iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37611

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Analysis and Stabilization of Slopes Using Geo5 Software

Prajwal A. Bokade[1], Vivek S. Suradkar[2], Shantanu N. Bokey[3], Rahul Ghindani[4], Prachi A. Berad[5], Abhishek M. Modak[6], Dr. A. I. Dhatrak[7]

[1, 2, 3, 4, 5, 6]*B.Tech Final Year Student, Government college of engineering Amravati.*

[7]*Associate Professor, Department of Civil Engineering, Government College of Engineering, Amravati, Maharashtra, India*

Abstract: ***With the development of technology and software, it has become easy to solve difficult problems in every field which use to take a lot of time. The use of software in the field of civil engineering has grown since the last decade. GEO5 is one such software which may be used to solve many geotechnical problems. GEO5 consists of wide range of powerful programs based on analytical method sand the Finite Element Method such as Stability Analysis, Excavation Design, Retaining, Wall Design, Foundation Design, Soil Settlement Analysis, Digital Terrain Model, Geotechnical Finite Element Analysis like analyzing and design of slope, design of retaining walls, settlement analysis, foundation design and much more .It is a very simple and powerful tool for solving geotechnical problems based on traditional analytical methods and Finite Element Methods (FEM).The easy-to-use suite consists of individual programs with a unified and user-friendly interface. Each program is used to analyze a different geotechnical task but all modules communicate with each other to form an integrated suite.***

In this project modules related to slope stability have been studied in details and then used them for analysis of slope stability. Using GEO5 software the geometry of problems were created in GEO5 and the analysis were carried out considering the stability and economic considerations. Also, the costs of different types of reinforcing methods were determined and compared. It is found that soil nailing is most economical.

Keywords: GEO5software, Analysis, Soil nailing, Anti-slide Piles, Anchors, Reinforcemet

I. INTRODUCTION

The use of software in the field of civil engineering has grown since the last decade. It has now become easy to analyze or design various Civil Engineering Structures using different software such as Stadd Pro, PLAXIS, MIDAS GTX, Geo5, OYASIS, Studds and many more.

An earth slope is an unsupported, inclined surface of a soil mass. Earth slopes are formed for railway formations, highway embankments, earth dams, canal banks, levees, and at many other locations. Basically, there're two types of slopes, natural and manmade (artificial). Each of these types may be composed of rock or soil. Natural slopes are also divided into two types, infinite slopes e. g the highway between two cities with different sea level rise or mountains. The other type of natural slopes is finite slopes (e. g hills).

The cost of earth work would be minimum if the slopes are made steepest. However, very steep slopes may not be stable. A compromise has to be made between economy and safety, and the slopes provided are neither too steep nor too flat. In other words, the steepest slopes which are stable and safe should be provided. The failure of a slope may lead to loss of life and property. It is, therefore, essential to check the stability of proposed slopes. The slope can be stabilized by using various methods such as soil nailing, anti-slide piles, anchors, reinforcement.

1) *Anchors:* Anchors are used for tensile stress. They transmit the forces from a structure (wall, foundation etc.) to the ground in which they are anchored. They are generally pre-stressed.
2) *Soil Nails:* Vertical or steeply inclined cuts can be made for open excavations using rigid soil nails reinforcement. Such cuts are also referred to as nailed soil walls. Unlike reinforced soil walls that are constructed from bottom to top, nailed soil walls are constructed from top to bottom, in steps as excavation proceeds incrementally.
3) *Anti-slide Piles:* Anti-slide piles are used to stabilize large landslides. This structure is similar to the pile wall, which is almost completely realized in the slope. This pile wall intersects a slip surface and helps prevent future landslides.

