



Special forms for shell

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Shell

- Concrete thin shell structure is a three-dimensional spatial structure that constructed from one or more curved slabs or folded plates. The thicknesses of curved slab and folded plates are small compared to their other dimensions. The outstanding features of concrete thin shells are their three-dimensional load-carrying behaviour which is governed by number of factors.

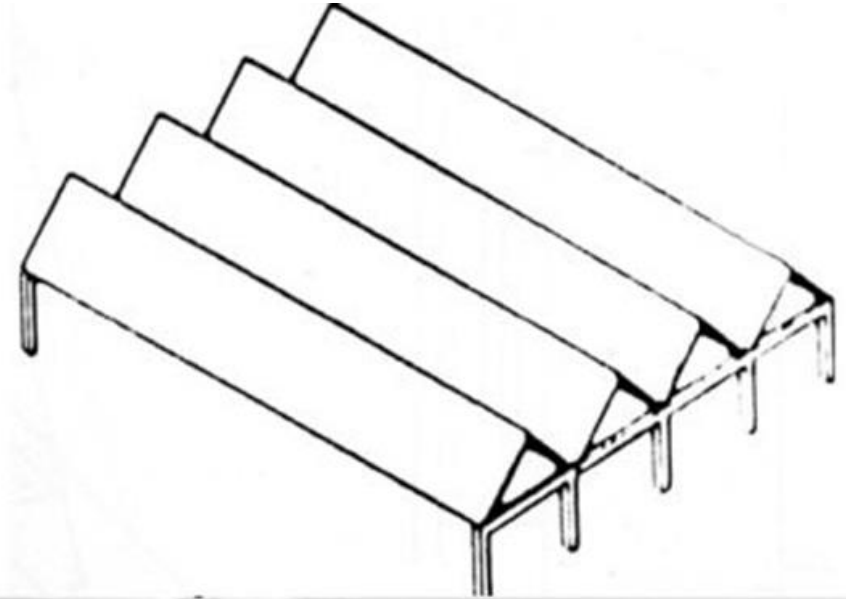


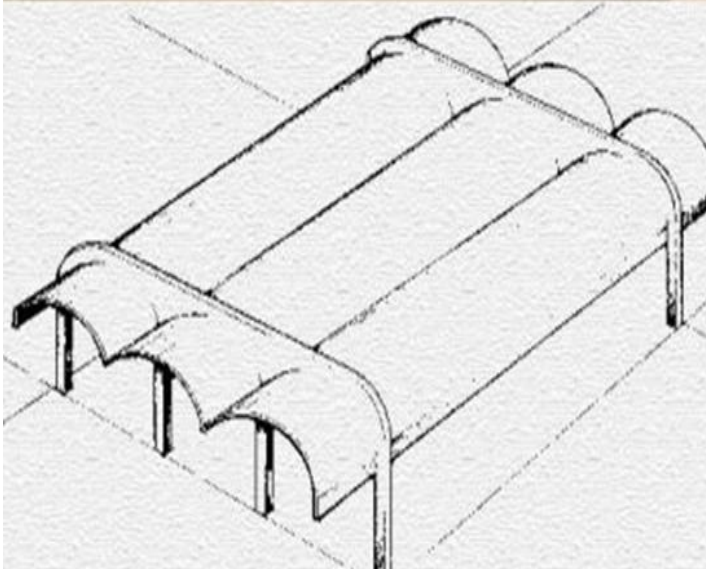
Different types of Shells

- Folded Plates
- Barrel Vaults
- Short Shells
- Domes (surfaces of revolution)
- Folded Plate Domes
- Translational Shells
- Warped Surfaces
- Combinations

1. Folded Plates

- It is a type of concrete shell structure that made up of thin flat slabs. These slabs are jointed along their edges to construct three-dimensional structure.
- Folded plate spans up to 30m with only 60mm thickness. nonetheless, folded plate structure with greater spans can be constructed. Added to that, it is aesthetically pleasing, reduce material and construction cost. However, difficult shuttering, requirement for extensive labour work and supervision, high cost, and difficulty in rising roofs are drawbacks of this type of plates.





