in the Greek cities of Herculaneum and Pompey.

In the Middle Ages paintings were forgotten. During the Renaissance, many artists began to return to the ideals of antiquity. At that time many temples, basilicas and dwellings were decorated with paintings (Fig. 39, 40).



Fig.41. Painting of the Sistine Chapel by Michelangelo, Vatican[16]



Fig.42. Painting of the Charlottenburg's Palace, Germany [16]

Subsequently, each of the new styles contributed to the history: in the lush era large ceilings were combined with the motifs of the ceiling painting, and, thanks to the rococo style, "women's themes" appeared – flowers, angels, garlands (Fig. 41, 42).

During the Enlightenment period, so-called painting-deceptions were enormously popular. Their secret was to depict the reality of fictional volumes and sizes.

The Modern era combined the Western and Oriental traditions into a single entity, so that the ceiling paintings included the whole plot lines, and also got involved with some eastern beliefs [3, 7].

For example, many city residents believed that plot lines from drawings on the walls or on the ceilings could protect the house from evil and misery.

- The artistic aesthetics in the motifs of painting domes and vaults of the Christian temples.

The image of the dome or the main arch is divided into central and peripheral. Among the central images are the Cross, the Monogram of Christ, the Lamb, the theophany composition ("Baptism").

The peripheral part of the dome, which is the entire area of the non central zone of the dome, usually includes the images of the apostles, prophets, forefathers, and in some cases the Heavenly Forces, the Virgin Mary and John the Baptist.



Fig.43. Painting of the Dome of the Pochaev Lavra, Ukraine [16]



Fig.44. The figure of the Holy Virgin Mary is made on the inner surface of the dome of Saint Sophia's Cathedral, Kiev [16]

“The Old Testament series row” of the central zone of the dome may have any topic, such as the theme of the Savior's Pedigree. The inscriptions on the dome's skull may be short texts (Fig. 43, 44) [2].

- Art aesthetics in the motifs of the painting of the dome of the Islamic temple.

Islamic architecture is one of the most complex forms of art based on geometry. Islam forbade the depiction of a person or any other living being, which contributed to the active development of geometric and plant ornamentation.

One of the features of the Arabic decoration is the "carpet" ornamentation, in which the pattern covers the entire surface of the object or the construction on the principle of "horreur vacui" (fear of emptiness).

There are two styles in the Islamic ornament: geometric – hirih and flora – islimi.

Hirih (pers.) is a complex geometric pattern, composed of a stylized rectangular and polygonal shapes (Fig.45, 46).



Fig.45. Girih Tiles and Islamic Geometric Designs in Modern Architecture [16]



Fig.46. Tashkent. Hazrati Imom architectural complex. [16]



Fig.47. Dome of the Islamic temple [16]



Fig.48. Dome of the Persian Temple [16]

Islimi (pers.) is a kind of ornament, built of a combination of a wicker and a spiral (Fig. 47, 48). It embodies the idea of a constantly changing floral ornament and includes an infinite variety of variants. It was widespread in clothing, books, interior mosque, dishes. Most of the time, these styles are used separately, but they can also be combined.[1-8].

VI. The vaults in modern interpretation – stretch ceilings

The history of the stretch ceilings is lost in the depths of centuries. It is known that even in ancient times in Egypt, Greece and Rome a similar method of treatment was used.

Ever since ancient times, it was known that the ideal ceiling (a prototype of a modern stretch ceiling) makes home even more comfortable. Different fabrics were used to create stretch ceilings. In Armenia, cotton was used, flax was used in Egypt and in Rome silk was used to create primitive stretch ceilings. Perfectly even surface of the stretch ceilings were archived by wetting the fabric, which then was stretched over a frame. While drying the fabric shrank. Thus, the first stretch ceilings were made [12]. Over time, these ceilings became obsolete.

In the middle of the twentieth century stretch ceilings began to gain popularity again. As the history was developing, there were even more and more ways of processing the ceiling. So the stretch technologies were forgotten. They haven't been mentioned until the 60s of the XX century. In 1967, in France, an idea to revive the technology of stretch ceilings appeared.