II. FEATURES OF GEO5

GEO5 is a geotechnical software suite which was developed by Fine software organization (Czech Republic). First programs were written by Jiri Laurin in 1989 in cooperation with the Faculty of Civil Engineering of CTU in Prague. In the year 1989, Geo1.0 software was launched which had the first geotechnical programs. Later on in 1992, first graphical outputs were added, then in the year 1995, full graphical user interface was added. In the year 2000, MS windows version was introduced. Earlier, when software were not in use, manual calculations were done and the process was tedious and repetitive, but now with the use of this software, design and calculations are more easier to do and also, the calculation can be performed using many analysis theories and verification according to various standards – (e.g. safety factor, theory of limit states, Eurocodes, including various national annexes, US LRFD standards or other national standards).

III. GENERALIZED METHODOLOGY

GEO5 programs are standard Windows applications and respect the standard properties of the Windows interface. Every module of Geo5 software has similar User Environment, which makes it very convenient to solve various Geotechnical Engineering problems. The frame "Settings" serves to the basic "Settings" of the program such as standards and theories of analyses, the way of proving safety of a structure and individual coefficients of the analysis. The "Geometry" frame allows selecting a desired shape of the structure. The "Terrain" frame allows specifying the terrain shape. The selected shape with a graphic hint of input values is displayed in the left part of the frame. In the "Add new soil" dialog window, a soil of required properties and parameters may be added as per requirement. A list of common types of soils with range of properties is also available and soils may be selected from the list, in absence of specific laboratory results. The selected soils then are assigned to the various layers of the subsoil strata. The "Water" frame allows for setting the levels of water. The frame "Analysis" allows user to carry out analysis of the structure and shows the analysis results. Several computations can be carried out for a single task. The analysis results are displayed on the desktop and are updated immediately for an arbitrary change in input data or setting.

IV. ANALYSIS FOR SLOPE STABILITY

The data selected for the analysis of slope is given in Table 1. Data consists soil properties, soil slope, reinforcing methods etc.

Table 1. Data adopted for parametric study

Data	Values
Soil	1) Silty Sand (Sm)Dense 2) Clayey Sand (Sc)Dense 3) Silt With Low Or Medium Plasticity(Ml,Mi)
Slope Angle	25,30,35,40,45,50 Degree
Ground Water Table	At 4 M Below Top of Slope
Height of Slope	6.5 M
Surcharge	100kN/m 5m Length
Soil Stabilization Method	Reinforcement, Anchors, Soil nails, Anti slide piles.

A. Details of Reinforcement Parameters Adopted Data

Constant as well as variable parameters taken for different types of reinforcements such as anchors, nails, reinforcements and anti-slide piles are shown in Tables below –

1) Anchors

Table 2. Constant parameters for anchors

Sr. No.	Parameter	Symbol	Value
1	Force	kN	240
2	Anchor spacing	m	1

Table 3. Variable parameters for anchors

Sr. No.	Parameter	Symbol
1	Free length	L (m)
2	Root Length	$L_{k(}$m)
3	Distances	X, Z (m)
4	Slope	α

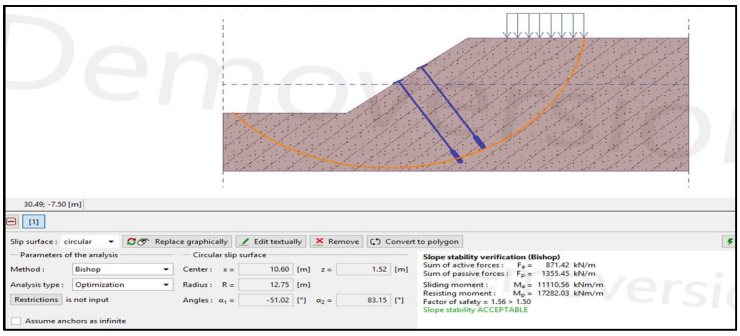


Figure 1. Anchors required to stable the slope of 40 degree.

2) Nails

Table 4. Constant parameters for nails.

Sr. No.	Parameter	Symbol	Value
1	Tensile strength of nail	kN	300
2	Pull out resistance	kN/m	25
3	Nail head strength	kN	40
4	Spacing	m	1

Table 5. Variable parameters for nails.