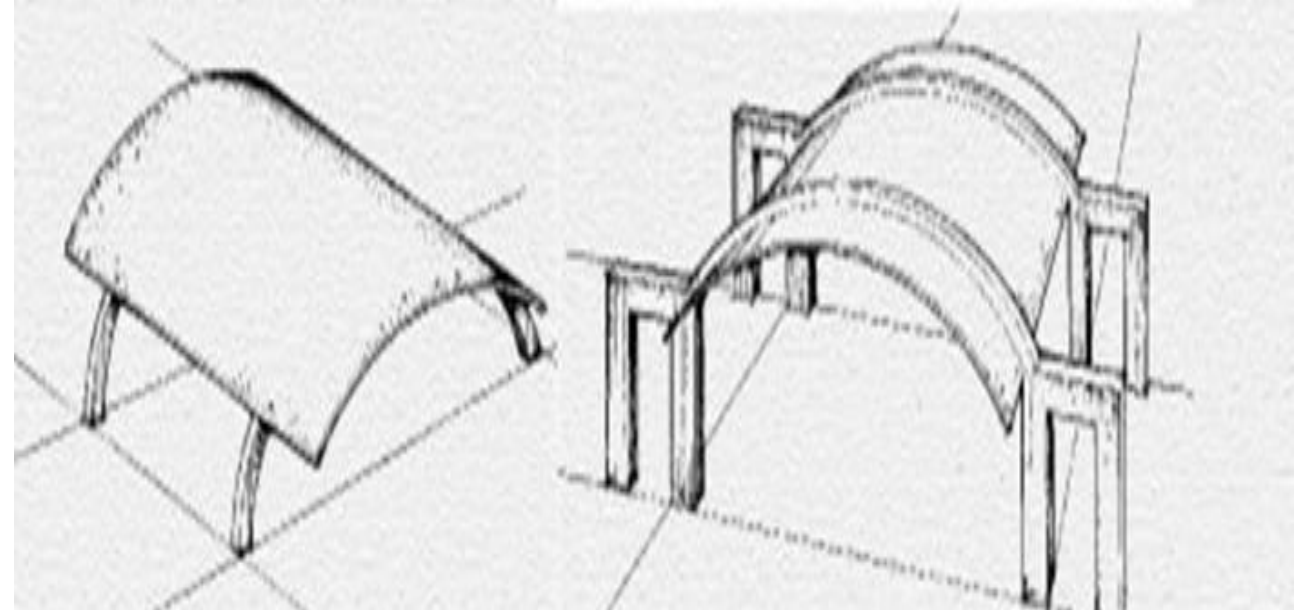
2. Cylindrical barrel Vaults

- Basically, barrel vaults are deep concrete beams with considerably thin web member that can be designed using conventional reinforced concrete design. Moreover, this type of concrete thin shell composes of cylinder, frame or ties at the ends including columns, and side elements which include a cylindrical element; a folded plate element; columns; or combination thereof.
- Furthermore, barrel vaults assumed to be very efficient due to the use the arch form to reduce stresses and thicknesses in the transverse direction. Added to that, it spans up to 45.72m that is why barrel vaults are the most useful shell structure. Finally, a barrel shell carries load longitudinally as a beam and transversely as an arch. The arch, however, is supported by internal shears, and so may be calculated.

