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Shells, folds, tents.

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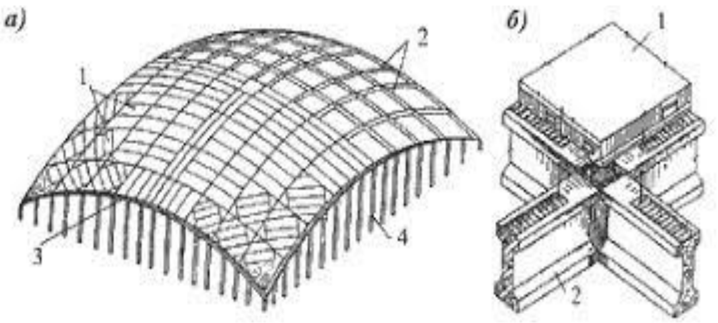
Abstract: Shells come in single and double curvature. The first include shells that have a cylindrical or conical surface. Shells of double curvature can be either shells of rotation with a curvilinear generatrix (dome, hyperbolic paraboloid, ellipsoid of revolution, torus surface, etc.), or shells of transfer with constant curvature in vertical planes along all successively located sections. Shells can also be created by combinations of various curved intersecting or mating surfaces.

Key words: Atmosphere, wall panels, curtain panels.

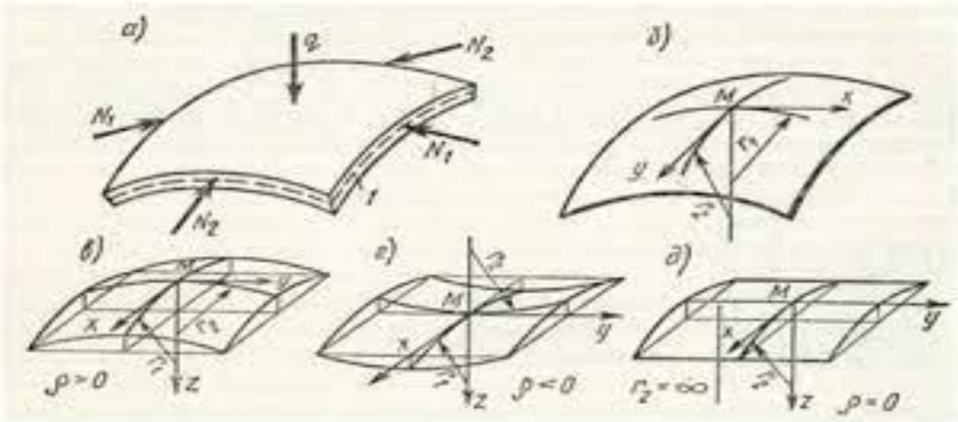
Thin-walled spatial coverings differ from flat ones in that a thin shell plate works primarily in compression, and tensile forces are rationally concentrated in contour elements, and all these elements work simultaneously in different planes. In this regard, thin-walled coverings such as shells, folds and tents are much more economical in terms of material consumption than flat structures, in which each element operates only in its own vertical plane. For example, in terms of concrete consumption, thin-walled coatings are on average 30% more economical than flat coatings, and in terms of metal consumption - by 20%. According to their structure, the shells are smooth, wavy, ribbed and mesh. Smooth shells are usually made of the same thickness over their entire surface, with the exception of the contours at the support and free edges, towards which these shells thicken.



Wavy or corrugated shells of double curvature, in addition to the main curvature, have an additional repeatedly repeated wave curvature, and the main curvature of the shell and the curvature of the will lie in two mutually perpendicular planes. Ribbed shells are those in which a thin curved wall is reinforced with ribs arranged in a certain order. The mesh shell consists only of ribs or rods, and the spaces between these rods are filled with some kind of non-load-bearing material - fiberglass, film, etc.