Sr. No.	Parameter	Symbol
1	Length	L (m)
2.	Distances	X, Z (m)
3.	Inclination	α

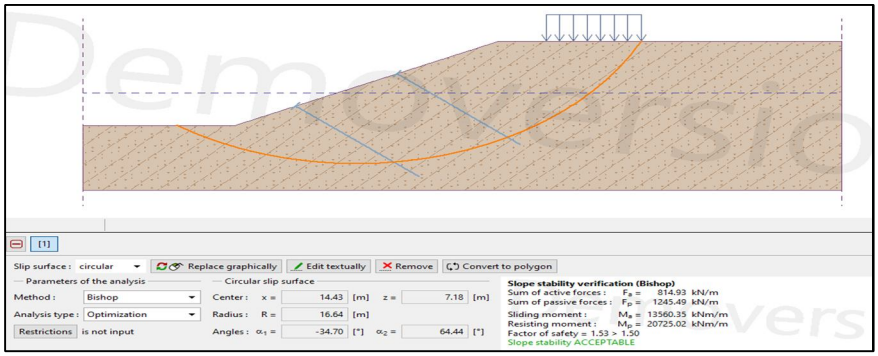


Figure 2. Nails Required to Stable the Slope of 25 Degree

3) Reinforcement

Table 6. Constant parameters for reinforcement.

Sr. No.	Parameter	Symbol	Value
1	Top spacing of reinforcement	U (m)	2.5
2	Spacing between reinforcement	S (m)	0.25 B
3	Tensile strength of reinforcement	R_t (kN/m)	200
4	Pull out resistance	C	0.8

Table 7. Variables parameters for reinforcement

Sr. No.	Parameter	Symbol
1.	Length of reinforcement	L (m)
2.	Distances	X, Z (m)

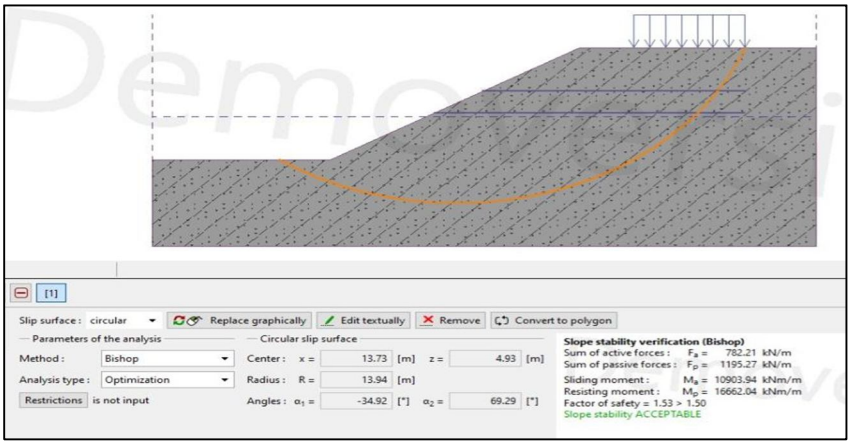


Figure 3. Reinforcement required to stable the slope of 30 degree

4) Anti-Slide Piles

Table 8. Constant parameters for anti-slide piles.

Sr. No.	Parameter	Symbol	Value
1.	Diameter of anti-slide pile	m	0.7
2.	Max. Bearing capacity	kN	300
3.	Pile spacing	m	1

Table 9. Variable parameters for anti-slide piles.

Sr. No.	Parameter	Symbol
1.	Length of pile	L (m)
2.	Distances	X, Z (m)