Fig.49. Matte stretch ceiling [16]



Fig.50. Glossy stretch ceiling [16]



Fig.51. Suzeme stretch ceiling [16]



Fig.52. Satin stretch ceiling [16]

In implementing the idea a significant role was played by new materials: a heavy fabric, which quickly loses its appearance has been replaced with lightweight plastic sheet of polyvinyl chloride (PVC). According to some data, stretch ceilings were invented in Sweden, but it was the French who have perfected the technology of making PVC-film, which is why the second name of the stretch PVC ceilings – “French ceilings”. This phrase has become anonymous, and does not speak of the country of the manufacturer any more. As the production of stretch ceilings does not require special licensing, now in many countries stretch ceilings (sometimes of dubious quality) are being mounted, and they are positioned exactly as “French ceilings” [11-14].

The surface of the material does not have to be firm and durable, as in the course of operation practically nothing touches it, but at the same time 20-30 mm of the height of

the room is lost. True, instead we get a clean and beautiful ceiling that does not differ from the traditional one. No wonder similar products – of different sizes, shapes and colours – are now so popular all over the world. Applicable material should be not only clean, durable, light, but also environmentally friendly.

There are also stretch ceilings made of fabric. In 1997, the Swiss company developed a unique technology for the canvas mount. This technology allowed to use lower temperatures. But there was a new problem – the PVC film was not strong enough for a new way of stretching. The solution to the problem turned out to be brilliantly simple – the decision was to return to the origins and to replace the film with a cloth! For 3 years there were experiments, development, searches for a material which will be as good as a PVC-film. Experiments ended with a great success.

In 2000, Europe started using this unique ceiling system. The basis was a wide loom of synthetic fabric. The width of the canvas reached 5 meters, which allowed to solve the problem of seams. With a small mass (canvas density is 240 g / cm), this material is 15-20 times stronger than PVC! The use of strong, light fabrics gave different decorative opportunities such as painting, decorative painting, printing and easy installation. Stretch ceilings can have different texture: matt (Fig. 49); glossy (Fig.50), which allows you to achieve the mirror effect and thereby visually expand the room; marble; suede (Fig. 51); satin (Fig. 52) [12-14].

VII. Ceiling of the present

The construction of arches never completely stopped in the Middle East, and now there is some revival of it. The main figure in this process is the architect Hassan Fathy, whose brilliant and original designs, using vaults constructed by the slanting method, are of great interest and have some followers, both in his own country and in other countries (Fig.53, 54). With the discovery of the merits of raw brick by the modern world, that understands the acuteness of energy problems, the practical significance of arches and vaults is becoming more and more obvious. Arches and vaults of raw brick are not only practical but also very beautiful.



Fig.53. Hassan Fathy, private house project [16]

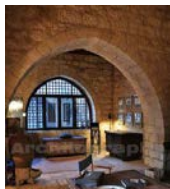


Fig.54. Hassan Fathy, private house project, interior [16]

In the “visual” world, rectangular and square shapes dominate. They allow the architect to reduce the sharpness and monotony of a straight line, and instead use the curves (the most common form in nature) – in almost unlimited number of variations [15].

In the XX century, a lot of great successes appeared in the construction made of reinforced concrete. A great

variety of shell designs appeared and hyperbolic paraboloids were better understood, which allowed to create a very thin, durable structures.

A great example is a cloud-ceiling made of geogrid “Paritzki & Liani Architects” for an office PRS in Tel Aviv, Israel (Fig.55) – it is an environmentally friendly geosynthetic material, which has a cellular shape and wide range of polygons. Geogrids are commonly used to reinforce retaining walls, as well as subbases or subsoils below roads or structures [14].

The ceiling, resembling honey comb at the hairdresser Les Dada East by Joshua Florquin in Paris, France (Fig.56) – The ceiling in Hairdresser’s Les Dada East is decorated with wooden hexagons. Hairdresser’s is located on the first floor of a building, built at the end of the 19th century in Paris. A founder of this place – Edoardo Shogi (Edoardo Seghi) – prefers natural cosmetics. That belief has also influenced the design of the place. An unusual interior of a barbershop is designed by an architectural company called “Joshua Florquin Architects”. The concept of using only natural ingredients defined the style of the interior, which resembles forest on a sunny day. Thus, the barbershop’s customers will have the opportunity to enjoy the work of a hairdresser, while being surrounded by some stylized trees and the light that penetrates through the “leaves” [14].



