



Structural Efficiency and Economy of Shells Foundations

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ABSTRACT

This thesis introduces shell foundation as the economic alternative to traditional foundations. Through study a type of traditional foundation and two types of shell foundations. So that the foundations are based on weak soil possessing the same properties, and is subject to a high structural load. In this paper, hyperbolic and conical shell footings were designed and compared with sloped square footing. The result were found that , the shell footing more economical than sloped footing , in terms of the size of the concrete mass and the amount of reinforcing steel area. As follows, hyperbolic 48.1%, conical 41%.

Keywords: shell foundations, hyperbolic, conical

1. INTRODUCTION:

An economic alternative to traditionally plain shallow foundations especially where heavy super structural loads are to be transmitted to weaker soil is opportune incentive to use shell foundations. Shells are thin-slab structures whose performance capabilities as a supporting element rely heavily upon their form and quality of construction materials used. shell foundations are composed of one or more curved slabs or folded plates whose relative thickness is inferior to its overall planar dimensions. To obtain maximum structural performance, shell foundations have been prevalently designed in arched, circular, triangular, conical, cylindrical, spherical, pyramidal, square and strip shapes.

The historical success of shells performance as a structure has motivated further research in its application and performance with the objective of

exploiting cost savings benefit applied in a geotechnical engineering context. The ingenuity of shell footings as foundations has all the ingredients any design engineer should look to satisfy; that of optimum strength at minimal cost that is both safe and elegant, yet endures. This combination of economy and efficiency coupled with long-term durability is the epitome of a sustainable structure

Structural efficiency and economy of shells. 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 membrane 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 utilisation 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 realised due to reduction in thickness more than offsets the extra due to curvature.

2. Related Study

Dr. Esmaili And N. Hata. (2008): think about on a definitive load limits of funnel shaped and pyramidal shell foundations on unreinforced and fortified sand were dictated by research center model tests and numerical examination. The outcomes were contrasted and those for roundabout and square level foundations. Eight establishment models on unreinforced and fortified sand were tried in which the impact of shell arrangement on extreme load limit was examined. Both the trial and numerical examinations showed that, if shell establishment thickness expands, the conduct of the shell establishment on either fortified sand or unreinforced sand gets nearer to that of level foundations. Another factor was likewise characterized to show a unique relation between a definitive load limit of shell and flat foundations.

Endalkachew Taye Chekol. (2009): This proposition presents shell foundations as a rule and funnel shaped write shell establishment specifically as a contrasting option to the ordinary plain establishment. The distinctive sorts of shells that might be utilized in foundations are presented with their geometry and applications under various circumstances. Shell foundations can be utilized as consolidated or disengaged balance. The easiest type of shell fitting for confined balance is cone shaped shells. Tapered shells are utilized as an other option to plain roundabout footings.

Pusadkar Sunil Shaligram (2015): conduct of triangular shell strip balance on georeinforced layered sand ". The outcomes demonstrate that a definitive bearing limit increments with diminish in crest edge. The geotextile layer at different levels beneath the balance demonstrates increment in extreme bearing limit at upper layer and abatement in the settlement. It was additionally watched that the position of geotextile beneath balance create better load settlement qualities when geotextile was set in the Prandtal's outspread shear zone.

Sheik and shilpa (2015): took a shot at investigation and plan of shell establishment SI9456-1980 arrangement ". They looked at between plan of hypar shell balance and slanted balance, and found that the hypar shell balance spare the solid and steel upto 43.78% and 4.76 separately.

Mohammed Y. Fattah . et al. (2015): The present investigation goes for concentrate the RPC as a

material used to build RPC shell foundations. An entire load-outline gathering was composed and manufactured for test work. Trial tests are directed to ponder the impact of steel fiber volumetric proportion (V_f), silica rage content (S_f), change whimsy, and ascent of shell to sweep of base proportion (f/r^2) on the conduct of cone shaped shell foundations .

Mahesh Salunkhe. et al. (2016): The target of this examination is to advance shell balance as a monetary contrasting option to customary establishment and configuration investigation of funnel shaped and hyperbolic paraboloid establishment and correlation between them.

Adel Hanna and Mohamed Abdel-Rahman (2016): Experimental examination of shell foundations on dry sand ". the subsequent bearing limits and settlements will be contrasted and traditional strip, round, and square level foundations. The present paper exhibits a trial examine on nine establishment models tried on free, medium, and thick sand states. The impact of shell setup and insertion profundity on a definitive bearing limit and settlement will be exhibited.

S. Thilakan and N.P. Naik (2016): Geotechnical conduct of strip bended shell establishment demonstrate ". The outcomes acquired were contrasted and those of a level strip balance having an indistinguishable width of 0.16 m from that of the bended shell estimated on a level plane. The thickness of shell was kept as 0.02 m and that of the level strip was kept as 0.04 m. The pressure disseminations and vertical removals were acquired and extreme burdens were resolved. The outcomes were deciphered utilizing a shell effectiveness factor and shell settlement factor. The bended shell strip establishment showed in excess of 30 percent more prominent extreme burdens and more than 50 percent lesser settlements when contrasted with that of level strip balance.

Endalkachew Taye Chekol (2016): an investigation on the outline and preferred standpoint of cone shaped compose shell establishment utilizing expository and FEM". The outcome unmistakably shows that funnel shaped shells spare more material than do as such plain round footings.

Amera Ratia Binti Ab Rahman. (2016): This exploration is fundamentally centered around the conduct of three distinct states of establishment viz; pyramidal shell establishment, hyperbolic paraboloid shell establishment and square level establishment

under hub stacking with various establishing levels. Three diverse stature/thickness proportion offlat and shell establishment made out of various materials.