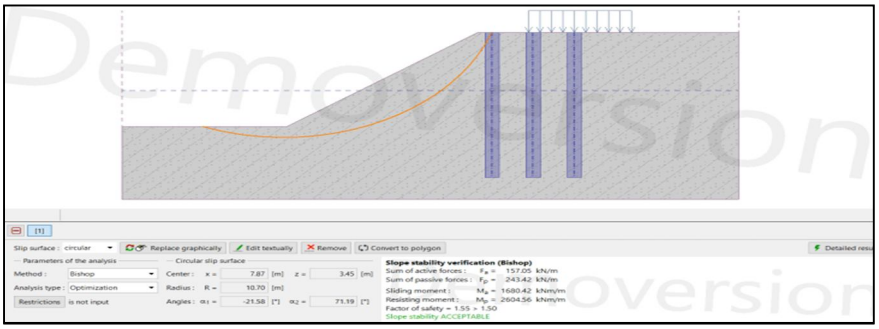


Figure 4. Anti-slide pile required to stable the slope of 35 degree

V. RESULTS AND DISCUSSIONS

GEO5 software is an easy-to-use software suite designed to solve various geotechnical problems. Analysis and design of various types of retaining walls can be done easily and efficiently using Geo5. In this project, analysis and stabilization of ground slopes with different steepness has been carried out. These problems have been solved using corresponding programs in Demo version of GEO5. As the demo version does not allow the printouts of output, the results of analysis and design have been presented in this chapter in the form of soft copies of output from the various programs in GEO5. These results are then suitably discussed.

A. Results of Parametric Study

The results of parametric studies for effect of steepness on factor of safety and effect of ground water table on factor of safety.

1) Result of Effect of steepness on Factor of Safety: Parametric study was carried out for effect of slope steepness on factor of safety on various slope angles viz. 25, 30, 35, 40, 45, 50 degrees. The soil data taken is as below.

Table 10. Soil parameters

Types Of Soils	Silty Sand (SM)	Clayey sand (SC) dense	Silt with low or medium plasticity (ML,MI) Firm consistency
Unit weight (γ)	18.00 kN/m^3	18.50 kN/m^3	20.00kN/m^3
Stress-state	Effective	Effective	Effective
Angle of internal friction (φ_{ef})	29.00^o	27.00^o	21.00^o
Cohesion of soil (c_{ef})	5.00 kPa	8.00 kPa	12.00 kPa
Saturated unit weight (γ_{sat})	18.00 kN/m^3	18.50 kN/m^3	20.0 N/m^3

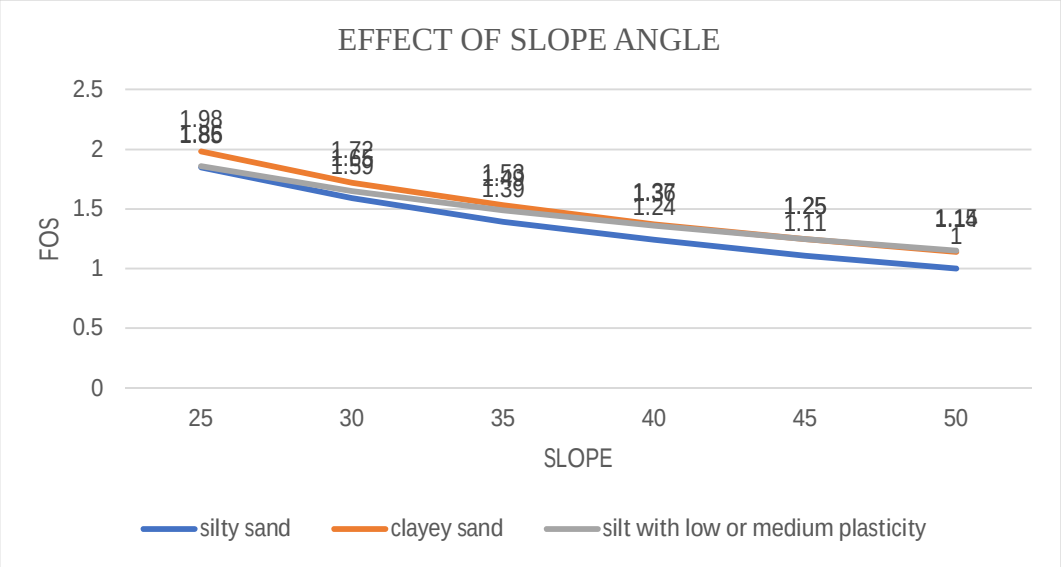


Figure 5Plot of FOS Vs ANGLE

2) *Result of Effect of GWT on Factor of Safety:* Parametric study was carried out for effect of GWT on factor of safety on various slope angles viz. 25, 30, 35, 40, 45, 50 degrees and various depths of GWT from top of slope.