Fig.55. Paritzki & Liani Architects, PRS office, Tel Aviv [16]



Fig.56. Joshua Florquin, Hairdresser Les Dada East, Paris [16]



Fig.57. Sawako Kaijima, Singapore’s Research Center [16]



Fig.58. Architectural bureau Atelier Marko Brajovic, Ceiling of red laces in the Camper shoe store, Australia [16]

A Japanese architect Sawako Kaijima (Fig.57), a professor at the Singapore University of Technology and Design, has developed a scattered lighting system for an area of 13x16 meters in a research center in Singapore. The scattered lighting system is mounted on a ceiling at a research center in Singapore. The system contains six thousand polycarbonate illuminating modules with LED bulbs. Each module contains two light-emitting diodes directed to the opposite sides. A system of lenses evenly dissipates light by refracting it. Thus, no object in the room can cast a shadow. Light is simply everywhere [14].

Arches are widespread today, both in architectural design and construction. They are also used for both facades and interior solutions (Fig. 53).

Modern construction materials allow designers to experiment with arches, giving them new additional features and shapes moving further and further away from the classics (Fig.54). Now it is safe to say that arched structures in the present interiors are bold, relevant and fashionable [1-3, 7].



Fig.59. Défense, Technology Center [17]



Fig.60. Museum of American Air Force in Cambridge [17]

VIII. Design of ceilings of the present

It's no secret that today interior design is a very deep and multifaceted process that requires deep knowledge of the capabilities of the latest technology. Nowadays designers can create magnificent works that capture the unique beauty of the images because of that knowledge.

Ceiling design, as well as any other field in design, is easily influenced by trends and peculiarities of each style. The ceiling must remain in harmony with other decorative elements in the interior. And it does not matter in which style design of the ceilings is executed.

Design of the ceilings in the classical style is one of the most interesting directions today (classical style involves using stucco decoration, paintings and massive chandeliers) (Fig. 61).



Fig.61. Design of the ceiling in a classical style [16]



Fig.62. Art Deco, Park lane hotel, London [16]

Design of ceilings in Art Deco style incorporates all of the best features from the previous styles (Fig.62).

Design of the ceilings in the modern style is a field for improvisations and applications of the bold designer's ideas. (Fig.58).

Conclusion

Ceiling had a diverse shape and structure throughout the human history. It was made of different materials: from primitive stand-beam structures to complex spatial vaulted systems.

The semi-cylindrical vaults and cross-vaults of the medieval Romanesque temples were replaced by the flying

buttresses and ribbed vaults of Gothic cathedrals (star-shaped, mesh-shaped, fan-shaped, cross vaults) (Fig. 39, 40), which seemed like they didn't obey the power of gravity.

The return to the ideals of antiquity during the Renaissance contributed to the distribution of polychrome on the vaults of buildings. Even Gothic-shaped Florentine dome (Fig.21) is replaced by a hemisphere, round Renaissance dome (Fig.22) is replaced by a dynamic baroque ellipse (Fig.26,27) and a semicircular vault is replaced by interesting paintings-deceptions. The Rococo style (Fig.28) brings the themes of Putty, Garlands, and the Modern era brings whole storylines.

Christian religion brought about hierarchy of symbolic paintings, religions of Islam perfected the technique of filling the surface of the vaults with geometric and floral ornaments [9, 12].

Thin and strong structures of the ceilings, triple shell of a dome, constructions from reinforced concrete, achievement of mathematical understanding of hyperbolic paraboloids have been replaced by historical analogues in ecostyle: reed, wood, glue, suspended, cassette, rail, hinged ceilings, caisson ceiling, etc. The modern interpretation of the vault is a stretch ceiling, a prototype from the antiquity (velarium of the Coliseum).

So nowadays, design of the ceilings in the modern style is a field for improvisations and applications of the bold designer's ideas.

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