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Slope Stability Analysis by Using Plaxis 2d in Kudiyanmala

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***Abstract*— Geotechnical investigations are essential for the design and construction of retaining walls,as they provide information about the soil conditions and slope stability. Plaxis 2D is a finite element software package that can be used to model and analyse the behavior of geotechnical structures, including retaining walls.The report disscuss the geotechnical investigation and design of a retaining wall for slope stability analysis using Plaxis 2D. Plaxis 2D will be used to model the retaining wall and analyse its behavior under different loading conditions. The results of the Plaxis 2D analysis will be used to optimize the design of the retaining wall and ensure that it is safe and stable.**

***Keywords*— Slope stability, Plaxis 2D,Finite element method, Slope modelling, Slope analysis, Factor of safety, Critical slip surface, Deformation, Slope design, Slope mitigation.**

I. INTRODUCTION

In the earlier times, the problematical sites were usually overlooked as there were abundant areas consisting of good quality soil. But now-a-days, rapid urbanization and industrialization are urging people to make use of these challenging sites. When the shear stress goes above the shear strength, slope tends to fail due to sliding movements of materials. Hence the factors that will increase the shear stress or reduces the shear strength, will have a high possibility of creating the slope failure. Landslides are one among the slope failure which causes high destruction in environment and also it's a natural phenomenon.

Slope stability analysis using PLAXIS 2D is a geotechnical engineering method and software application used to assess the stability of slopes, embankments, and other geotechnical structures. PLAXIS 2D is a widely used finite element analysis software that allows engineers and geologists to model and analyze the behavior of soil and rock masses under various loading conditions, enabling them to make informed decisions about slope stability. PLAXIS 2D is a finite element analysis software that specializes in modeling two-dimensional geotechnical problems. It is widely used for simulating soil and rock behavior under different loading conditions, including gravity, surcharge loads, and seismic forces.

In slope stability analysis using PLAXIS 2D, the geotechnical engineer creates a digital model of the slope under consideration. This model represents the physical characteristics of the soil or rock layers, including their properties, geometry, and boundary conditions. The software then uses finite element analysis to simulate the behavior of the slope under various loading scenarios .Slope stability analysis using PLAXIS 2D is applied in a wide range of engineering projects, including the design of embankments, dams, retaining walls, open pit mining operations, and highway construction. It is also essential for evaluating the stability of natural slopes in geological and environmental studies.

II. OBJECTIVES

The objective of slope stability analysis is to obtain the safer slope comparing to before designing. It is widely used by geotechnical engineers in a variety of industries, including construction, mining, and transportation. To study the civil engineering related software like PLAXIS 2D .Geotechnical investigation and data collection of slope. To find out the stability of the slope. Analyse the remedial measures for slope failure after the surveying is done

III. SCOPE OF THE STUDY

It is decided to analyse the stability of a slope using PLAXIS 2D. The project deals with data collection and analysis of stability of slope intended for Fathima UP School ,Kudiyanmala. The main cause for analysis of slope stability are to reduce the chance of slope failure, increase safety, increase slope stability.

IV. METHODOLOGY

The first phase of the project is the site selection. The site visit helps in collecting data and to conduct survey. The selected site, Fathima UP School ,Kudiyanmala is finalized .The slope stability of the school campus is a major concern. There have been several landslides in the area in the past, and the school campus is located in a landslide-prone zone. A detailed slope stability analysis is needed to assess the risk of landslides on the school campus and to develop mitigation measures

A. Methodology flow chart

a) Selection of Site

b) Geotechniccal investigation

c) Learning software

d) Reconnaissanse survey

e) Data collection
f) Slope stability analysis using software

V. SITE ANALYSIS

A. Proposed Site

The proposed site is located at Fathima UP School, Kudiyanmala. The site is in a small town located in Kannur district. It is south Kannur. This site is selected nearness to the college and also easiness to transportation.

Fig 1 Proposed site

B. Land survey

Surveying is important in slope stability analysis because it provides accurate data on the slope geometry, soil properties, and groundwater conditions. This data is essential for creating a model of the slope and performing stability analysis Climactic Condition
A reconnaissance survey is an initial and rapid assessment of a particular area or site to gather preliminary information and assess its suitability for a specific purpose, such as engineering, environmental, or geological studies. Reconnaissance surveys are typically conducted before detailed and in-depth investigations to determine if further, more extensive studies are warranted. These surveys are characterized by their quick, qualitative, and often visual nature.

VI. SOIL TESTING

Soil testing in geotechnical investigations is crucial for understanding the properties and behavior of soil at a specific site. These tests help engineers and geologists assess the suitability of the soil for construction projects and determine the necessary foundation design or soil stabilization techniques.

A. Core cutter method

The core cutter method is a technique used to determine the in-situ (in-place) density of cohesive soil. This method helps in assessing the degree of compaction of soil layers within an embankment, roadbed, or any other compacted soil structure. It's particularly useful in construction projects where achieving a certain level of soil compaction is crucial for stability and load-bearing capacity.