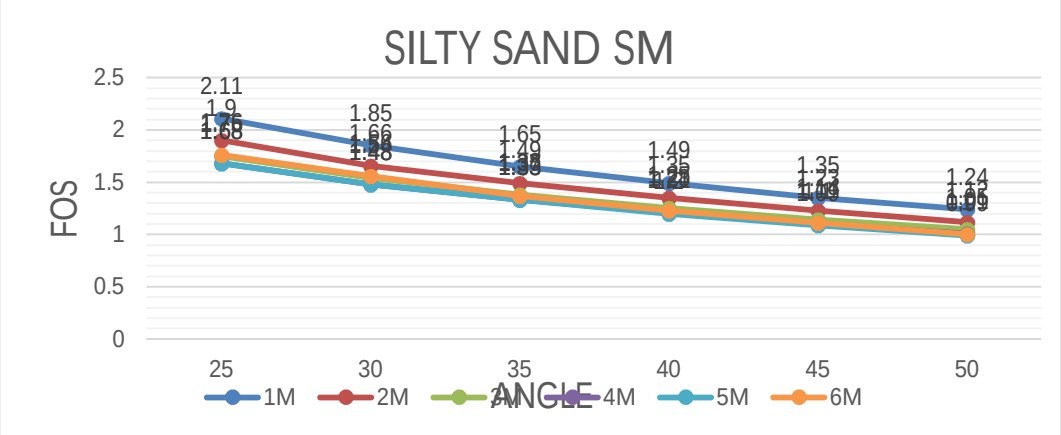


Figure 6Plot of FOS Vs ANGLE for silty sand for various

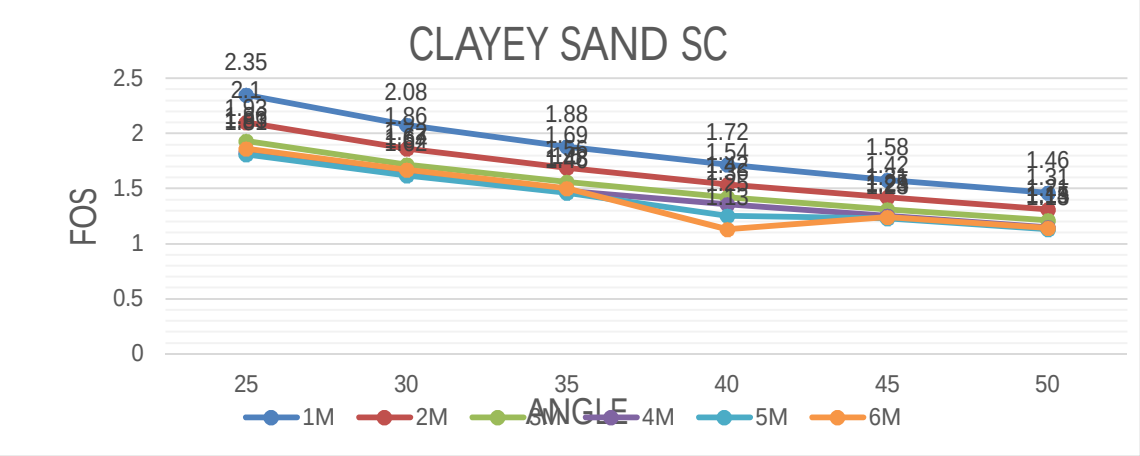


Figure 7Plot of FOS Vs ANGLE for CLAYEY SAND for various GWT

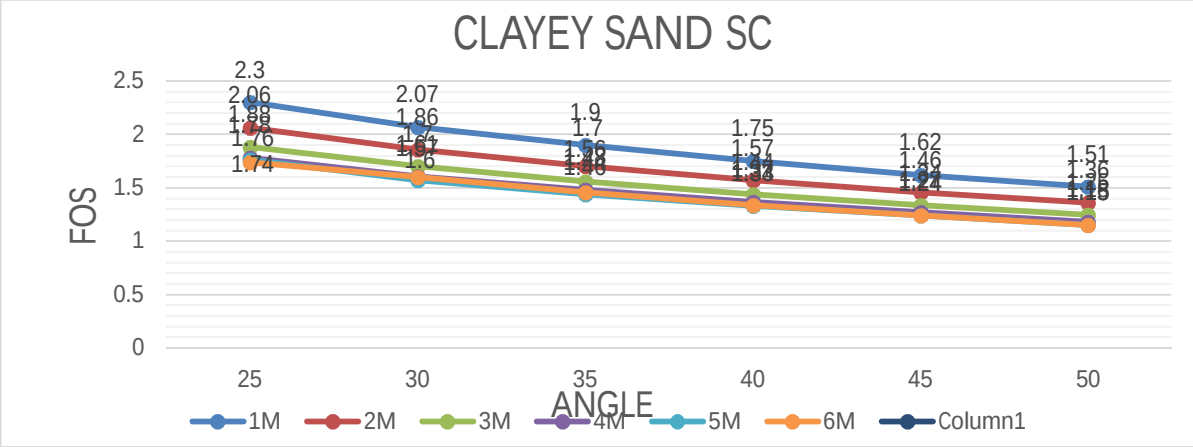


Figure 8 Plot of FOS Vs ANGLE for Silt with low or medium plasticity for various GWT

B. Results of Slope stabilization

Stabilization was done on various slope angles viz 25, 30, 35, 40, 45, 50 degrees by using various types of reinforcement available in GEO5 software. Various soil profiles were taken for stabilization. The parameters taken for reinforcements were constant while some were variable and can vary according to each angle of slope.

Table 11. Values of FOS For 25,30 ,35degree Slope After Stabilization.

Soil	Reinforcement			Anti-slides pile			Anchors			Nails		
	FACTOR OF SAFETY											
	25	30	35	25	30	35	25	30	35	25	30	35
Silty sand medium	1.54	1.53	1.56	1.53	1.53	1.55	1.53	1.54	1.56	1.53	1.54	1.52
Silty sand dense	1.56	1.53	1.56	1.59	1.53	1.57	1.57	1.54	1.54	1.53	1.54	1.52
Sp medium	1.57	1.50	1.55	1.57	1.56	1.57	1.51	1.51	1.58	1.51	1.56	1.54