3. Problem Description

Diminishing accessibility of good construction destinations and expanding construction exercises for infrastructural developments all through the world has constrained the structural specialists to use inadmissible locales or weak soil.

Turn out to be extremely important And with the requirement for multi-story undertaking, which produces colossal burdens, interestingly weak soil.

The scope of this study can be explained by explaining the requirements of code IS 9456-1980 and design requirements, comparing design results between shallow foundations and shell foundations.

The objectives of the present study are:

- Study of shell foundations as an alternative to shallow foundation.
- Studying the size of the underlying stress in the soil after applying the load in the case of the shell foundation and shallow foundation.
- Analysis of the data obtained through this study with the data of previous studies to illustrate the economic and engineering efficiency of the shell foundation.

4. Proposed Methodology

Structural loads are applied to weak soil, and the foundations of shell foundations and shallow foundations of structural load applied to weak soil

The design data is then compared

The size is footing in both cases.

To known out the:-

1. Amount of savings in building materials.
2. The amount of steel used.
3. Effective soil stress.

And we can comparing design results between shallow foundations and shell foundations.

Hyperbolic

- 1- Find Shell dimensions.
 - Required base area.
 - Length, Width, Rice, Warp of shell, Base pressure.
- 2- Calculate membrane shear on factored load.
 - Factored pressure.
 - Membrane shear.
 - Thickness.
 - Shear stress (τ).
- 3- Design the steel in shell (find area of steel for tension due to shear).
(Some recommend 0.5 % as minimum steel to reduce crack width in the slab). This steel is more than, the minimum is 0.12 % for shrinkage.
- 4- Check compression in concrete in the shell.
- 5- Find tension in edge beam and area of steel as in beam.
 - Max tension (each shell).
 - Area of steel required = $\frac{\text{max tension} * 10^3}{\phi * f_y}$
 - Assume width = 1/2 size of the column.
- 6- Find compression in ridge and provide steel as in column inclined length or ridge beam.

$$\sqrt{a^2 + b^2}$$

- Compression = (shear * length) * 2
..... (From two sides).
- Compare the above compression as calculated from the column load.

$$\text{Comp} = \frac{PL}{4h}$$

Conical

- 1- Find base diameter based on safe bearing capacity .

$$\frac{\pi D^2}{4} q_{safe} = \text{AREA}$$

- 2- Find shell parameters (S1), (S2) and (Θ).
Where
(S1) - Distance from apex to column.
(S2) – Distance from apex to end of shell.
(Θ) – half central angle.
- 3- Find vertical pressure (q_v) for factored load.
- 4- Maximum compression per meter is at base of column at the top of the cone ($S = S_1$)

$$N_c = \frac{q_v}{2S_1} \tan\theta (S_1 - S_2)$$

- 5- Design for compression
With minimum thickness for cover < 50 mm for steel... etc
Last thickness = 120 mm

- 6- Check where no compression steel is required (let is be S from both apex).

$$\text{Compression token per mm} = \frac{q_v * 2(S_1^2 - S_2^2)}{2S}$$

- 7- Check percentage of steel at bottom (where compressions least).

Assuming constant thickness of shell.

We must provide minimum steel $P = \frac{A_{steel}}{\pi * D * t_{minimum}}$

- 8- Design for maximum hoop tension @ S_2 :
 $N_t = q_v * S_2 * \tan\theta$

- 9- Design for hoop tension N_t at place where column and steel meet.

- 10- check elastic stress in tension (elastic design).

DESIGNE OF SQUARE FOOTING

- 1- Find size of footing or dimensions.
- Area (A) = $\frac{\text{service loads}}{\text{allowable bearing capacity}}$
- Load = 1.0 LL + 1.0 DL + Wt of footing.

- 2- Ultimate soil reactions (only DL + LL to be token).

$$\text{Design load} = 1.5 \text{ DL} + 1.5 \text{ LL}$$

$$\text{Reaction} = \frac{\text{Design load}}{\text{Area}}$$

- 3- Depth for one way shear.

Assuming min shear = 0.35 N/ mm².
(Corresponding to 0.2% steel).

$$d = \frac{p(L-a)}{2p+700L^2} \text{ (in meters).}$$

- 4- Depth of tow way shear.

IS code critical section at d/2 from face as in flat slabs .

- Parameter = 4 (b + d).
- Shear = Reaction (L² - (b + d)²).
- Shear value = 0.25 \sqrt{fck} .

- 5- 5- Depth from bending (for square of L).

$$M = \frac{p(L-a)^2}{8L}$$

- 6- Reinforcement required

$$\sqrt{\frac{M}{Ld^2}} = \sqrt{\frac{1246.2}{5200 * (1330)^2}} = 0.135 \text{ (top layer).}$$

- 7- Check development length, (Length from the of the column).

RESULT

Comparison between shell foundations (hyperbolic and conical footing) and sloped footing Through the comparison we came to the following results

	Hyperbolic	conical	square
Volume (m ³)	19.87	22.6	38.3
area steel (mm ²)	3354.11	9160	14247
percentage save concrete	48.10%	41%	-
percentage save steel	76.50%	35.70%	-

Table 1. Comparison Table

Conclusion

The Hyperbolic and conical shell footing were designed and compared with sloped footing. The following conclusion can be drawn:

- 1) The hyperbolic shell footing were found economical than that of conventional footing, and its saves the concrete and steel up to 48.10%.
- 2) The conical shell footing were found economical than that of conventional footing, and its saves the concrete and steel up to 41%.
- 3) It gives minimum materials consumption over the conventional footing.
- 4) It gives the greater load capacity and stability over the conventional footing.

- 5) On the other hand, they need trained labor, so they are common use in East Asia due to low wages and high building materials.

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