3. Short shell

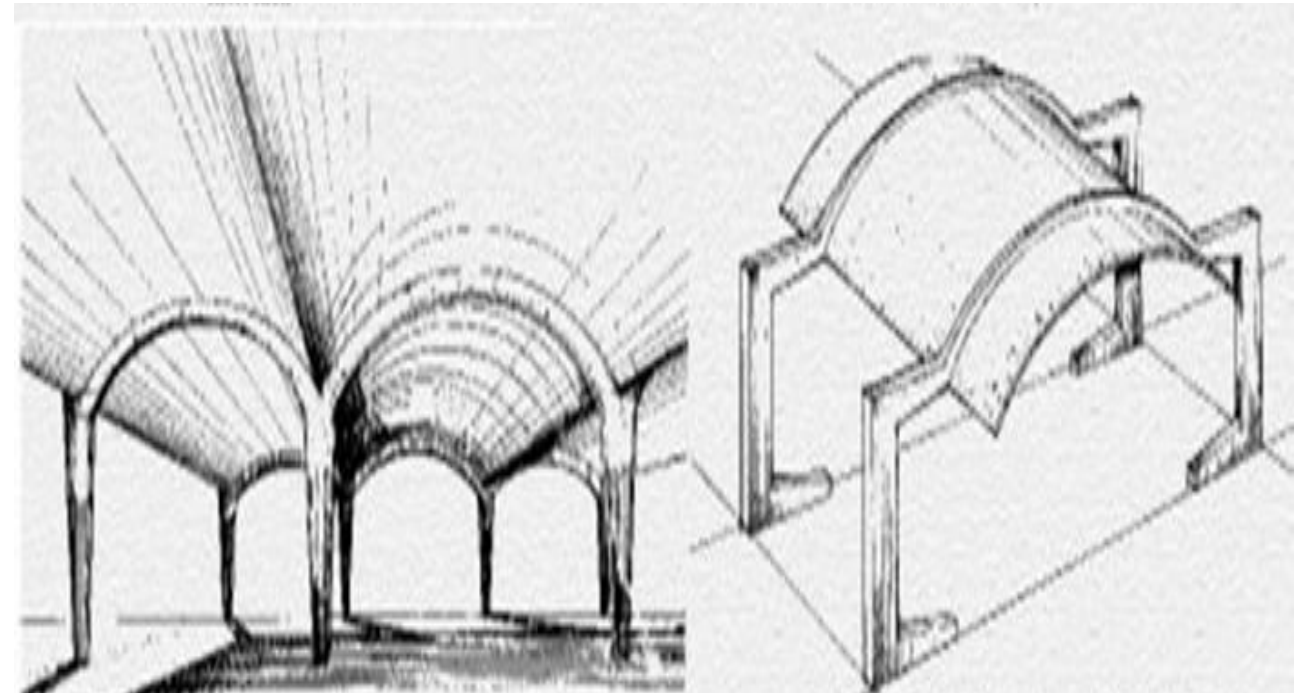
It is a cylindrical shell that has a considerably large radius in comparison with its length. Short shell consist of shell element spans between arches, arch structure, and edge beams provided at the lowest point of the shell. In small structure, it is permissible to omit edge beams in small structure.

Moreover, the short shell carries load in two ways; as an arch carrying load to the lower elements. and as a curved beam to the arches. Lastly, the thickness of the shell can be quite thin due to these properties.