Sp dense	1.54	1.56	1.59	1.53	1.52	1.54	1.59	1.63	1.59	1.56	1.58	1.53

Table12. Values of FOS For 40,45,50degree Slope After Stabilization.

Soil	Reinforcement			Anti-slides pile			Anchors			Nails		
	FACTOR OF SAFETY											
	40	45	50	40	45	50	40	45	50	40	45	50
Silty sand medium	1.55	1.55	1.53	1.65	1.54	1.54	1.55	1.57	1.57	1.55	1.52	1.52
Silty sand dense	1.55	1.59	1.53	1.64	1.52	1.52	1.55	1.56	1.56	1.55	1.52	1.52
Sp medium	1.54	1.57	1.55	1.58	1.60	1.60	1.54	1.60	1.60	1.54	1.58	1.58
Sp dense	1.54	1.59	1.60	1.53	1.58	1.58	1.57	1.56	1.56	1.56	1.53	1.53

C. Cost Analysis

Cost of each type of reinforcement is given below. **Cost:**

Reinforcement = 150 / m2 Nails = 50/m

Anchors = 600/m Anti-slide Piles - Rate of Steel = 60/kg

Rate of Concrete = 6000/ m3

Table 13. Cost Required For 25, 30 Degree Slope

Type of Soil	Reinforcement		Nails		Anchors		Anti-slide Piles	
	25	30	25	30	25	30	25	30
Silty Sand (Dense)	2118	3900	850	1000	5100	5400	27837	35791
Silty Sand (Medium Dense)	1930.5	3900	650	1000	4800	5400	25849	35791
SP (Medium)	1930.5	3900	700	1000	4500	4800	51698	65617
SP (Dense)	1555.5	1774	650	1350	4200	8400	51698	47721

