Numerical Study on Stability of Slope Using Geo-Technical Software

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Abstract: Studying the stability of slopes is crucial in geotechnical Engineering to predict the failure of slope. The software such as plaxis, GeoStudio, Abaqus and Geo5 are used for numerical analysis. The "Abaqus" software is used for numerical analysis on stability of slope. Slope stability is considered as one of the most important sectors which should be addressed properly in Geotechnical engineering. This project investigates and discusses the stability of unreinforced soil mass with different density and different slope angles. It presents the results at 30°, 35°, & 45° and evaluates factor of safety and crest settlement over unreinforced soil slopes subjected to static loading over.

Keywords: Abaqus, soil density, crest settlement, slope inclination, factor of safety.

I. INTRODUCTION

Slope stability is an important aspect of geotechnical engineering, making sure the safety of natural and man-made earth structures. This study provides numerical research into slope stability using ABAQUS, an effective finite element software program acknowledged for its accuracy in modelling complex soil behaviors. The main objective of this research is: [1] To study the effect of inclination and [2] to study the effect of density.

A key parameter analyzed is the factor of protection (FoS), that is described as the ratio of resisting forces to driving forces; a FoS greater than one shows a stable slope. This analysis aims to simulate real-world conditions and predict failure mechanisms, supplying valuable insights for design and preventive measures. The results will help in understanding critical slope parameters and enhance geotechnical design practices.

The reference data is taken from "Stability of a Compacted Sand Slope Model Subject to Crest Load", Said Djelabi 1, Hatem Karoui 2, Wissem Frikha 2, Mahmoud Dlala 1, Mounir Bouassida 2, Tarek Ninouh 3 and Moufida El May 1. In which the focus is on behavior; failure load; rigid foundation; sand and slope. In this PLAXIS software was used for numerical analysis.

To validate the methodology, numerous pieces of literature have been referenced. Djelabi et al. [1] explored the effect of crest loading conditions on compacted sand slope models, highlighting the position of load placement and compaction in slope behavior. Their findings show that the software of crest load boundary conditions in the ABAQUS model. Rathod et al. [2] offered the dynamic stability analysis of reinforced slopes, indicating that reinforcement layers change the slope's resistance underneath seismic loads. Sun et al. [3] brought the use of distributed fiber optic sensing for real-time monitoring, which underlines the growing importance of integrating experimental techniques with numerical models.

Samal et al. [4] emphases on the static stability of bamboo grid-reinforced slopes, demonstrating how biomaterials can improve stability, a factor applicable to sustainable geotechnical solutions. Harabinova et al. [5]

provided observation of slope stability analysis techniques, along with classical and numerical techniques, providing a capable situation for the current study. Mohamed et al. [6] highlighted the function of soil nailing and foundation proximity, presenting a detailed understanding of load distribution effects.

Khaksar and Haghighi [7] studied geogrid applications in arid areas, showing how geosynthetic materials make contributions to soil stabilization in challenging environments. Srinivas and Padmavathi [8] tested each static and dynamic behavior of nailed slopes, providing insights into failure mechanisms under various load conditions. Shiferaw [9] performed a study on slope height and angle, which directly aligns with this thesis's focus, particularly in interpreting FoS trends. Finally, Ai et al. [10] analyzed progressive failure during earthquakes, presenting a dynamic perspective on slope failure progression and highlighting the significance of incorporating time dependent failure modes.

These reference studies provide groundwork for the numerical research performed on this thesis. Using the advanced modelling abilities of ABAQUS, this research explores how variations in slope density, inclination angle, and height affect slope stability. By analyzing the factor of safety (FoS) under different conditions, the study aims to enhance our know-how of failure mechanisms and contribute valuable insights for enhancing slope design and safety in geotechnical engineering.

II. METHODOLOGY

1. <u>Case Study Selection</u>

A relevant case study has been selected based on a published paper titled "Stability of a Compacted Sand Subject to Crest Load" This serves as the reference model for numerical simulation and analysis.