A - Pure Arch Short Shell

B - Massive Abutment Short Shell

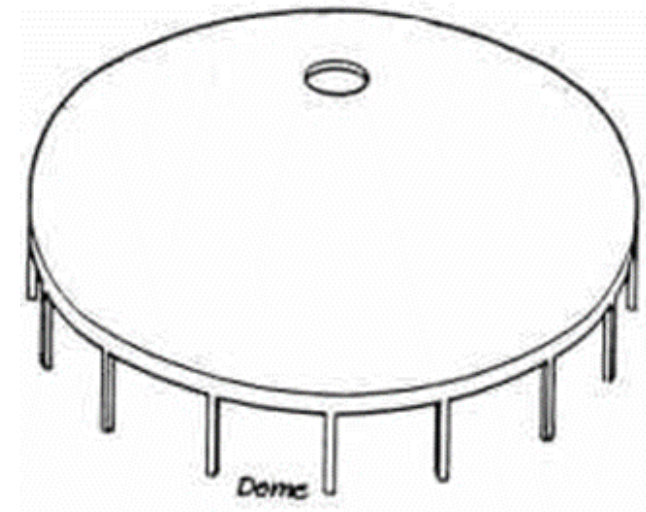


C - Rigid Frame Short Shell

B - Cantilever Abutment Short Shell

4. Domes

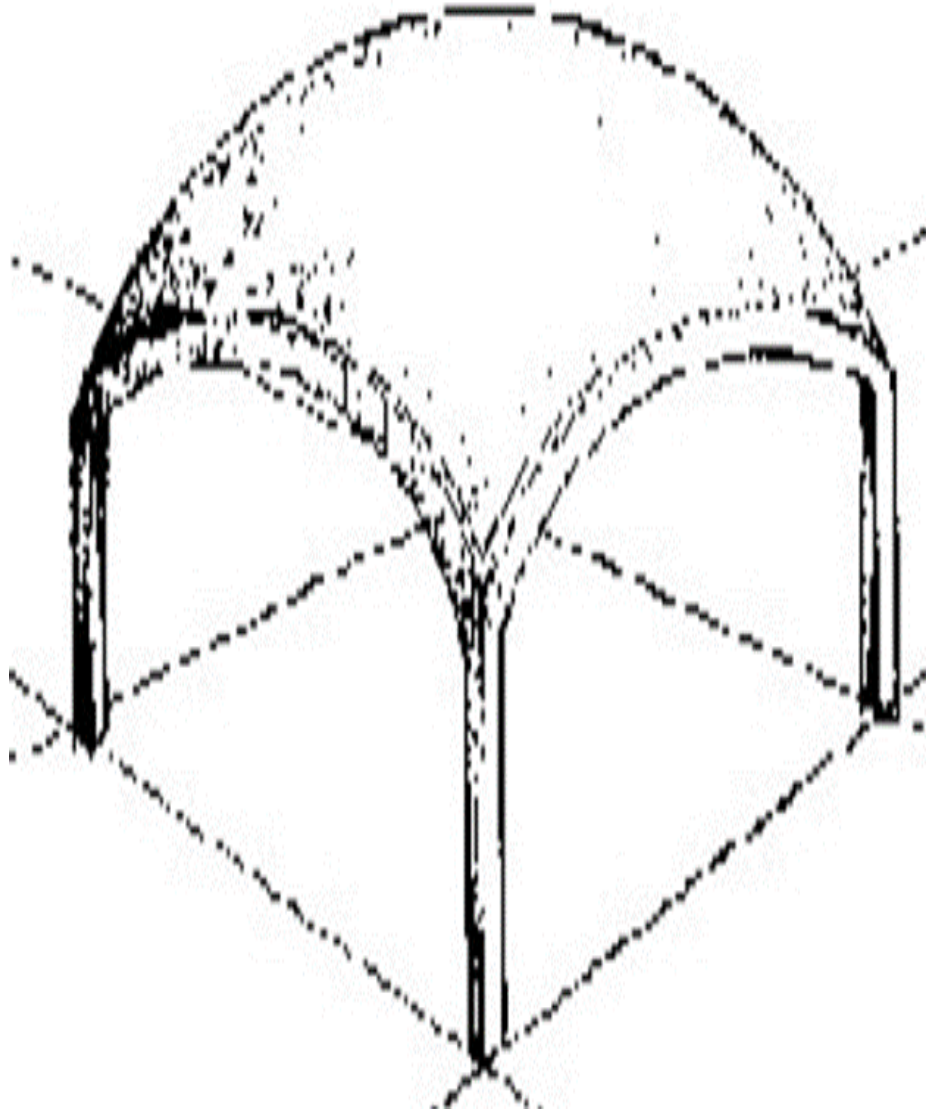
- They are structures that cover a more or less square or circular area. Domes are hemisphere in shape and used as a roof structure. Support element of domes include columns, circular or regular polygon shaped wall.
- Moreover, they are membrane structures; the internal stresses are tension and compression and are statically determinate if the proper edge conditions are fulfilled. Furthermore, in a dome of uniform thickness, under its own weight, the ring stresses are compression until the angle to the vertical is about 57 degrees. Lastly, if the dome is less than a full hemisphere, a ring is required at the base of the dome to contain the forces.



5. Folded plate domes

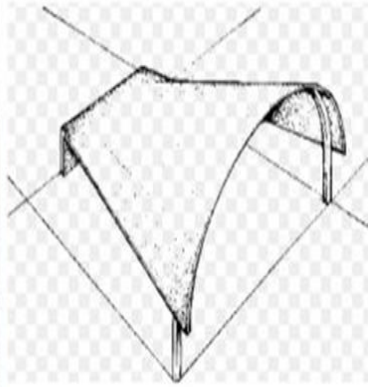


- It is a type of thin concrete shell structure that consists of plane slabs and plates. various configurations of folded plate domes are available and being constructed.
- Domes may be constructed with small angles between the plates or with large angles between plates and the structural action may be considerably different for each type. folded plate dome surfaces is easier to construct since they are flat. Nonetheless, for slab spans over 16 ft, the shell wall is thicker than a curved surface because bending must be considered. the sound waves in areas covered with folded plate domes are not converge. Therefore, it is more desirable to the curved dome for use in an auditorium. Finally, the structural design of folded plate domes follows that of folded plate barrels.



