



TOPIC: A COMPARATIVE STUDY OF USING SOIL NAILING AND GROUND ANCHORS FOR SLOPE STABILIZATION

Presented by

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Outline

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Introduction

Soil nailing and ground anchors are techniques used to strengthen a retaining wall, an existing slope or excavation wall.

The factor of safety values obtained depends on variables such as (1) the length of nails or anchors, (2) the nails' or the anchors' inclination angle, (3) the angle of the slope, (4) the patterns for spacing, as well as (5) the height of the slope.

The analyze was done by using the Bishop simplified method that assumes a circular failure surface and calculations were validated by the limit equilibrium method (LEM) using Slide v6.0 software.

The nails and anchors characteristics, and the soil and slope characteristics used in the study are going to be described in this presentation.

Soil nailing and anchors

Soil nailing and ground anchors consist of installing steel bars or sections into the soil. These reinforcements are closely spaced and are installed as a front face support. Soil nails are later grouted if they are installed in drilled holes. Non-grouted soil nails are also possible if nails are driven into the ground.

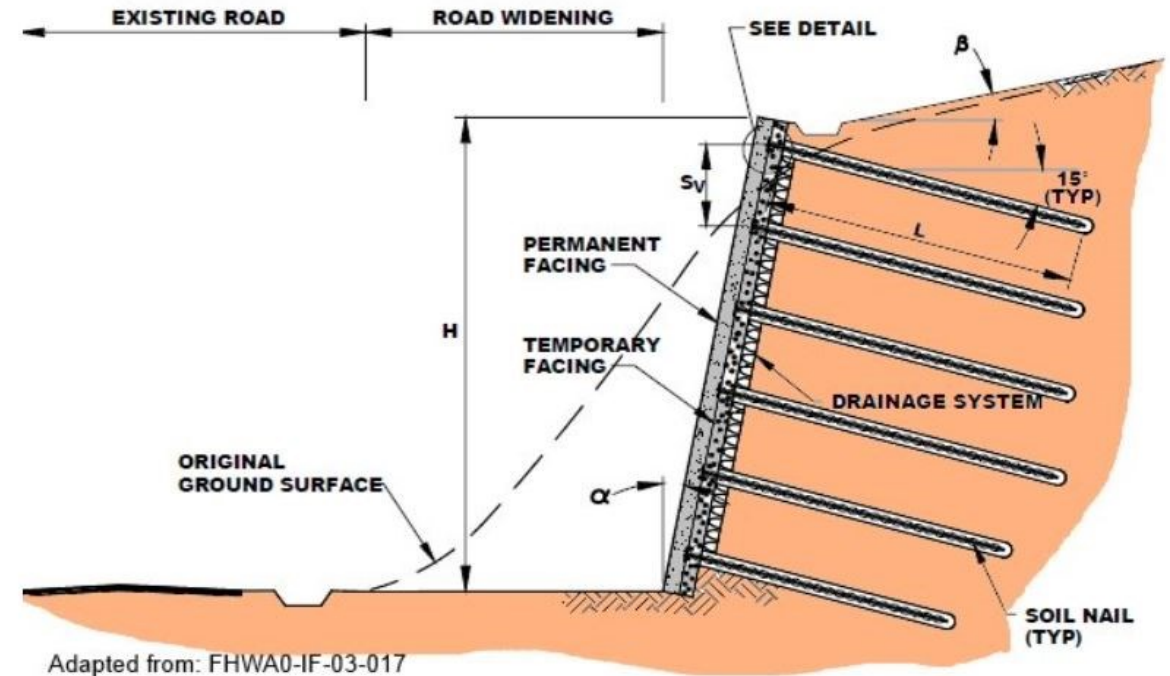


Fig.1: soil nailing presentation

(Design of soil nail walls-Information, DeepExcavation)



Literature review

The pull-out resistance of soil nails is a vital factor in the design, which is a function of soil conditions, nail length, nail surface conditions, and nail installation method. Najaf et al, 2021 studied 45° , 63° , and 80° as the excavation slope angles and seven inclinations angles of nails 5° , 10° , 15° , 20° , 25° , 30° , and 35° (Najaf et al., 2021).