2. <u>Model Validation</u>

- Type of Validation: Numerical validation
- Tool Used: ABAQUS software
- The selected case study model is validated numerically using ABAQUS to ensure the accuracy of simulation parameters.

3. <u>Parametric Studies</u>

The study focuses on the effect of two key parameters on slope behavior:

a) **Effect of Inclination (θ) on Slope**

- Inclination at 30˚
- Inclination at 35˚
- Inclination at 45˚

b) **Effect of Soil Density on Slope**

- Density (D_1) = 1835.5 kg/m³
- Density (D_2) = 1682 kg/m³
- Density (D_3) = 1500 kg/m³

4. <u>Simulation and Analysis</u>

- **Tool**: ABAQUS
- Nonlinear analysis is performed to study slope deformation and stability under different conditions.

5. Result Interpretation

- Post-processing is conducted in ABAQUS to generate results and graphical reports.
- Comparative analysis is performed for various parameter conditions to determine trends and critical values.

III. VALIDATION

The validation is based on graph trend for angle of 30º on entire crest surface the following graph shows that the increasing trend of data observed in referred paper is also reflected in the simulation results, where increasing in settlement with respect to increase in load.

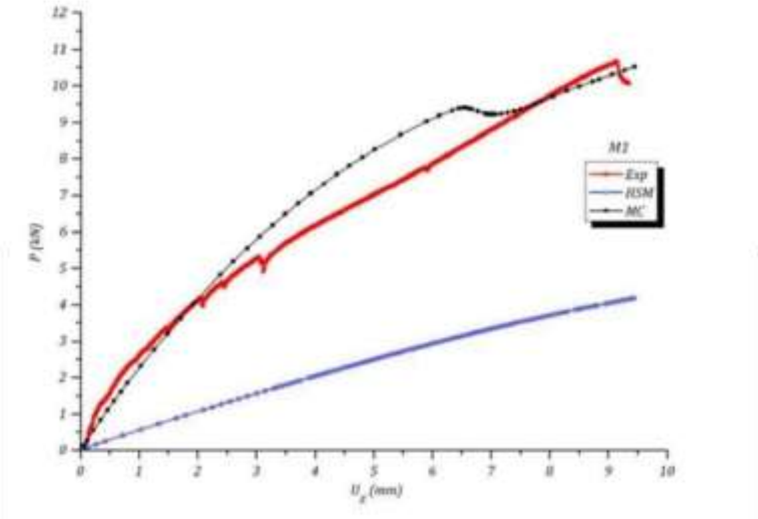

Fig. 1 Evolution of the reaction force versus vertical displacement from reference paper.

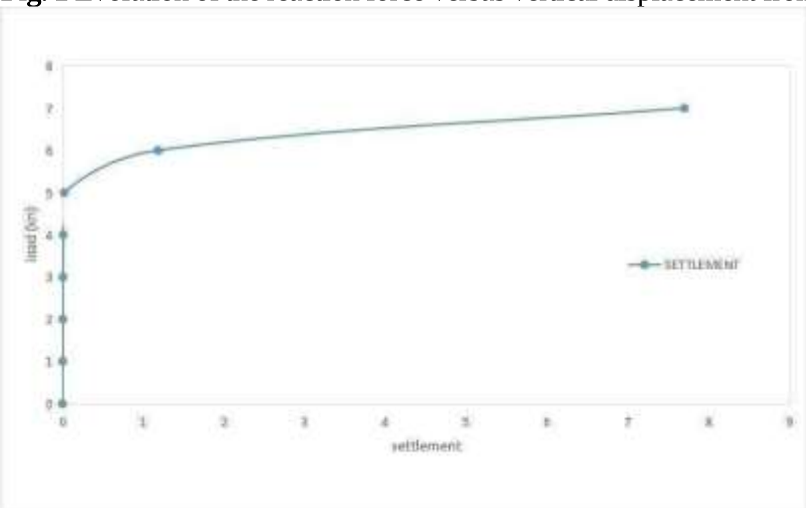

Fig. 2 Reaction force versus vertical displacement in Abaqus

IV. RESULT & DISCUSSION

4.1 The effect of Inclination on Slope

TABLE 1

SR. NO	Angle	Settlement (mm)	Ultimate Load (KN)	FOS
1.	30°	1.35	6	5.78
2.	35°	140.31	6	4.15
3.	45°	198.88	6	2.06

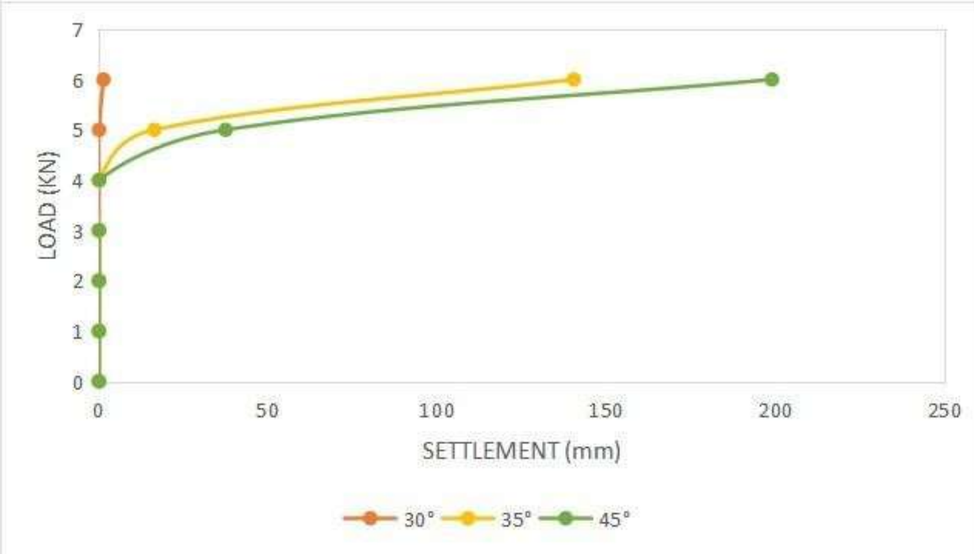

Fig. 3 Settlement Rate V/s Load graph for inclination of slope

The above graph shows the relationship between Settlement Rate (in mm) vs Load (in KN) for different angles that is 30º, 35º and 45º. From the graph, we came to an understanding that as the slope inclination (angle) increases the settlement increases.

4.2 To Study the effect of Density on Slope

TABLE 2

SR. NO	Density(kg/m3)	Settlement (mm)	Ultimate Load (KN)	FOS
1.	1835.5	198.88	6	2.06
2.	1682	225.36	6	1.98
3.	1500	274.452	6	1.11

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Fig. 4 Settlement Rate V/s Load graph for Density of slope

The above graph shows the relationship between Settlement Rate (in mm) vs Load (in KN) for different densities that is D1 -1835.5, D2 – 1682, D3 – 1500 with 45⁰ as its critical angle. From the graph, we came to an understanding that as density decreases the settlement increases.

V. CONCLUSION

- In this study, we used ABAQUS software to understand different factors like slope angles, and soil density influence the stability of slopes.
- By running simulations, we noticed how these parameters change the factor of safety, settlement, and total movement before failure.
- The Settlement at angles 30°, 35°, & 45° has found to be 1.35mm, 140.31mm, & 198.88mm respectively.
- The Factory of safety for an angle of 30°, 35°, & 45° has found to be 5.78, 4.15, & 2.06 respectively.
- The Settlement for density i.e., D1= 1835.5 Kg/m3, D2=1682 Kg/m3, & D3=1500 Kg/m3 has found to be 198.88mm, 225.36mm, & 274.45mm respectively.
- The Factory of safety for D1, D2, & D3 has found to be 2.06, 1.98, & 1.11 respectively.
- This study shows that both slope angle and soil density have a big impact on the safety factor. As slope inclination increases, the settlement rate increases.
- Lower inclinations and higher densities are more beneficial for sustaining slope stability.

VI. REFERENCE

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