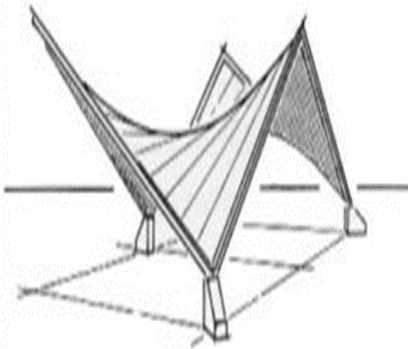
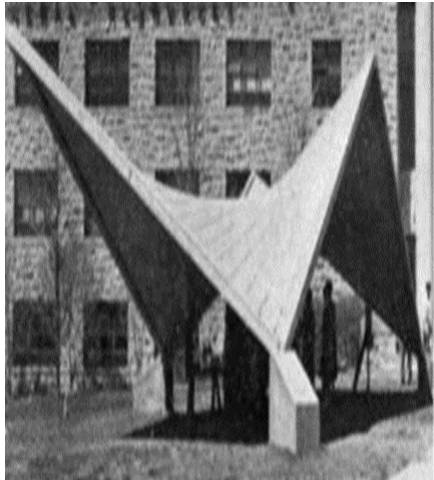
6. Translation Shells

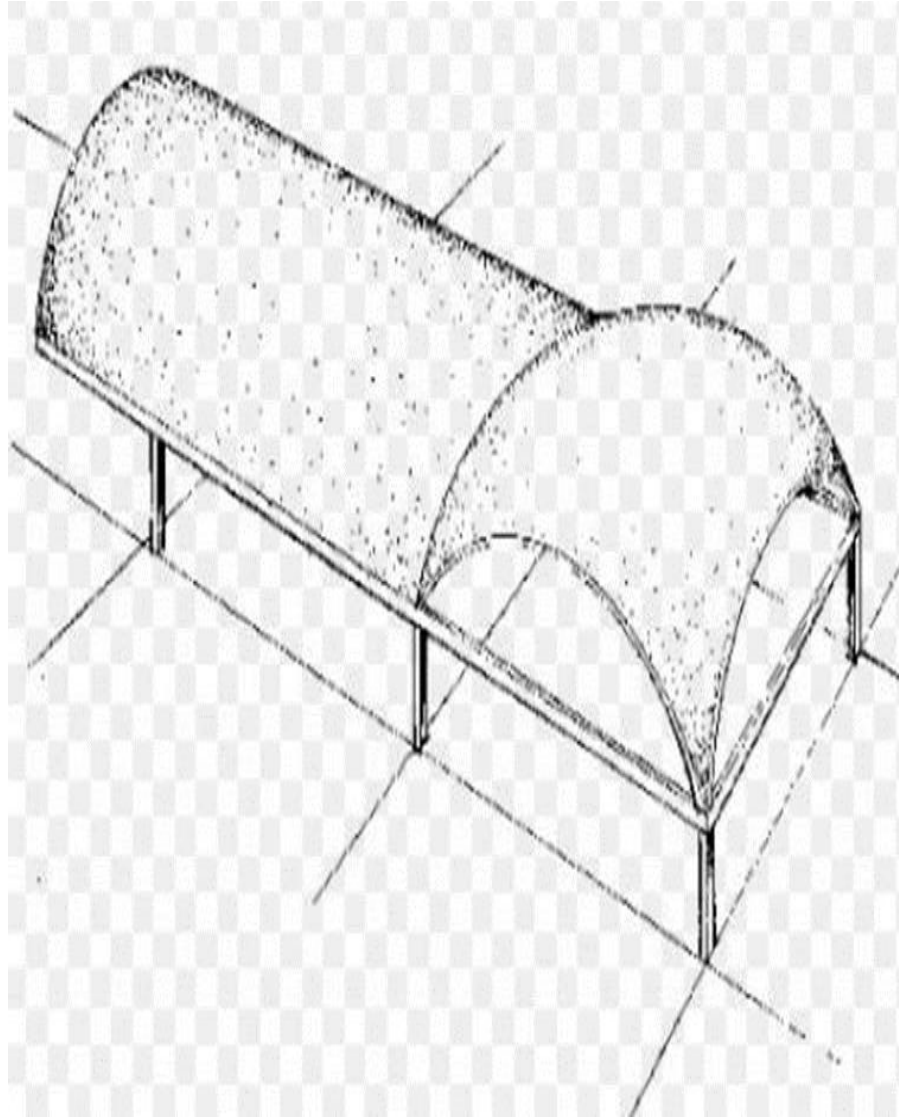
- A translation shell is a dome set on four arches. The shape is different from a spherical dome and is generated by a vertical circle moving on another circle. All vertical slices have the same radius. It is easier to form than a spherical dome. The stresses in a translation shell are much like a dome at the top, but at the level of the arches, tension forces are offset by compression in the arch. However, there are high tension forces in the corner.



