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FINITE ELEMENT ANALYSIS OF SKIRTED FOUNDATION RESTING ADJACENT TO SAND

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Abstract— Skirt foundations are generally used to improve the bearing capacity of the shallow footing on sandy soil. These are also considered as an alternative to the deep foundations in low strength soil. Slope stability is the resistance of inclined surface to failure either by sliding or collapsing. This paper reports the application of using a skirted foundation system to study the behavior of foundations with structural skirts adjacent to a sand slope. The skirts effect on controlling horizontal soil movement and decreasing pore water pressure beneath foundations and beside the slopes. This thesis paper is investigated numerically using MIDAS . A series of models for the problem under investigation were run under different skirt depths and location from the slope crest. Nodal displacement and element strains were analyzed for the foundation with skirts.

Index Terms—Slope Stability, Skirt Foundation, MIDAS, Finite Element Modelling.

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1 INTRODUCTION

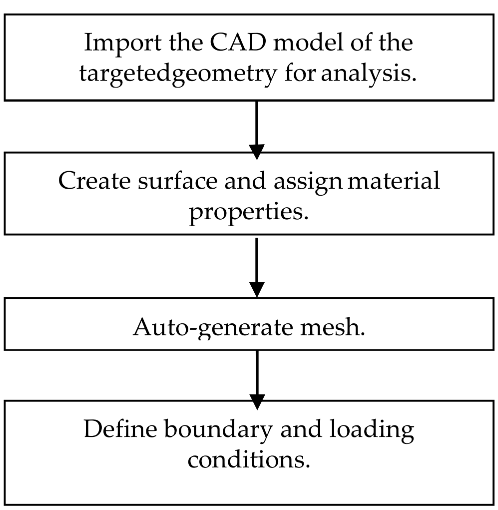
HE skirted foundations are used to improve the bearing Tcapacity and reducing the settlement of footing resting on soil.Many soil stabilization methods are available, but it may be prohibitively expensive and restricted by the site conditions. In this case structural skirts is an alternative method of improving the bearing capacity and reducing the settlement of footing resting on soil.In skirted foundation it form an enclosure in which soil is strictly confined and acts as a soil plug to transfer the load of superstructure to soil.Skirted foundations are mainly used in offshore structures like wind turbine,oil,and gas industry etc.Main functions of skirted foundations are control the settlement during service life,less impact to environment during installation and operation.

