ABSTRACT

Funicular shells have been successfully used as roof elements of many structures. They have proved more economical and efficient than other types of roofs for different spans and loading conditions. The use of funicular shells as foundation elements in place of conventional reinforced concrete footings and rafts is, therefore, of interest. This will result in saving of materials like cement and steel and encourage use of prefabricated units for a builtup foundation. The present study was undertaken with a view to identify the parameters involved both in terms of soil and structure and also the economy which can be effected.

A review of literature showed that very little work has been done in the use of funicular shells as foundation. The differences in the behaviour of shell elements have been studied and inferences drawn regarding the special requirements for their use as foundations. The essential advantage of the shell foundation is that it directly rests on the soil and derives full support from it. This reduces the possibility of local buckling to a minimum. The downward convex shape of the shells exerts a favourable influence on the distribution of soil stress. The studies undertaken also revealed the greater efficiency and the higher ultimate capacity of the funicular shells when used as foundation elements.
Studies were conducted on shell models of various depth/span ratios and raft model of same size in the field and in the laboratory. It was observed that the shell with the least depth/span ratio consistent with the required rigidity for the shell, is the best one for use as a foundation element.

Prototype shells were also cast and tested in the field and the laboratory. They were loaded along their edge beams in different modes - uniformly distributed load on edge beams, concentrated loads on edge beams at their centres and at the corners of the shells. Under different types of loading, the collapse loads fell in a narrow range, eventhough, the failure mechanisms differed significantly from case to case. Using Haidukov's theory, the collapse loads were calculated for the cases of the shells with uniformly distributed load on their edge beams and they agreed well with the values obtained from tests within experimental limitations. In all the cases of loading, cracks developed first on the edge beams and they proceeded on to the shells leading to their collapse. Therefore, it was inferred that by strengthening the edge beams, the shells could be put to its optimum use. This finding led to the use of multiple shells by suitable connecting elements of sufficient rigidity to transmit the loads to the shell through their edge beams.

Tests were conducted on multiple funicular shell footing with shell models, and shells of two sizes with
suitable connecting elements on a test bed of sand with low relative density. It was observed that for the multiple funicular shell footing, the performance was primarily governed by the rigidity of the connecting elements. In all the cases, the ultimate capacity of the units were more than the sum total of the ultimate capacities of individual shells in them. For a multiple funicular shell footing with comparatively rigid connecting elements tested on a dense sand bed, the ultimate capacity of the unit was more than four times the sum of the ultimate capacities of the shells in it. An optimum design for the multiple funicular shell footing will result when the connecting beams, the edge beams, and the shells in the unit fail simultaneously.

The performance of an experimental structure constructed on a multiple funicular shell raft on fills over soft marine clay deposits of Kuttanad was monitored for a long period. It was found satisfactory from considerations of bearing capacity and settlement.

The studies conducted on a strip foundation in the laboratory test bed indicated its potential use for combined footing.

The analysis of the cost of funicular shell footings and rafts and comparable foundation elements of reinforced cement concrete revealed significant savings in scarce building materials and construction costs by adopting the former.