Table 14. Cost Required For 35, 40 Degree Slope

Type of Soil	Reinforcement		Nails		Anchors		Anti-slide Piles	
	35	40	35	40	35	40	35	40
Silty Sand (Dense)	4050	4950	1500	1500	9600	9600	83512	83512
Silty Sand (Medium Dense)	4050	4050	1500	1500	10200	9600	119303	83512
SP (Medium)	3600	3900	1000	1500	9600	9600	65617	83512
SP (Dense)	3600	3450	800	1200	4800	8400	59651	83512

Table 14. Cost Required For 45, 50 Degree Slope

Type of Soil	Reinforcement		Nails		Anchors		Anti-slide Piles	
	45	50	45	50	45	50	45	50
Silty Sand (Dense)	4350	4650	1650	2000	9600	9600	79535	95442
Silty Sand (Medium Dense)	4350	4650	1650	2000	9600	9600	79535	95442
SP (Medium)	3750	3450	1500	2000	9600	9600	71582	95442
SP (Dense)	3300	3900	1350	1500	9000	9600	63628	95442

VI. CONCLUSIONS

From the results, it is concluded that:

A. It is found that FOS safety decreases as we goes on increasing the angle of slope. FOS is highest for 25° slope and is least for 50° slope.

B. It is found that the FOS increases when GWT is near to the top of slope and it goes on decreasing as ground water table goes down up to a certain limit. If ground water table goes further below that limit the FOS increases again up to a limit and becomes constant after certain depth of GWT.

C. Slopes up to 35 degree requires less quantity of reinforcement for stabilization and can be economically stabilized using various types of reinforcement. Slopes greater than 35 degree requires large quantity of reinforcement and cannot be stabilized economically.