7. Wrapped surfaces

- Warped surfaces have a great advantage for shell structures because they may be formed from straight form boards even though they are surfaces of double curvature. There are two types which are most useful namely Conoid and hyperbolic paraboloid shell





8. Combinations

- The above shell structure are basic types. So, it is possible to construct different and safer shell structure by combining portion of the basic shell structure. Intersection shells, barrel shell and folded plate, barrel shell and short shell, barrel shells and domes of revolution, and barrel shells and conoids are all concrete shell combinations. So, numerous combinations can be formed to reach the desired safety and capacity.



Form for shells

THE DESIGN AND CONSTRUCTION OF FORMS IS A MAJOR CONSIDERATION OF COSTS, AND INVOLVES A SIGNIFICANT PROPORTION OF THE TOTAL COST. IT IS IMPORTANT TO UNDERSTAND THE VARIOUS TYPES OF FORMING AND THEIR ADVANTAGES AND DISADVANTAGES



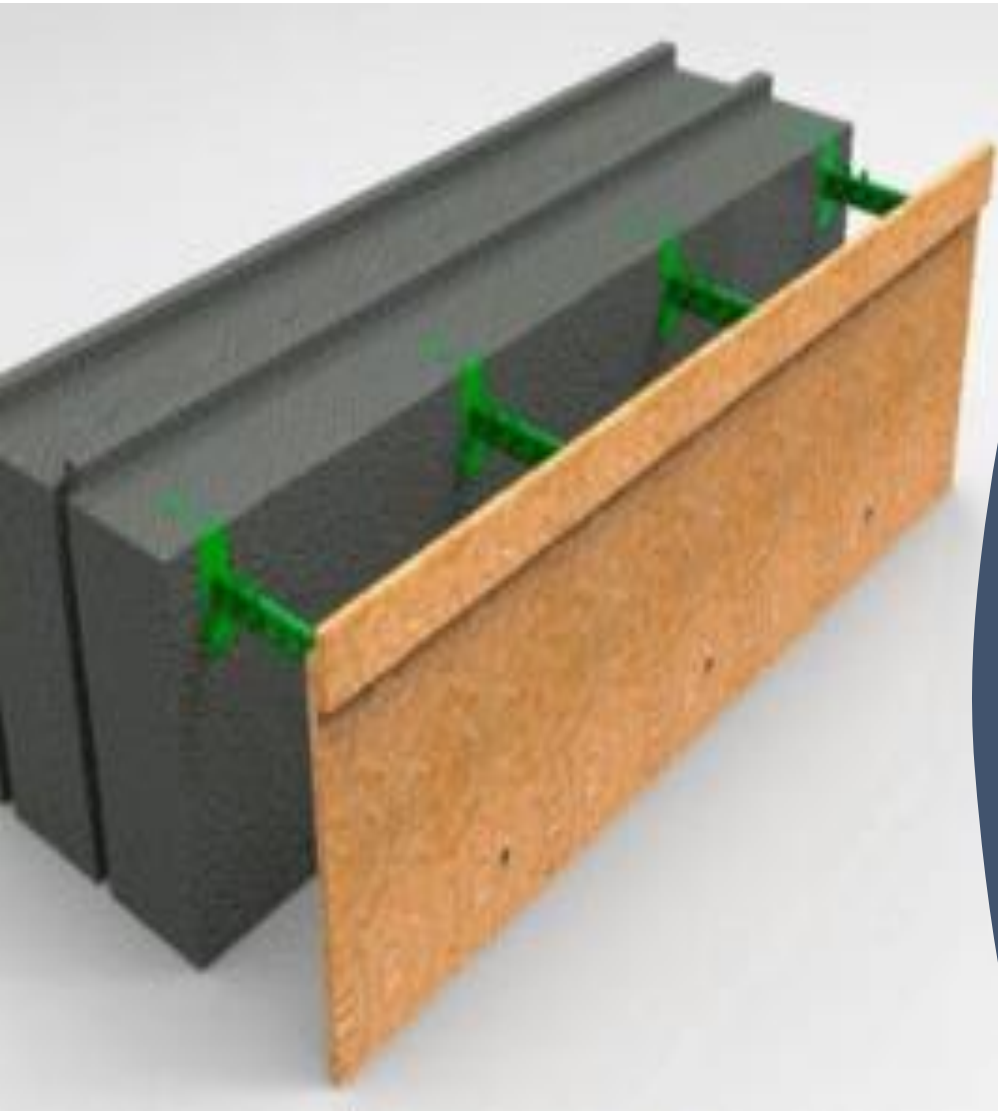
Types of formworks

- Single use form
- Demountable panels
- Movable forms Small
- Movable forms large
- Precast shells
- Earth



1. Single use forms

- The entire roof is formed at one time, and the forms are not reused. This method is satisfactory, either for small or large shells, where there is a single structural element. It requires a large amount of forming materials in comparison to the final area of the shell. An advantage is that it is not necessary to have an elaborate schedule of sequential forming, reinforcement pacing, concrete placing, curing, and decentering. All of the forming can be done at one time, then the reinforcing, and so forth. On large shells, patented steel scaffolding is often used and may be rented. Single use forms should be considered if there are fewer than, say, 4 units.



2. Demountable panels

- The form is constructed with panels supported by shores arranged so that the shores are built into and support the shell directly. Then some of the panels can be taken down and moved ahead in one or two days without disturbing the shores. A crew can be kept continuously busy removing and reerecting panels and shores. It is important to have available more panels and shores than required for each concrete placing operation, otherwise this system will have no particular advantage in terms of labor efficiency. Some of the built-in shores should remain in place until adequate concrete strength precludes excessive deflection from overloaded young concrete. The contractor and the engineer should fully agree upon the schedule for removal of panels and shores. This method is most useful when, say, three or four structural units are to be built which require some mutual support.