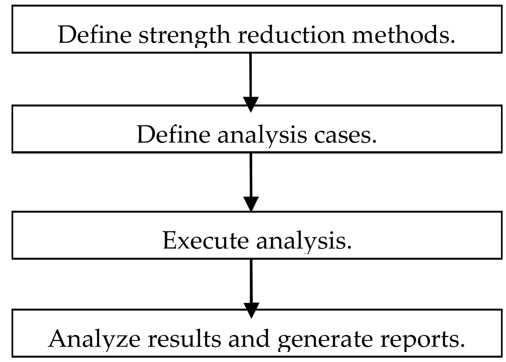
When footing is located on a sloping ground,the bearing capacity of the footing may be significantly reduced,depending on the location of footing with respect to the slope.Different methods to improve the slope stability are:modifying the slope surface geometry,using soil reinforcement,nailed elements or piles,installing retaining walls etc. Using structural skirts in conjunction with foundation is a method to safeguard slope from collapsing and control the lateral deformation of a slope.Skirts also increase the inertial stability of a slope by decreasing the slope deformation.Effect of skirted foundation on sandy slope is analysed by finite element method.This analysis helped in better understanding of the failure pattern and in discovering the results that cannot be measured in the laboratory for the adopted system. **W.R.Azzam** Finite element analysis of skirted foundation adjacent to sand slope under earthquake loading. This paper reports the application of using a skirted foundation system to study the behavior of foundations with structural skirts adjacent to a sand slope and subjected to earthquake loading. The effect of the adopted skirts to safeguard foundation and slope from collapse is studied. A two dimensional plain strain program PLAXIS, (dynamic version) is adopted. A series of models for the problem under investigation were run under different skirt depths and lactation from the slope crest. The effect of subgrade relative density and skirts thickness is also discussed. The research results showed a great effectiveness in increasing the overall stability of the slope and foundation. **Hisham.T.Eid** in his journal paper the behaviour of axially loaded skirt foundation was studied by the numerical analysis method. Different shear strength properties of surface foundatio , pier foundation, skirted square foundations were utilized in his numerical analysis.A physical model testing was carried out to support numerical analysis results. In this journal, the effect of size of the foundation, skirt length, shear strength of sand on settlement of skirted footing were assessed. Settlement reduction was found to exceed a value of 70% in the case of L/D ratio of 2. In this experiment work,a dimensionless chart was developed for friction angle and relative density. From this work it was concluded that skirt foundation shows the bearing capacity and settlement which was close to that of pier foundation of same width and depth. **Kangkan Sharma and Dr.Nayanmoni chetia** attempt to determine the behaviour of surface raft in both confined and unconfined case under two different soil model hardening soil model and Mohr- Coulomb model using finite element FEM software PLAXIS 2D. In numerical extensive finite – element analysis is carried out using plaxis 2D to study the effects of skirts on the behaviour of uniformly loaded surface foundation on sand . The geometry of the finite element soil model have been taken for the analysis and it was 15BX20B having different raft sizes of B=10m,15m and 20m with skirt depth(Ds) = 0.5B, 1B, 1.5B, 2B, 2.5B, and 3B. The analytical results show that with the increase in skirt depth, the bearing capacity increases and settlement decreases for both the model. The enhancement of bearing capacity and reduction in settlements by skirts were clearly observe from both the models. **W. Yoo** Laboratory investigation of bearing capacity behavior of strip footing on geogrid-reinforced sand slope This paper presents the results of laboratory model tests on the bearing capacity behavior of a strip footing on a geogrid-reinforced earth slope. A wide range of boundary conditions, including unreinforced cases, was tested by varying parameters such as geogrid length, number of geogrid layers, vertical spacing and depth to topmost layer of geogrid. The results were then analyzed to establish both qualitative and quantitative relationships between the bearing capacity and the geogrid parameters. **Sareesh Chandrawanshi, Rakesh Kumar Etal** display the result of load tests that was conducted on a circular footing that was resting on sand. And studied the influence of cylindrical skirts with different heights and diameters in medium dense sand. They said that the pressure corresponding to 5mm settlement , increases by the confining of sand with skirts and due to that skirt restricts the lateral displacement of

. The relative density of sand is kept at 50% to study the phenomenon for medium dense sand. For the case of skirts having small diameters, the effects was very small and had an optimum value for a specific diameter of skirt with the diameter of pile. They concluded that the use of circular skirt has significant effect on improving the bearing capacity of footing. And also founded that as the skirt height is increased the bearing capacity also increase and the optimum depth was three times the diameter of footing for relative density of 50%.

1.2 Objectives : The main objective of proposed work is to stability analysis of skirted foundation and effect of adopted skirts to safeguard the foundation and slope from collapse. And also to evaluate degree of displacement induced in adjacent structure and soil layer during operation.

2 METHODOLOGY





MIDAS/ GTS Software

Midas/ GTS NX is a comprehensive geotechnical finite element software package that is well equipped to handle the wide range of 2-Dimensional and 3-Dimensional analysis of deformations and stability of most of soil structures in various geotechnical applications including : Deep Foundations, Complex Tunnel systems, Seepage Analysis, Consolidation Analysis, Embankment Design, Dynamic and slope stability analysis. Types of soil models available in the MIDAS software are: Linear Elastic, Tresca, Von Mises, Mohr-coulomb, Drucker-prager, Strain softening, Soft soil creep etc.GTS NX also offers an advanced user friendly modeling platform that enables different levels of precision and efficiency.

- Skirted foundation analysis using MIDAS/ GTS : GTS NX is fully equipped to model and analyze each phase of construction of skirted foundation. Analysis can be performed to obtain maximum axial forces, sheer forces, bending moments and radial displacements of the skirted foundation.

Geometry of the model

Figure1,represents the geometry of the skirted foundation. The subsoil consists of deposit of a sandy layer of 20m thickness and slope height of H,is constant equal to 8m.The slope angle is taken as 40^0 .The model considered as Mohr-coulomb model and the model behaviour chosen as undrained behavior.The material properties of the soil required for the study is shown in table1 and they are derived from previous literature (ref.journal).The water table is located at a depth of 1m from the surface. When we consider the skirt,its composed of steel with its mechanical properties shown table2.

2D Finite Element Mesh

Following are the steps involved in finite element mesh development.

