Comparitive Study of Plain Foundations with Shell Foundations

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Abstract : The spread footing for columns transmitting heavy load to weak Soils tends to be massive, if rafts are provided. Shell foundation can serve as better replacement to plain foundation as economic alternative where heavy super structural loads are to be transmitted to weaker soils. The substitution of shell foundations for spread footings and rafts can therefore lead to considerable saving in concrete and reinforcing steel.The sector of spherical dome, in inverted positions can serve as rafts for structures such as water tanks.

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1. INTRODUCTION

Shell foundations are in general economic alternatives to plain shallow foundations in situations involving heavy superstructural loads to be transmitted to weaker soils. The use of shells in foundations, as in roofs, leads to considerable saving in materials, and in the case of shells with the straight-line property and axisymmetric shells, this is achieved without much extra input of labour. The resulting economy is substantial in the developing countries of the world – many of which are in the Asian region, Africa and Latin America – where materials of construction are scarce and expensive, but labour, comparatively cheap and abundant. This factor alone points to the need for the construction industry in these countries to increasingly gravitate towards this technique in the interest of conserving the scarce materials of construction, if not economy itself. An added advantage is the scope they offer for precasting, thanks to the conspicuous reduction in weight, which makes even large size shell footing amenable to precasting. This section throws light on the scope and inherent advantages of the use of some select shells in different form of substructures, especially foundations.

The basic difference between a plain structural element like a slab and a non-planar structural element like a shell is that, while the former resists vertical loads, including self weight, in flexure, the same loads induce primarily a direct, in-plane or memSsbrane state of stress in a shell, which may be tension, compression or shear, but all lying in the plane of the shell. Concrete as a material of construction is most efficient in direct compression, least efficient in tension, with the efficiency in bending lying between the two. Thus if a plain roof slab is substituted by a shell, and if the geometry and boundary conditions of the shell are such that the same applied load induces a state of membrane compression, and that too of a low magnitude, better material utilization results, which in terms of design means a substantial reduction in thickness. This reduction in thickness, however, has been achieved at the cost of extra surface area needed on account of the curvature of the shell, which means that there is a net saving in material provided the saving realized due to reduction in thickness more than offsets the extra due to curvature. A structure however takes its final shape only when the materials of construction are combined with labour. This means that if we combine the aspects of material and labour, there will be net economy in respect of the shell only when the saving in cost realized from saving in material more than offsets the extra due to labour.

2. COMPARISON OF PLAIN AND SHELL FOUNDATION

I. Plain Foundation (Flat Base)

In plain foundations the loads are direct transferred to the foundation base and from foundation to the soil. This transfer of load is counter acted only by the upward base pressure which in turn creates the bending and shear stresses on the foundation.

Stability analysis aims at removing the possibility of failure of foundation by tilting, overturning, uprooting and sliding due to load intensity imposed on soil by foundation being in excess of the ultimate capacity of the soil. The most important aspect of the foundation design is the necessary check for the stability of foundation under various loads imposed on it by the tower, which it supports. The foundation should remain stable under all the possible combinations of loading, to which it is likely to be subjected under the most stringent conditions.

II. Shell Foundations

The basic difference between shell foundations and plain foundations is there geometry. The structural geometry of shell enables it to give maximum structural strength with maximum use of materials.

Shell foundations are basically respond to compressive force. Due to the curved shape the larger area of contact with the soil is obtained in case of shell structures, which cause the greater area of dispersion for the load. Thus load intensity gets reduced, and foundation can sustain comparatively heavy superstructural loads. Also, while counteracting the vertical loads, tangential, circumferential and meridonal stresses are also developed in the shell type of foundations.

The toe element of shell footings are formed by reinforced edge beams following the shells perimeter. The girder, sloped ridge and edge beams would intuitively seem to be taking primary stresses from an applied load, whereas the shell fins themselves absorb secondary stresses. Adding edge beams and increasing their depth of embedment has seemingly demonstrated to have improved stress transferral with increased load carrying capacities of shell footings

3. EFFICIENCY OF PLAIN AND SHELL FOUNDATIONS

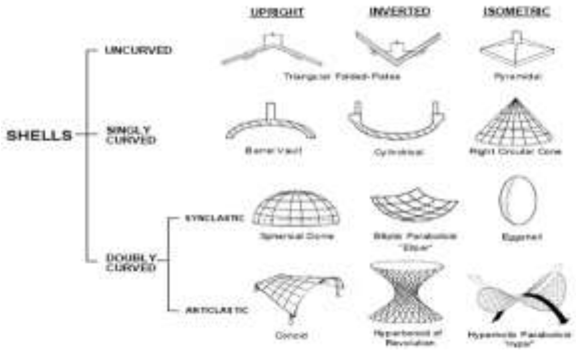
The basic difference between a plain structural element like a slab and a non-planar structural element like a shell is that, while the former resists vertical loads, including self weight, in flexure, the same loads induce primarily a direct, in-plane or memSsbrane state of stress in a shell, which may be tension, compression or shear, but all lying in the plane of the shell. Concrete as a material of construction is most efficient in direct compression, least efficient in tension, with the efficiency in bending lying between the two. Thus if a plain roof slab is substituted by a shell, and if the geometry and boundary conditions of the shell are such that the same applied load induces a state of membrane compression, and that too of a low magnitude, better material utilization results, which in terms of design means a substantial reduction in thickness. This reduction in thickness, however, has been achieved at the cost of extra surface area needed on account of the curvature of the shell, which means that there is a net saving in material provided the saving realized due to reduction in thickness more than offsets the extra due to curvature. A structure however takes its final shape only when the materials of construction are combined with labour. This means that if we combine the aspects of material and labour, there will be net economy in respect of the shell only when the saving in cost realized from saving in material more than offsets the extra due to labour.

4. SHELLS IN FOUNDATION

A shell as a foundation footing can be generally classified based on its curvature and thus fall within three major categories: uncurved, singly–curved and doubly–curved. An uncurved shell is that of a plate or flat footing case which is folded in an upright or inverted position where a radius of curvature does not exist. Singly–curved shells have one set of curves in

one direction and are known to have zero Gaussian curvature. By forcing a singly–curved surface into a planar surface characterizes it as being developable whereas doubly–curved shells resist this tendency and are referred to as non–developable having curvature in two directions. The higher rigidity of the doubly–curved shell reflects a stiffer form and thus a

conceivably stronger shell. Considering the two curvatures of either the same or opposite directions for the doubly–curved shell further subdivides them into being synclastic or anticlastic, respectively. Synclastic shells are formed by two sets of bent lines curving in the same direction, also known as shells of positive Gaussian curvature. Anticlastic shells are shells of negative Gaussian curvature. A secondary subdivision depends upon whether the developing shell surface is one of translation, revolution and/or ruled type. For example, a cone surface is developed by revolution of a ruled surface and a hyperbolic paraboloid is a shell of translation and a ruled surface. The straightline property is one in which a section of zero curvature exists typically in anticlastic shells where lines of positive and negative curvatures are straight lines. All ruled surfaces, therefore, exhibit the straight–line property.



5. CONCLUSION

The basic governing criteria found in the analysis of plain foundation are the depth of footing. Depth of any footing proportional to the area. Where there is restriction on the area for particular foundation the depth needs to be increased. Also there are some restrictions for the provisions of depth of foundations.

Shell foundations prove to be more efficient, especially in such cases as mentioned above. They cover a larger surface

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area of soil due to their geometries along with lesser thickness comparatively.

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