3. Movable forms

For inverted HP umbrella shells, for example, forms for one unit can be constructed in quadrants so it is necessary to decenter only a few inches. Then the quadrants may be separated and moved to the next unit to be constructed. Fortunately this type of shell is structurally self-supporting so it is not necessary to leave shores in place until the next element is joined to the structure. However, for umbrella shells, the corners may tend to sag, so re-shores should be used at these places.



On shells other than umbrellas, it may be necessary to decenter the forms for a major portion of the full height of the shell. This method requires a considerable investment in mechanical equipment such as long hydraulic jacks or the repeated use of short jacks. The mechanical ingenuity of the contractor is very important for proper design of this type of forming system.



5. Precast shells

- Precasting has the advantage that material and construction conditions are under the best control, forms may be constructed for repeated use, and concrete materials may be better controlled. The disadvantage is that it is usually necessary to transport the shell units over a considerable distance if they are built in a Precasting yard. If they are precast on the construction site, then the transportation is easier, but it is necessary to have large cranes to move and to lift them into place. A structural problem is the connection of these shells to the supporting columns. Precasting should be considered only for small units.

6. Earth.

- A number of shells have been built by using earth as a forming material. The surface of the earth mound is covered with a suitable contact material such as plywood to make the under surface of the concrete acceptable. After casting the concrete, the earth is excavated. Most of the structures built in this manner have been domes. Shells have also been built without forms by using a close grid of reinforcing bars with the concrete placed by shotcrete



Shell Structure Examples



LOTUS TEMPLE



OPERA HOUSE IN SYDNEY



GEODESIC SHELL OF
NAGOYA DOME IN JAPAN



SHELL OF KRESGE
AUDITORIUM



A simple video for
understanding

QUESTION

1

Name different types of shells

Question

2

Name different type of formwork used

Question

3

Name any famous shell structure

Question

A close-up photograph of a wood surface, showing concentric growth rings in shades of brown, tan, and dark blue. The rings are curved and follow the shape of the wood piece.

Thank you