Smooth reinforced concrete shells are always made monolithic, while in prefabricated elements they must be reinforced with ribs. Wavy and ribbed shells can be monolithic or prefabricated. In prefabricated shells of small spans, in addition to reinforced concrete, asbestos cement, metal and plastic can be used. In prefabricated shells, each element along the edges must be reinforced with ribs, along which adjacent elements are connected and monolid with each other. Mesh shells are assembled from individual rods or from entire sectors made of reinforced concrete and metal. In the manufacture of monolithic shells, the most difficult thing is the preparation of curved formwork and scaffolding, which is associated with significant wood consumption and requires very high precision execution. When concreting a number of complex shells, it is advisable to use rolled formwork with a device for mechanically lowering and lifting it. When installing a prefabricated reinforced concrete shell, no formwork is required; assembly is carried out on so-called jigs or trusses with purlins on which prefabricated reinforced concrete slabs are laid, which are then welded and monocoated together. Sometimes, for convenience, installation is carried out at ground level, and then the finished shell is raised using jacks to the required level. Reinforced concrete and metal shells are used in coverings with a span of up to 100 m, and sometimes more.

Cylindrical shells (as opposed to vaults) rest on end and intermediate diaphragms. Diaphragms, rigidly connected to the shell, fix its shape, absorb forces in their plane and ensure the stability of the entire shell. Any rigid structure can serve as a diaphragm: a solid wall, a truss, a frame, etc. The edges of the shell must be reinforced with rigid side elements. The wavelength of the cylindrical shell or its pitch 1 usually does not exceed 12 m. The ratio of the lifting boom to the wavelength is taken to be no less than 1/7, and to the span length f/L no less than 1/10. The thickness of the reinforced concrete cylindrical shell is taken from 1/250 to 1/350 of the span L; it is taken into account that it increases 3–4 times near the side elements due to the appearance of large folding forces in these places. Cylindrical shells in the longitudinal direction work like a bent beam, and in the transverse direction they work like a vault, and the thrust from this is perceived here by diaphragms, puffs or funny shells. The cylindrical shell currently covers spans of up to 100 m, and in some cases more.



Barrel shells, unlike cylindrical shells, have a longitudinal axis that is not rectilinear, but curved along a curve with a convexity upward, which is most often outlined in a circle. In this case, the shell has the shape of a torus, in which the ratio of the diameter of the ring to the diameter of its longitudinal section is expressed by a number of at least five. Barrel shells work both in the transverse and longitudinal directions like vaults, and therefore in the longitudinal direction they have fashionable ties suspended under the longitudinal ribs and receiving thrust in the direction of the span. The cross-sections of barrel shells are usually assumed to be circular along the entire length of the vault, with the exception of the support zones. In the support zones, the shell of large spans ends with a conoidal surface, providing a transition from the circular cross-section of the middle zone to a rectangular one - along the line of support. In prefabricated shells, slabs of intermediate zones are mounted on metal lattice supports. Spherical shells represent part of the surface of a ball. They usually have the shape of a dome, resting along the entire perimeter or on individual points located along the contour. The dome shell is the simplest and most economical in terms of material consumption. When constructing prefabricated domes, they are cut with horizontal and meridional seams into elements having the shape of spherical trapezoids, or they are solved as a polyhedron, divided into elementary triangles.

Shells with a transfer surface or torus are externally similar to spherical ones, however, they are more convenient for covering rectangular rooms in plan, since all four diaphragms on which such shells rest can have the same or almost the same height. The surface of the transfer shell is formed by the translational movement of one curve along another, provided that both curves are curved upward and are in two mutually perpendicular planes.The surface of a torus is formed by transforming a segment of a circle around an axis lying on its plane. The surface of such prefabricated shells is usually divided into rectangular elements, each of which is a slab reinforced at the edges with ribs. The ribs can be directed downward, as provided for in the design of the coating of the Novosibirsk shopping center.

A shell with the surface of a hyperboloid of revolution is obtained by transforming a hyperbola around an axis of symmetry lying between its two branches. Such shells are most often designed as square or rectangular in terms of covering, in which both pairs of opposite corners are at different elevations, and the surface itself is formed by straight lines connecting two opposite sides in pairs.

A thin-walled coating with such a slightly twisted surface has significant rigidity, and with a small difference in angular marks it is easily divided into flat squares or rectangles. By combining hyperbolic surfaces with each other, it is possible to achieve a wide variety of coating shapes.

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