NUMERICAL ANALYSIS OF LOAD-DISPLACEMENT BEHAVIOUR OF SKIRTED RAFT FOUNDATIONS

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Abstract - Skirted foundation is one of the new approaches for improving the performance of shallow raft foundation by using skirts to it. Skirted foundations are the shallow foundations in which the footing is reinforced by the addition of vertical plates or skirts. The improvement in performance of skirted foundation depends on the geometrical and structural properties of the skirt and footing such as shape, depth of the footing and skirt, skirt geometry etc.;soil characteristics namely index properties of soil and the interface conditions of the soil-skirt-foundation systems such as roughness and material of the skirt etc. In this study an attempt has been made to determine the behavior of surface raft with and without skirts and compare the bearing capacity and corresponding settlement in two soil model- Hardening soil model and Mohr-Coulomb model using a finite element software PLAXIS 3D.

Key Words: Raft foundation, Bearing capacity, settlement, Plaxis 3D, structural skirt.

1.INTRODUCTION

Now a days geotechnical engineers are seeking an alternative method for improving the bearing capacity and reducing the settlement of footing resting on soil. There are different methods of soil stabilization that can be prohibitively expensive and restricted by the site conditions. In certain conditions they are difficult to apply the existing foundations. In such cases, structural skirts hold as good alternative method for improving the bearing capacity and reducing the settlement of footing resting on soil. Structural skirts have been used for a considerable period to increase the effective depth of the foundations in marine and other situations where water scour is a major problem. In this method, the improvement of bearing capacity does not require any soil excavation and is also not restricted by the presence of a high ground water table. Skirts provided with foundations, form an enclosure in which soil is completely confined and acts as a soil plug to transfer the load of superstructure into the soil. Skirted foundations have been considerably used for offshore structures like wind turbine due to easy installation compared to deep foundation. The skirted foundation consists of a slab and a shell and may have any shape. The footing slab may be circular, square or rectangular in shape and accordingly the skirt wall will have the same shape in section as that of the slab. The skirt wall angle with the vertical may vary from zero to a value less than 90 degree. It is recommended by researchers that the proposed foundation can be used as foundation for small buildings, industrial floors, storage tank, grain silos, industrial chimneys etc. It is a believed that the vertical skirts improve the foundation capacity by „trapping" the soil beneath the raft and between the skirts so that applied load is transferred to the soil at the skirt tips. Skirt foundations have different functions such as control of settlement,during operation at installation site it has less impact to environments. It is used to satisfy bearing capacity requirement, and help to minimize the embedment depth and dimensions of the foundation. Moreover single skirt can be provided under footing resting on soil bed where the soil underneath is having variation in its properties in horizontal direction. Sometimes, the architectural requirements of a structure need some portion of the structure to be on weak or filled up soil. In such cases if a skirt is provided on one side of the footing, the soil particles near the skirt will be prevented from lateral movement. Hence bearing capacity of the foundation can be increased and the tilt of the footing can be reduced.

2. MATERIALS

2.1 Sand

The sand used in the study is locally available river sand. The index and engineering property of the sand was studied in the laboratory and the results are as given in Table 1.

Table -1: Properties of sand used in the study

Property	Values
Specific Gravity, (*G*)	2.7
Classification	SP
Relative density	79.36%
Friction angle (ϕ)	32^{o}
Dry weight of soil(γ_{dry})(KN/m^3)	17

3. NUMERICAL MODELLING

An extensive finite-element analysis is carried out using plaxis 3D to study the effects of skirts on the behavior of uniformly loaded surface foundation on sand. The geometry of the finite element soil model taken for the analysis is 15B X 20B with different raft sizes of B =10m,12m,15m,17m,20m with skirt depth (Ds)= 0.5B,1B,1.5B,2B.The soil used for the analysis purpose was basically cohesion less sandy soil. The Hardening-soil model and Mohr-Coulomb model are used separately to represent the behavior of sand using Fifteen-node triangular elements. Both the footing and skirts were considered as linear elastic material. Figures 1 and 2 shows the geometric model of raft foundation without skirt and with two side vertical skirt for one typical case 15m raft foundation

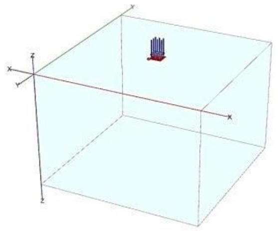

Fig -1: Model geometry (Without skirt)

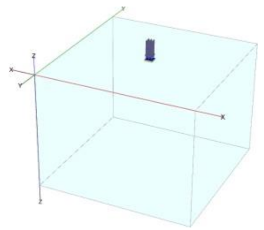

Fig -2: Model geometry (With skirt)

Six different skirt ratios (D_s/B) were tried for namely 0.5, 1, 1.5, 2, 2.5 and 3 to study the performance of different Skirts on raft foundation.

4. RESULTS AND DISCUSSION

Using the tabulated soil properties analysis was done in Plaxis 3D for raft foundation without skirt and with Vertical skirt at two sides.The modeling and results Obtained from PLAXIS 3D is presented herewith.

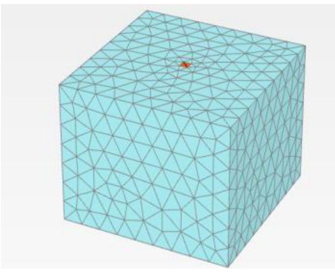

Fig -3: Finite-element mesh of raft size B=10m (Without skirt)

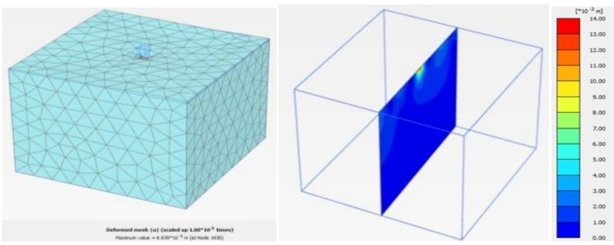

Fig -4: Deformed mesh of raft size B=10m (without skirt) using Mohr –Coulomb model

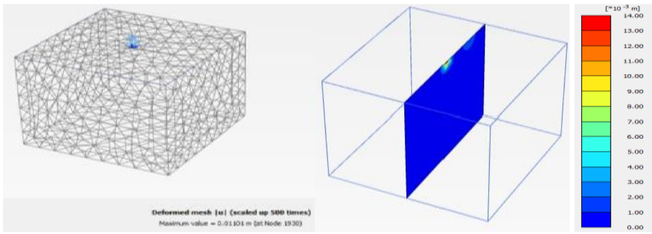

Fig -5: Deformed mesh of raft size B=10m (without skirt) using Hardening soil model

Fig 4 and Fig 5 shows that the settlement value obtained for the raft size 10 m without skirt using mohr coulomb model is 0.008939m and that of hardening soil model is 0.01101m.The value obtained from settlement equation is 0.016984m. From this it is clearly understood that the value obtained from hardening soil model is much closer to the value obtained from theoretical settlement equation. The settlement obtained from Mohr-Coulomb model was more than that by Hardening-soil model.Similarly 12m, 15m, 17m, 19m raft foundation without skirt was carried out in both soil models.

Analysis of 10m raft foundation with 1.5B vertical skirt was carried out as stated earlier and results has been presented in figure

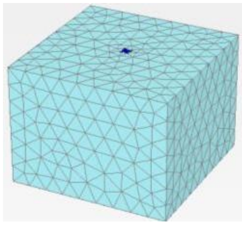

Fig -6: Finite-element mesh of raft size B=10m (With skirt)

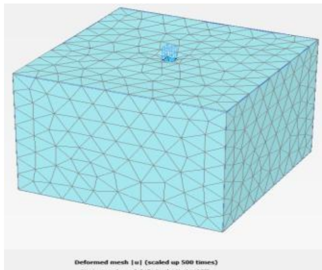

Fig -7: Deformed mesh of raft size B=10m with skirt depth of 1.5B using Mohr –Coulomb model

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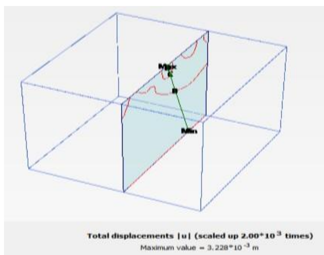

Fig -8: Total displacement contours of skirt depth 1.5B

Similarly settlement corresponding to raft size of 10m,12m,15m,17m,20m with skirt depth of 0.5B,1B,1.5B,2B was observed to be less in Hardening-soil model as compared to Mohr-Coulomb model. In Hardening-soil model settlement decreases for skirt depth of 0.5, 1, 1.5, and the settlement increases for skirt depth 2 and the settlement decreases in raft size up to 17m and then increases. The mesh deformation or extreme displacement is less in Hardening Soil model, which is due to more stiff behavior of HS model. Compared to Mohr Coulomb (MC) model, HS-model are more accurate because it uses three different inputs of stiffness parameters which are E50, E_{ur} and E_{oed} while MC-model only consider for E value which is limited number of features that soil behavior show in reality. For MC-model, Hooke's single stiffness model with linear elasticity in combination with an ideal plasticity, whereas the HS-model use double stiffness model for elasticity in combination with isotropic strain

5. CONCLUSIONS

The performance of a raft footing with a structural skirt resting on sand when subjected to a vertical load is investigated through a numerical study. A series of soil modeling's were conducted in PLAXIS 3D to evaluate the performance and reduction in settlement of a raft footing with and without a structural skirt. Following are the conclusions drawn from the results and prolonged discussions presented above;

- Results of the analysis indicate that the use of structural skirts reduces the settlement for both the models, but the performance of Hardening-soil model is better than the Mohr Coulomb model.
- The settlement decreases for raft size 10m, with skirt 0.5B to 1.5B and then increases when the skirt depth is increased to 2B in both the soil models.
- The settlement decreases for raft size 12m, with skirt 0.5B to 1.5B and then increases when the skirt depth is increased to 2B in both the soil models. Same results are produced when the raft sizes are modified to 15m, 17m and 20m.
- In this study it was found that the settlement decreases for a skirt depth of 1.5B irrespective of raft size.
- Detailed experimental study is required to find the variations in the measurement of settlement values

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