D. Soil nailing proves to be most economical method of soil reinforcement.

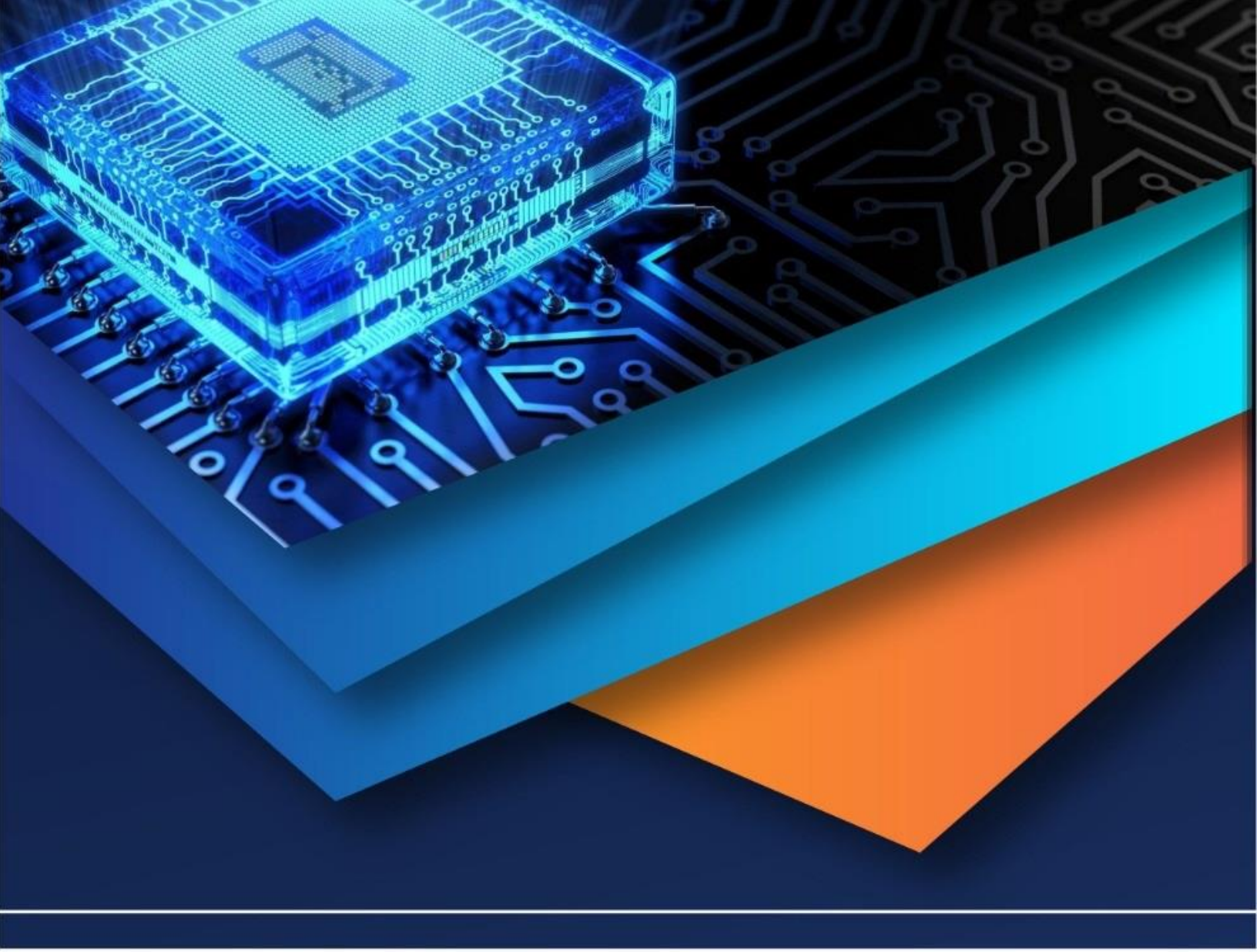
REFRENCES

[1] C. R. Shah , S. S. Sathe , P. B. Bhagawati and S. S. Mohite, “A hill slope failure analysis: A case study of Malingoan village, Maharashtra, India”, Taylor & Francis, GEOLOGY, ECOLOGY, AND LANDSCAPES 2021, VOL. 5, NO. 1, 1–6 https://doi.org/10.1080/24749508.2019.1695714 .

[2] S. Chhabra and D. Kanwar, “STABILITY ANALYSIS AND FOUNDATION DESIGN USING GEO5 SOFTWARE”, Department of Civil Engineering Jaypee, University of Information Technology.

[3] K. R. Arora, “Soil Mechanics and Foundation Engineering”, Standard Publishers and Distributors, New Delhi, 7th edition, 2018.

[4] D.Varghese and D.Isaac, "FEM ANALYSIS OF SLOPES IN IDUKKI USING GEO5", International Research Journal of Engineering and Technology (IRJET),Volume: 07 Issue: 08 | Aug 2020 www.irjet.net.
[5] A. Hankare, A. Kumavat, S. Kulkarni and V. Patil, "Stability Analysis of Finite Slope using Limit Equilibrium Method", International Research Journal of Engineering and Technology (IRJET) Volume: 07 Issue: 05 | May 2020 www.irjet.net.
[6] Mr. D. Salunkhe and G. Chvan, "An Overview on Methods for Slope Stability Analysis", International Journal of Engineering Research & Technology (IJERT), Vol. 6 Issue 03, March-2017http://www.ijert.org www.ijert.org.
[7] C. T. Veena, "Unit-2 Earth Slope Stabilities", GEOTECHNICAL ENGINEERING-2.
[8] M. Nader, "Determination of the Critical Slip Surface in Slope Stability Analysis", Eastern Mediterranean University August 2013 Gazimağusa, North Cypru.
[9] http://www.finesoftware.eu/help/geo5/en/theory-01/



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY