



Some Questions about Structural Schemes of Buildings

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Annotation: Architectural design solves complex problems in which function, construction and art form act as a whole. Sometimes buildings are erected as prefabricated-monolithic, in which case the core of rigidity is performed in monolithic reinforced concrete structures.

Key words: Vaulted, arched, suspended, order, anesthesia-free, frame, columns, diaphragm, monolithic, prefabricated.

Architectural design solves complex problems in which function, construction and art form act as a whole.

Structural scheme of the building called a system of vertical (walls, pillars) and horizontal (floors, coatings) elements that provide the building with spatial rigidity. Structural schemes depend on the type and location of the vertical and horizontal elements of the supporting frame of the building.

Historically, there were three constructive systems (Fig. 1.), Known since ancient times:

- **rack and beam (or frame)**, in which the horizontal element (beam) works in bending;
- **vaulted and arched**, in which the material works in compression, transferring load and dead weight from the upper elements to the lower ones;
- **hanging**, in which the horizontal elements work in tension.

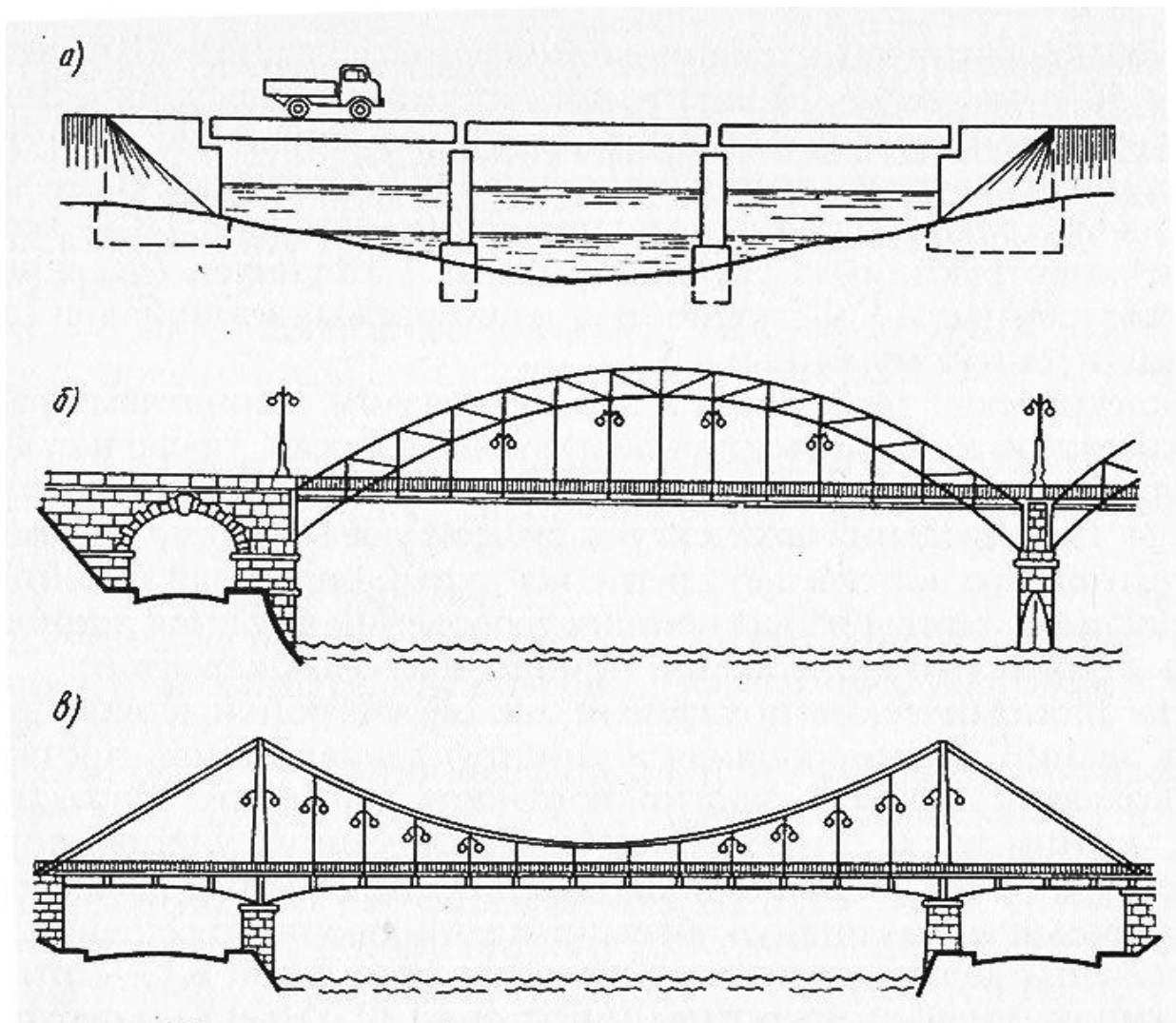
Each system was matched with the most suitable material for it.

Wooden structures were used in the rack-and-beam system: wooden beams that worked well for bending spanned large spans up to 10 m. On the basis of this system, 3 main orders arose in Ancient Greece.

In vaulted and arched structures that arose later, stone became the main material, which worked well in compression, but poorly in bending, providing spans only up to 3.5 m.

The arched system, developed from the frame scheme, can work separately from the wall.

The conjugation of the arch with the masonry of the wall has a semicircular shape (archivolt) or is tied up with the masonry. The heels of the arches rest on pillars through the entablature (impost) or on columns, forming arched colonnades (arcades).



Rice. 1. Traditional structural systems:

a - post-beam, b - vaulted-arched, c - suspended

The corner supports of the arched systems are reinforced with supporting pillars (buttresses). The material for the arch system was first stone and then brick. In ancient times, outstanding arched and domed buildings of large spans were erected from stone.

For example, the diameter of the dome of the Pantheon in Rome is 43.5 m. The use of reinforced concrete facilitates the construction of vaults and domes. The design of thin-walled reinforced concrete shells and their varieties - folded surfaces (folds) have been developed.

After the introduction of metal structures into the architecture, they began to use the third system - suspended.

Byte coverings, stretched or supported by a cable system, can be of various shapes.

In modern mass construction, it is not necessary to cover large spans, therefore, three schemes of the rack-and-beam system are mainly used:

- **frameless** with load-bearing external and internal walls (with longitudinal or transverse), and the load-bearing walls can be longitudinal, transverse or both longitudinal and transverse;
- **with incomplete frame:** inner frame and load-bearing outer walls;



- **frame** (with a full frame), i.e. with bearing separate supports, which consists of vertically placed racks (columns) and beams (girders) resting on them.

The connection of vertical and horizontal structural elements may allow rotation of one element relative to the other; such a connection, which allows changing the geometric shape of the conjugation, is called hinged.

If the connection of horizontal and vertical elements is tightly sealed in order to increase the rigidity of the structure, then such a connection is called rigid. In this case, the rack-and-beam system turns into a frame system with rigid frame nodes, and the beam turns into a crossbar - a horizontal frame element. The rigidity of the structure can be achieved by introducing rigid planes - stiffness diaphragms.

The installation of individual supports (columns) connected by crossbars (floor beams), with the floor slabs being pulled onto the crossbars, makes it possible to block large spaces, inside which you can change the size of the premises by moving the partitions-enclosing structures. This is how the concept of flexible planning arises - the ability to change the location and size of the premises during the operation of the building.

Frame buildings most fully meet the requirements of modern construction, while frameless buildings are usually used for residential buildings and small public and industrial buildings. The latter are reliable and simple, but have drawbacks: due to the limited length of the floor slabs, which does not exceed 6 m, it is necessary to build walls to wipe off the slabs, so it is impossible to design a large free room according to this scheme.

Depending on the material, buildings are divided into: brick, concrete, reinforced concrete, wooden, etc.

There are buildings made of piece elements, prefabricated from large-sized elements (block and panel), as well as from monolithic materials.

Buildings with load-bearing walls are material-intensive. To facilitate and reduce the cost of such structures, frame-panel buildings are used, which consist of a prefabricated reinforced concrete frame (columns, crossbars, stiffening walls), reinforced concrete floor panels, prefabricated flights of stairs and enclosing structures - expanded clay concrete or multilayer panels. Wall panels are either hung on the frame, or they are self-supporting.

По характеру работы каркасы делят на три типа: *рамные, связевые и рамно-связевые.*

In the frame frame (Fig. 2) the crossbars of the floors are located in the longitudinal and transverse directions; they are connected to columns with rigid nodes, which requires monolithic joints, so this type is rarely used.

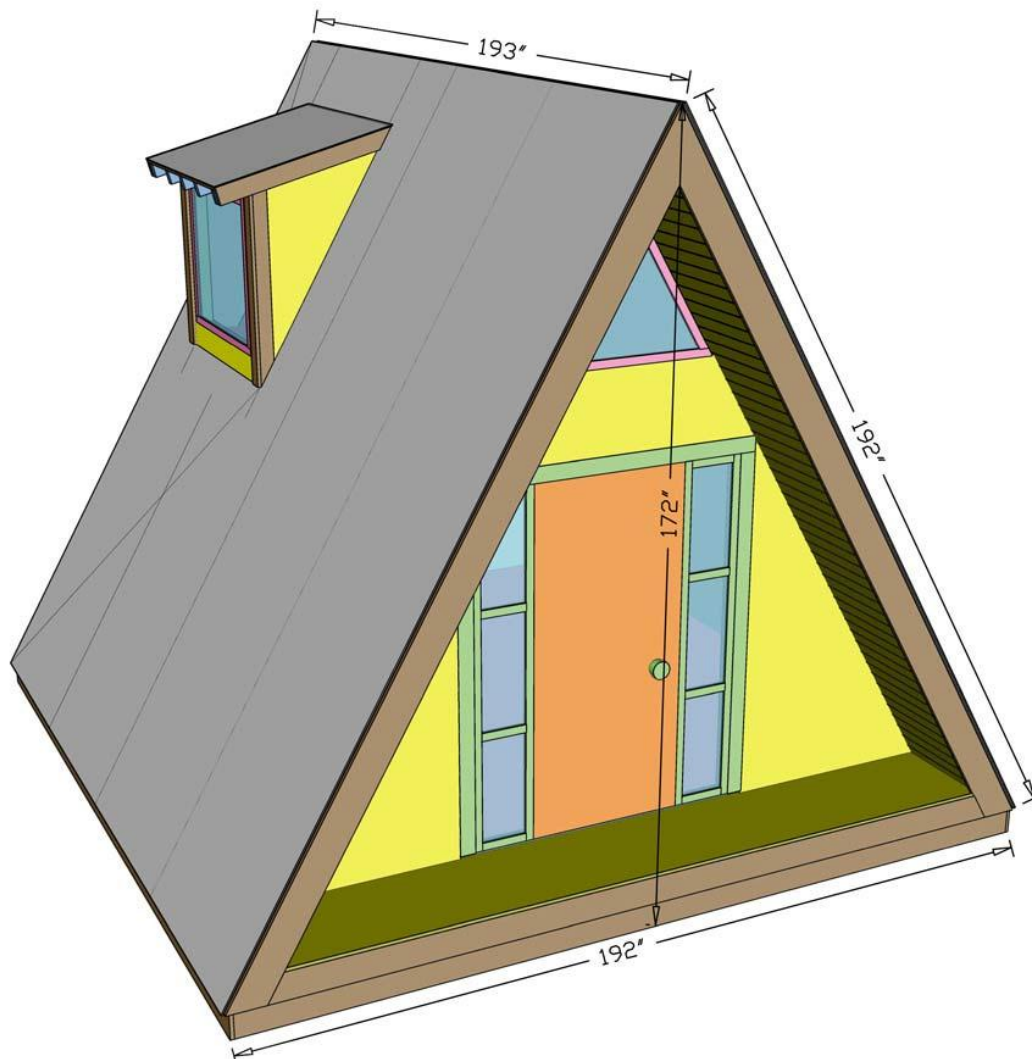


Fig. 2. In the frame frame the crossbars of the floors are located in the longitudinal and transverse directions;

In a bonded frame, the connection of columns and crossbars is hinged, therefore, vertical stiffening braces (cross-shaped, portal, etc.) or stiffening diaphragms (special reinforced concrete partitions) are required. Interconnected floor slabs form a rigid horizontal element of the building.

The frame-braced frame is provided with frames in one direction, and vertical stiffeners in the other. This option is made in precast concrete structures and is most common in frame buildings.

The reinforced concrete frame has two varieties: monolithic, performed on site in the formwork, and prefabricated - from prefabricated elements.

As a result, buildings are sometimes erected as precast-monolithic, in which case the stiffening core (staircase, elevator shafts) is made in monolithic reinforced concrete structures. A frame made of monolithic reinforced concrete is made only with appropriate justification.

The metal steel frame ensures the rigidity and stability of the building with its spatial system of various types of connections: frame, diagonal, braced, etc. It is much more expensive than reinforced concrete.



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