An increasing of the magnitude of the nail pull-out force was found, for the slope with the same height, as the angles of the excavation slope increases. Also, the maximum force was generated at the seventieth percent of the height from the upper edge of the slope, and for the nails situated at an angle of about 30° . (Najaf et al.,2021).



The previous studies on lateral retaining wall displacement for soil nailing showed that the FEM (finite element Method) model gave the lesser value of maximum lateral deformation of the secant pile, compared to the design charts and the field measurement (Lyman et al., 2022). In their study the two-dimensional finite element analysis (2D FEM) was used for the analyze and parameter such as soil nailing length, inclination and horizontal spacing, excavation depth and thickness of the clay layer, and the undrained shear strength of the soil.

In another study a comparative analysis between SLOPE/W (limit equilibrium based) and PLAXIS 2D (finite element based) have been done for two slope angles and different inclinations for slope stability using nails. The founding was that the limit equilibrium method give higher values of factor of safety than the finite element method, also that the slope reinforced with inclination angle of 15° was found the most stable slope (Rawat and Gupta, 2016).

Methodology

In this study, the simplified Bishop method is used through Slide v6.0 software.

Slope angle α of 60° , 45° and 30° are designed. Nails and anchors length used are 10m, 13m and 15m. Finally, the slopes heights are 10m and 15m.

For soil nail walls, nail lengths are typically in the range of $0.8H$ to $1.2H$, where H is the retained height of the wall (Bridges, 2017).

The research was done on a clay soil with a unit weight of 19 KN/m^3 , the cohesion $C=25\text{kPa}$ and, the internal friction angle $\phi=5^\circ$. In all types studied, an additional uniform distributed surcharge of $q=10\text{kN/m}^2$ is put at the top of the slope to be consider as a building.

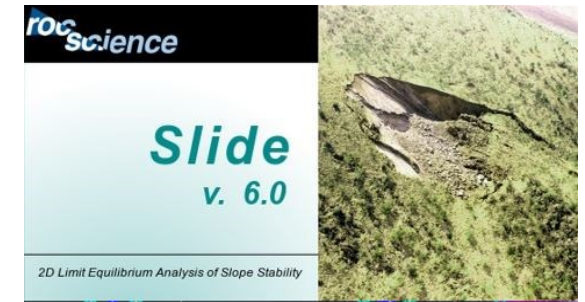


Fig.2: Slide v6.0 software

Properties of reinforcements



Table 1: patterns characteristics

Nails		Anchors	
Tensile capacity	100kN	Anchors capacity	100kN
plate capacity	100kN		
shear capacity	50kN		
bond strength	50kN/m		

The above table shows us the nails and anchors characteristics used in this study. These values are taken as the normal values we can find for the such kind of nails and anchors.

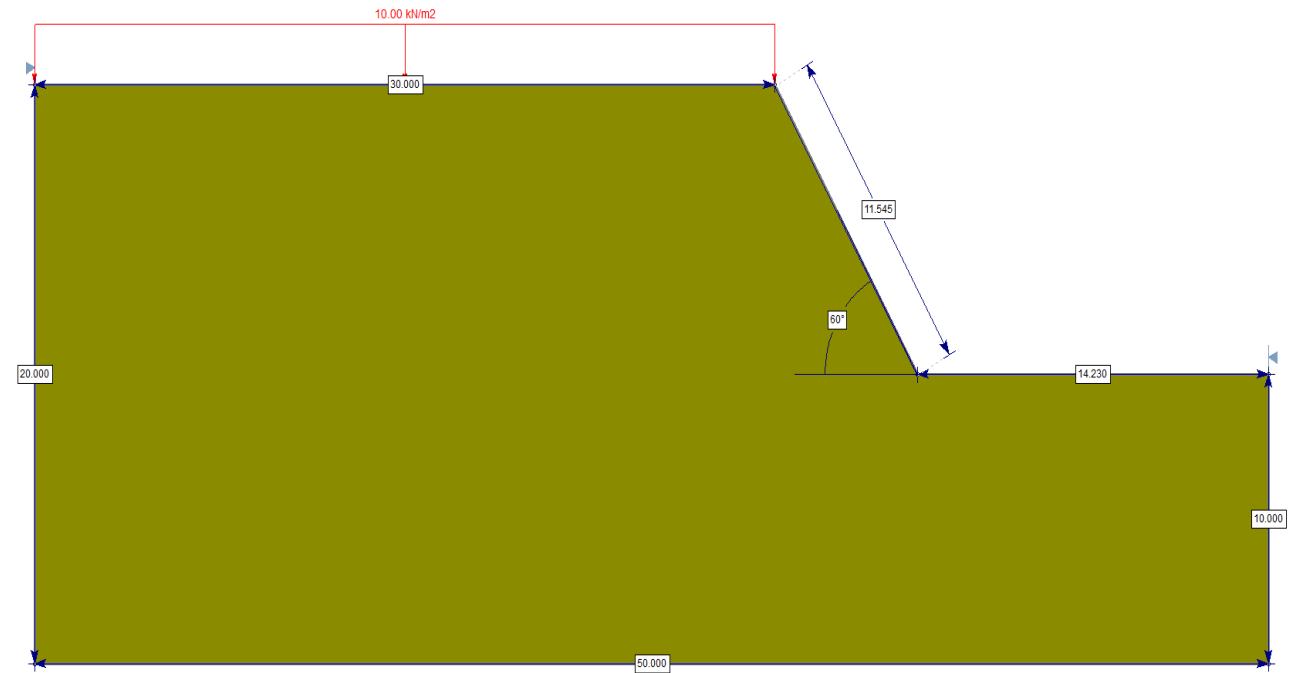


Fig.3: unreinforced 60° slope, with factor of safety:0.780



Fig.4. a 30° slope with nails

(Designing Buildings, 2020)



Fig.5. a 45° slope with nails



Fig.4. a 60° slope with nails (Designing Buildings, 2020)

Results and discussion

Graphics for the slope with angle $\alpha=60^\circ$ with all different cases. The same process is done for the slope of 30° and 45° .

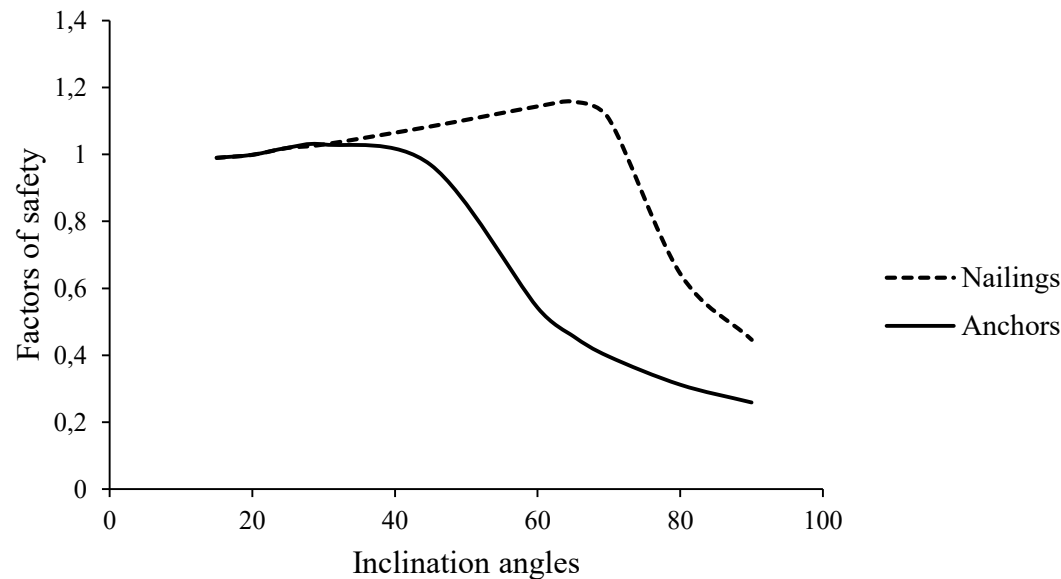


Fig 3. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=60^\circ$, $s=1\text{m}$ and $l=10\text{m}$

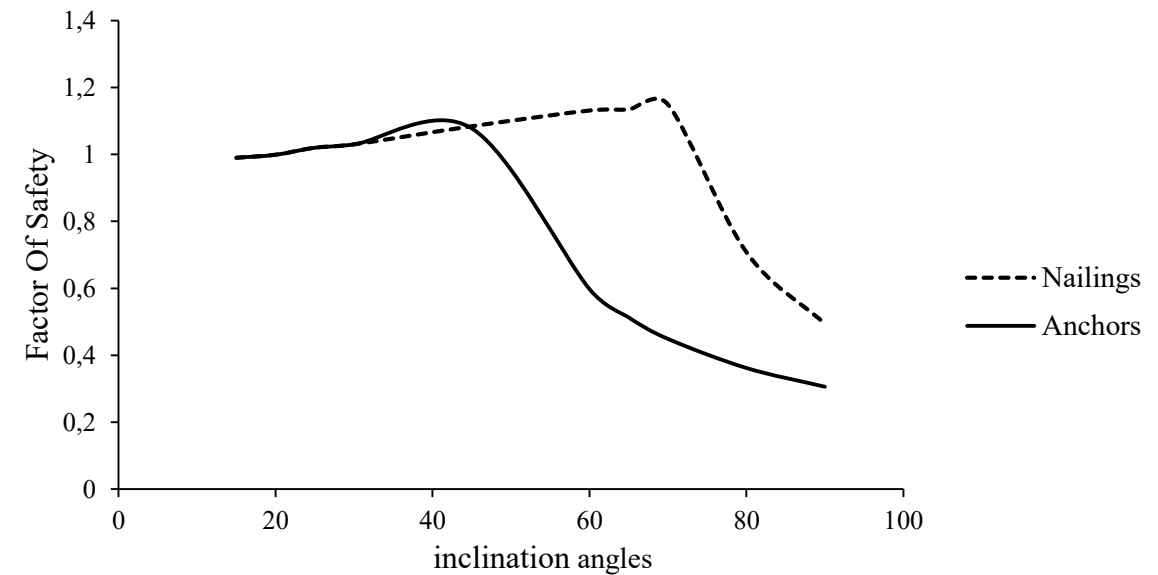


Fig 4. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=60^\circ$, $s=1.5\text{m}$ and $l=10\text{m}$

Effect of length on Factor of Safety

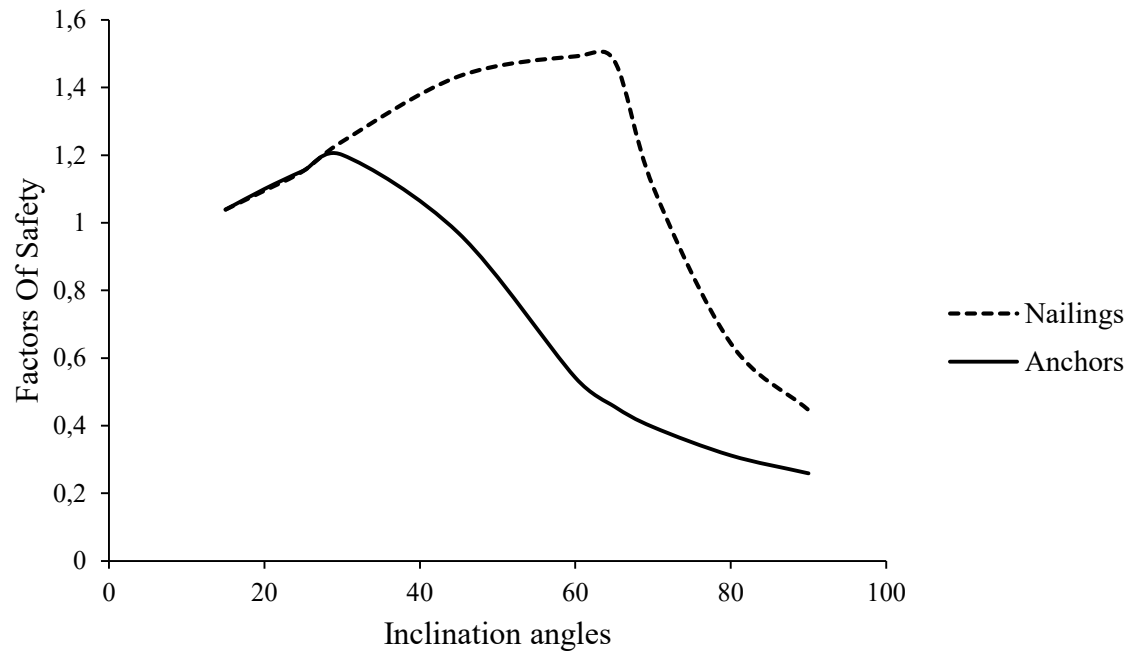


Fig 5. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=60^\circ$, $s=1\text{m}$ and $l=13\text{m}$

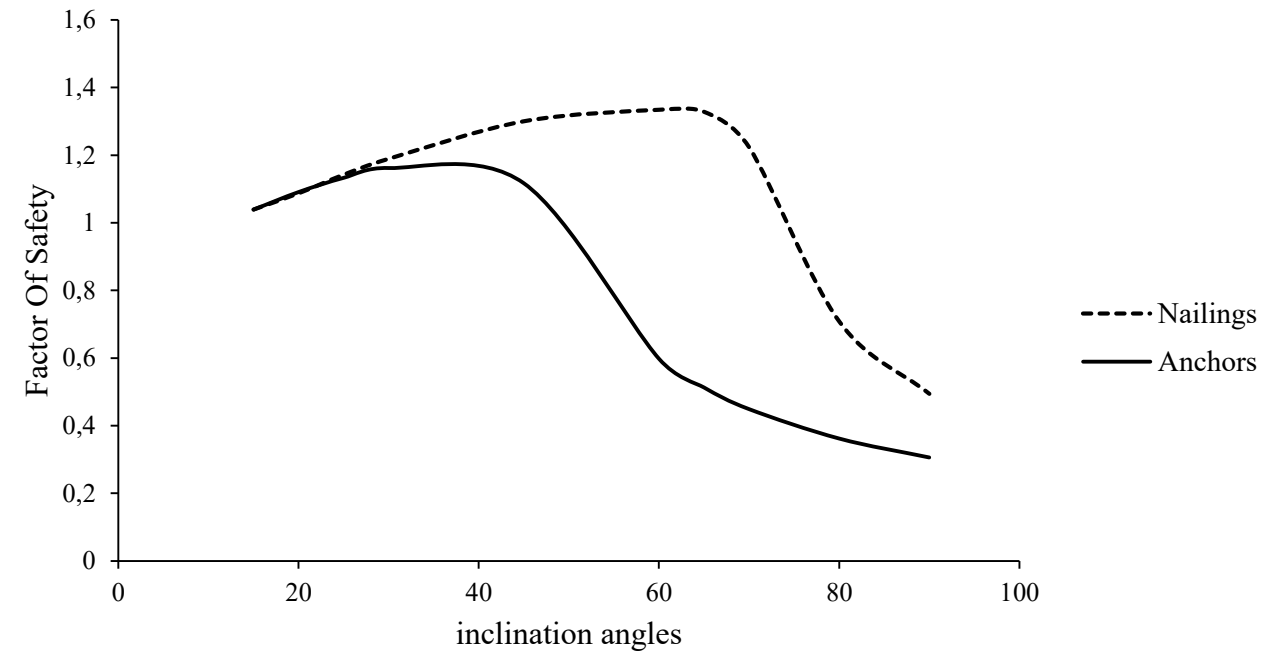


Fig 6. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=60^\circ$, $s=1.5\text{m}$ and $l=13\text{m}$

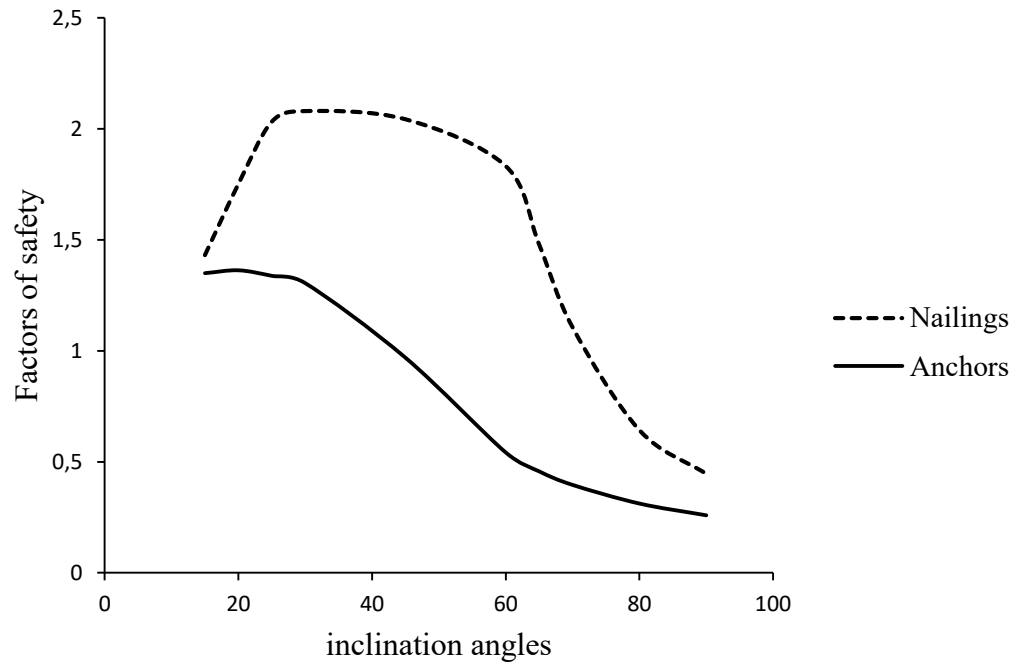


Fig 7. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=30^\circ$, $s=1\text{m}$ and $l=15\text{m}$

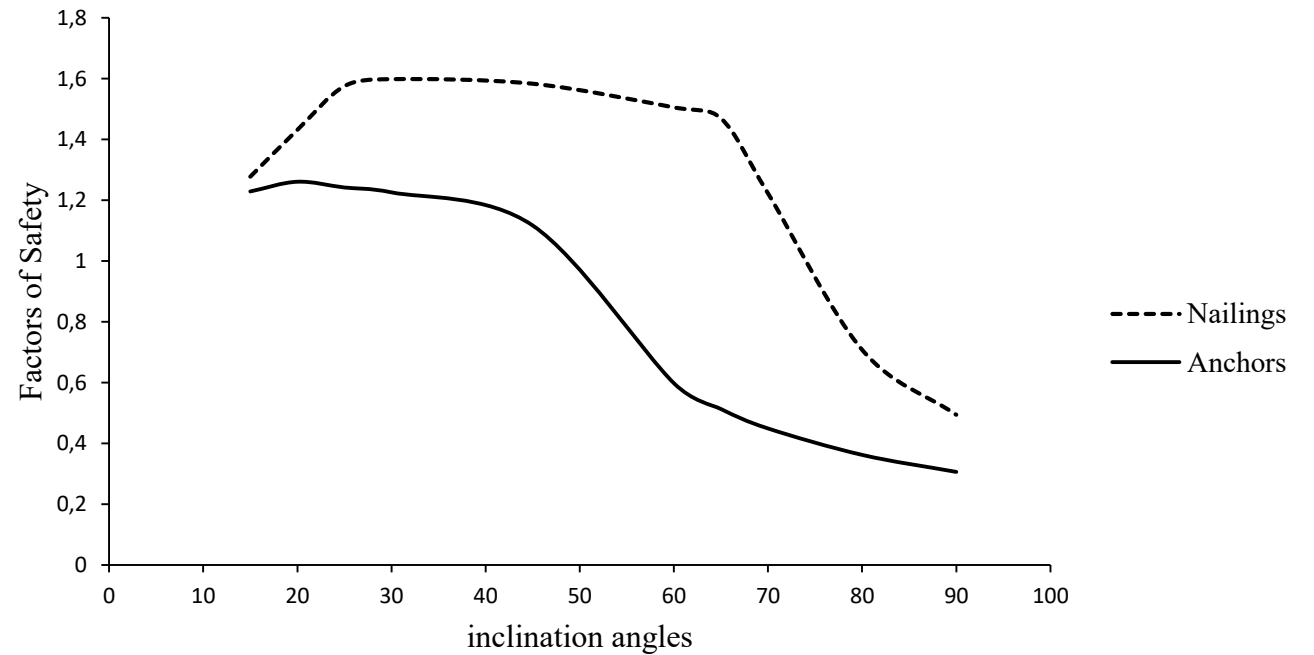


Fig 8. Relationship between inclination angle and F.S for nails-anchors for $H=10\text{m}$, $\alpha=30^\circ$, $s=1.5\text{m}$ and $l=15\text{m}$



Discussions

For the slope with angle 60° , increasing the length of nails and anchors improve the factors of safety, and the nails perform much better than the anchors. The effect of spacing patterns is decreasing the factor of safety.

Anchors stop giving effects to the slope after inclination angle $\beta=30^\circ$. And in the other side, the nails perform up to $\beta=70^\circ$. And the maximum factor of safety for all cases is found when increasing the length of patterns and it is at $\beta=30^\circ$ for nails and $\beta=20^\circ$ for anchors, all with the length of 15m.

The fact of increasing the height of slope give lowest factor of safety. No case gives F.S greater than 1. We can think about retaining wall in this case.



In case 2 when the slope angle equal 45° , again the nails give better results. The increase in slope height also does not provide a good factor of safety. It's still lesser than 1 for all cases. From $\beta=60^\circ$, anchors stop performing. For nails, the increase in length provides a higher factor of safety to the extreme inclination angle, 70° - 80° .

In case 3 when the slope angle is 30° , the nails provide an increasing factor of safety by increasing the inclination angle β . Again, here the maximum values are found to the extreme inclination angle.

For all cases, it was found that nails and anchors should be close enough to provide a reinforcing of the soil and to reduce the load on individual nails or anchors.



Conclusion

In this study, it can be concluded that the nails exhibit better performance than anchors in the given clay slopes. It was found different values of factor of safety using the Bishop simplified method and they have been compared. The factor of safety depends on some variable parameters and those parameters have been studied.

The soil in this study was a clay soil, and the results obtain will be useful only for this type of soil. The increasing of slope height in our case does not give good results and our suggest is to go for retaining wall.

For further research, gathering data as done in this study, going for linear regression for predicting the factor of safety using nails could be interesting.



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