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Step 1 : Analysis Case setting.

Step 2 : Define Ground and Structural Materials.

Step 3 : Define Properties.

Step 4 : Modeling.

Fig 2 shows the generated 2D finite element mesh. In this study an element with nodes are employed. The element consist of 7633 nodes.

TABLE.1.CHARACTERISTICS OF SOIL

SOIL PROPERTIES	
Type of model	Mohr coulomb
Type of behaviour	Undrained
Soil weight(kN/m^3)	17
Slope angle β	408

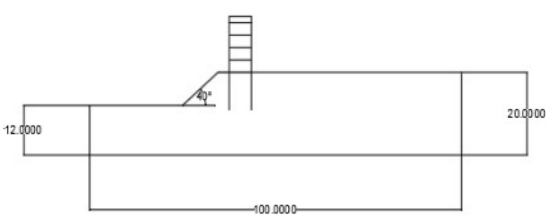

Fig.1.geometry of the finite element model and studied parameter

TABLE.2.SKIRT PROPERTIES

Youngs modulus	2x10^8 (kN/m^2)
Unit weight(kN/m^3)	39

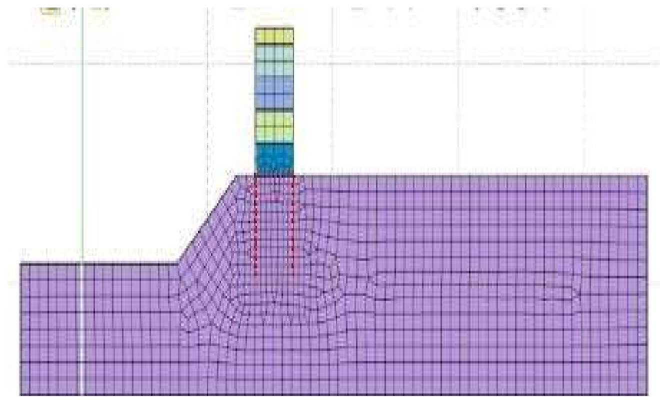

Fig.2.2D finite element mesh

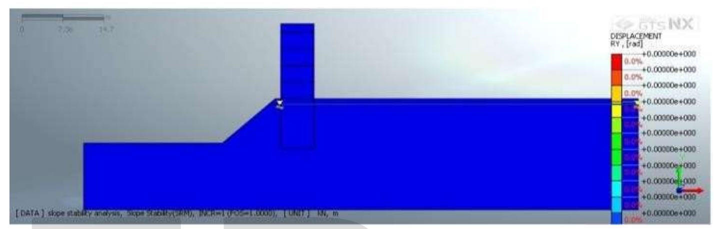

Fig.3.Displacement

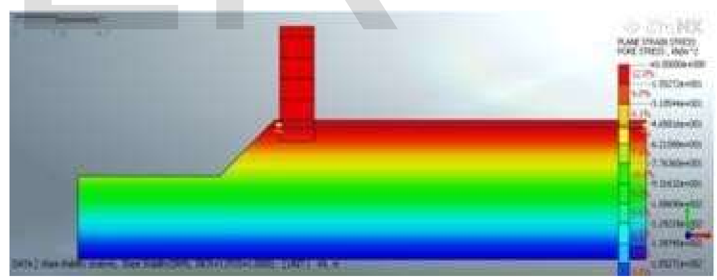

Fig.4.Plane strain stress

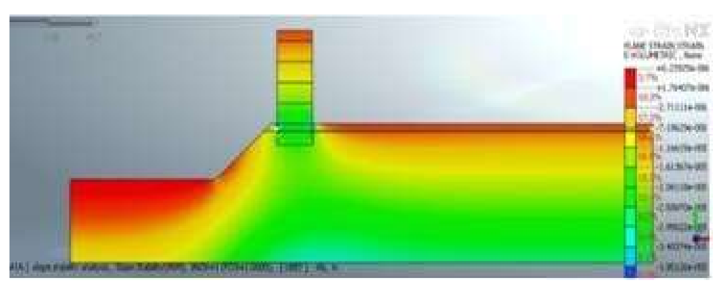

Fig.5.Plane strain strain

3 Analysis and Discussion

TABLE.3.DEPTH AND DISPLACEMENT

Depth(m)	Displacement(m)1m crest			
	0.5B depth	1B depth	1.5B depth	2B depth
0.007813	0.000743	0.000743	0.000743	0.000743
0.015625	0.001498	0.001498	0.001498	0.001498
0.023438	0.002263	0.002264	0.002264	0.002264
0.03125	0.003038	0.003038	0.003038	0.003038
0.039063	0.003824	0.003824	0.003824	0.003824
0.046875	0.004623	0.004623	0.004623	0.004623
0.048828	0.004882	0.004882	0.004882	0.004882
0.049805	0.005055	0.005055	0.005055	0.005055

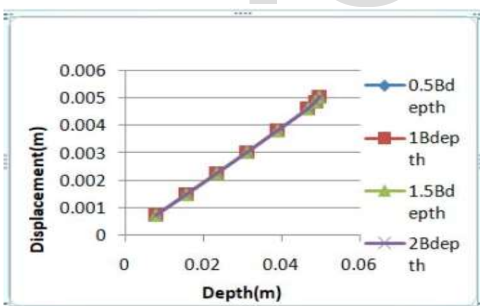

Fig.6.Displacement vs Depth

TABLE.4.DEPTH AND STRESS

Depth(m)	Stress(kN/m ²)1m crest			
	0.5B depth	1B depth	1.5B depth	2B depth
0.007813	0.004509	0.004506	0.00451	0.00451
0.015625	0.020408	0.020413	0.020409	0.020409
0.023438	0.050309	0.050303	0.050316	0.050317
0.03125	0.080622	0.080564	0.080651	0.080662
0.039063	0.199437	0.199427	0.199456	0.199459
0.046875	0.251458	0.251516	0.251461	0.251454
0.048828	0.279233	0.279267	0.279254	0.279253
0.049805	0.24625	0.246334	0.246249	0.246238

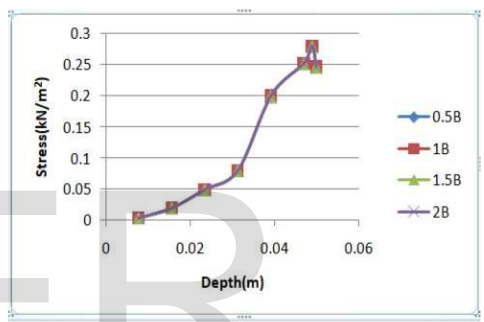

Fig.7.Stress vs Depth

TABLE.5.DEPTH AND STRAIN

Depth(m)	Strain 1m crest			
	0.5B depth	1B depth	1.5B depth	2B depth
0.007813	2.81E-05	2.81E-05	2.81E-05	2.81E-05
0.015625	6.65E-05	6.65E-05	6.65E-05	6.65E-05
0.023438	0.000114	0.000114	0.000114	0.000114
0.03125	0.000171	0.000171	0.000171	0.000171
0.039063	0.000236	0.000236	0.000236	0.000236
0.046875	0.00031	0.00031	0.00031	0.00031
0.048828	0.00037	0.00037	0.00037	0.00037

0.049805	0.000429	0.000429	0.000429	0.000429

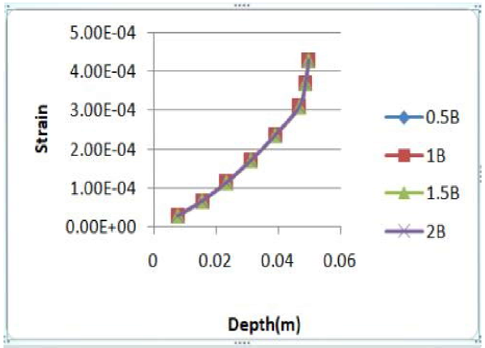

Fig.8.Strain vs Depth

4 Conclusion

- ∑ Using structural skirts in conjunction with foundation is a good method to safeguard slope from collapsing and to control the lateral deformation of a slope.
- ∑ The deformation behaviour of a slope stabilised by skirts is obviously different from case of foundations without skirts.
- ∑ Skirts effectively increase the inertial stability of a slope by decreasing the slope deformation.
- ∑ Increasing the distance from crest and depth of skirt , also increases the slope stability.
- ∑ The lowest displacement is obtained for 1.5m crest and 1.5B depth.
- ∑ Plane strain forces, strains, as well as the stresses were found to be lowest at 1.5m crest 1.5B depth.

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