B. Water content test

Determining the water content of soil is crucial in various fields like agriculture, construction, and environmental science.

C. Swell index

The Swell Index Test is performed to understand the swelling characteristics of soil when it comes in contact with water. Expansive soils tend to swell significantly when wet and shrink when dried, causing structural issues

D. Standard proctor test

The Standard Proctor Test, also known as the Standard Compaction Test, is a method used to determine the optimal moisture content at which soil achieves its maximum dry density.

E. California Bearing Ratio test

The California Bearing Ratio (CBR) test is a standardized test used to evaluate the mechanical strength of natural ground, subgrades, and base courses for pavements and road construction. It measures the load-bearing capacity of a soil compared to a standard crushed rock material under controlled conditions

F. Sieve analysis

The grain size analysis test is performed to determine the percentage of each size of grain that is contained within a soil sample, and the results of the test can be used to produce the grain size distribution curve. This information is used to classify the soil and to predict its behavior.

VII. PLAXIS 2D

A. General

PLAXIS 2D is a specialized finite element analysis (FEA) software designed for geotechnical engineering and soil-structure interaction analysis. It is widely used by geotechnical engineers, civil engineers, and geologists to model and analyze two-dimensional geotechnical problems.

B. Finite element analysis(FEA)

PLAXIS 2D is built on the principles of the Finite Element Method (FEM), a numerical technique used for simulating and analyzing complex problems by discretizing them into smaller elements .
In geotechnical engineering, FEA is particularly valuable for studying soil-structure interaction and modeling the behavior of soils and rocks under various loading conditions

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C. Application and purpose

The PLAXIS 2D is primarily developed for geotechnical analysis and plays a vital role in a wide range of applications, including but not limited to Slope stability analysis, foundation design, excavation support system design, tunneling and underground construction, retaining wall analysis, ground improvement projects.

VIII. SOFTWARE VALIDATION

A. General

The Data validation is a critical step in the analytics world to ensure a smooth data workflow. Any inconsistencies in data at the beginning of the process may impact the final results, making them inaccurate. Therefore, checking the accuracy and quality of data before processing it is extremely important. To study the effective stresses, active pore pressure, excess pore pressure of different soils using PLAXIS -2D software. Data validation on the embankment model referred from a journal is analyzed and validate.

Investigation of soil stability is an important issue which could not be neglected; therefore, embankment modeling is a crucial item in geotechnical field. In this content, software for numerical modeling which has also geotechnical features, are in priority. In this study, the performance of PLAXIS software is investigated. First its performance was evaluated for modeling a simple embankment. The verification of the results obtained by PLAXIS geotechnical software in modeling of embankment based on theoretical equation of geotechnical soil parameters and PLAXIS 2D software were investigated. By studying the results, it can be said that PLAXIS has the capability to analyze soil parameters. This is highly important in soil stability analysis

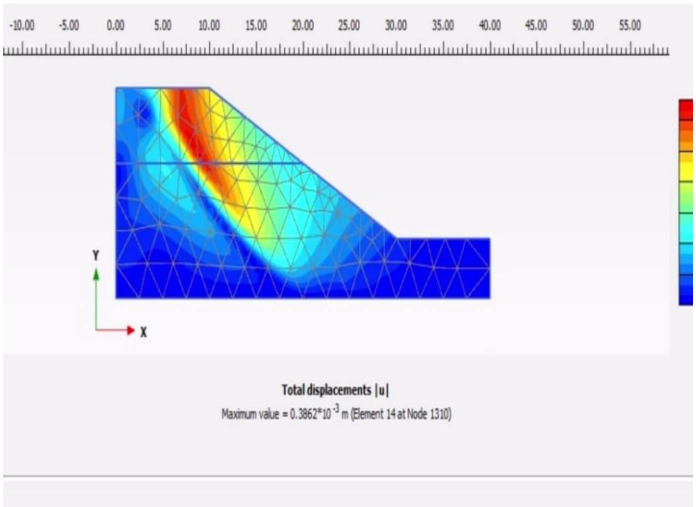

Fig 2 Total displacement of the model in the journal

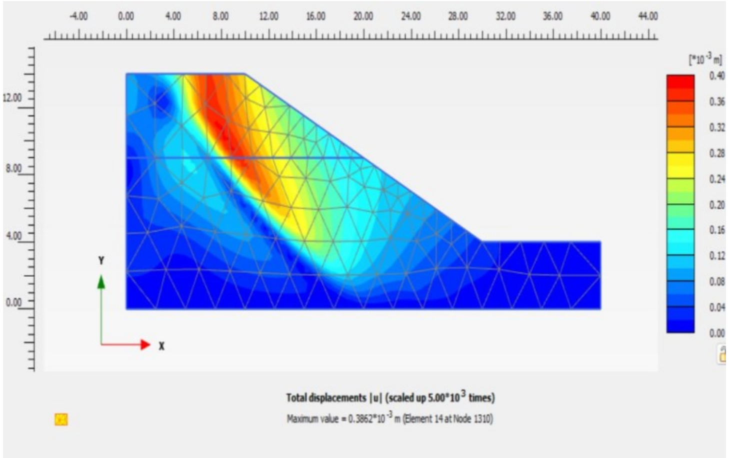

Fig 3 Total displacement of the modeling obtained in the software modeling

IX. SOIL NAILING

A. General

Soil nailing is a method used to stabilize slopes and excavations by reinforcing the soil with mild steel, timber or aluminium nails. The nails are typically grouted into the soil to create a composite material that is more resistant to movement. Soil nailing can be used for a variety of applications, including stabilizing slopes along roads, railways, and other infrastructure projects, creating retaining walls for excavations, reinforcing foundations and repairing landslides

B. Grouted soil nailing

Grouted nailing is a soil reinforcement technique used to stabilize slopes, excavations, and retaining walls. It involves inserting steel bars (nails) into the soil and then grouting them in place with a cement-based material. The grout binds the nails to the soil, creating a reinforced zone that can resist lateral earth pressure

X. SPECIFICATION

A. General

The site at Kudiyanmala ,UP School ,Chemperi has an angle of slope of 61.5 ˚ with horizontal ground surface .Soil nail is inserted to this slope at an angle of 45 ˚ with the horizontal surface .

For the soil nail method ,the nail used are aluminium , mild steel or timber. The nails are spaced at a distance 1m ,1.25 m or 1.5 m . The length of soil nail is within range of 0.8 H to 1.2 H , hence length is provided as 1 m . Diameter of soil nail selected are 100 mm, 150mm or 200mm.

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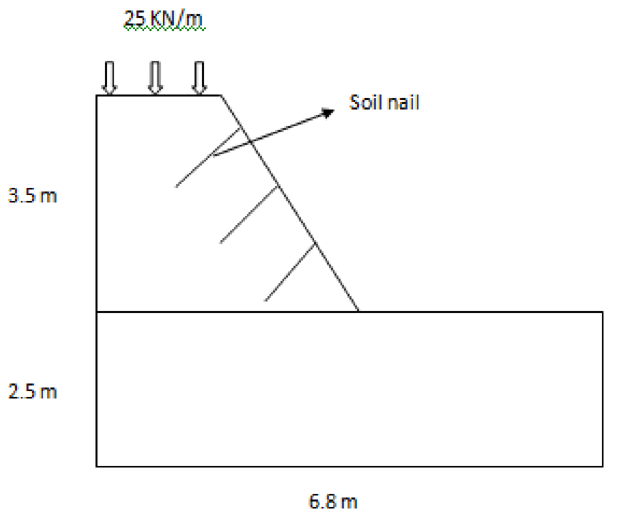

Fig 4 Dimensions of slope

XI. RESULT AND DISCUSSION

Based on length of soil nail, spacing of soil nail, material used, diameter provided for the inserted nails, load at site, angle of slope and angle of nail with horizontal surface influence the output obtained from PLAXIS 2D software

A. With 1m Spacing

During soil nailing method mild steel, aluminium or timber nail is used. Soil nail is of diameter 100 mm,150 mm or 200 mm. The nails are spaced at a distance of 1m from each other.

1) Mild Steel soil nail with 100 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100 mm. Deformation is obtained as shown in fig 5

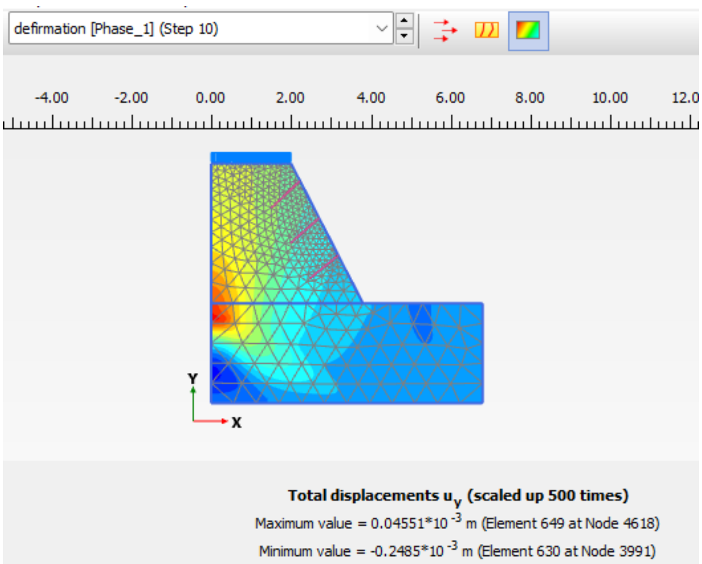

Fig 5 Total Displacement while using mild steel soil nail with 100 mm diameter

2) Mild Steel soil nail with 150 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150 mm. Deformation is obtained as shown in fig 6

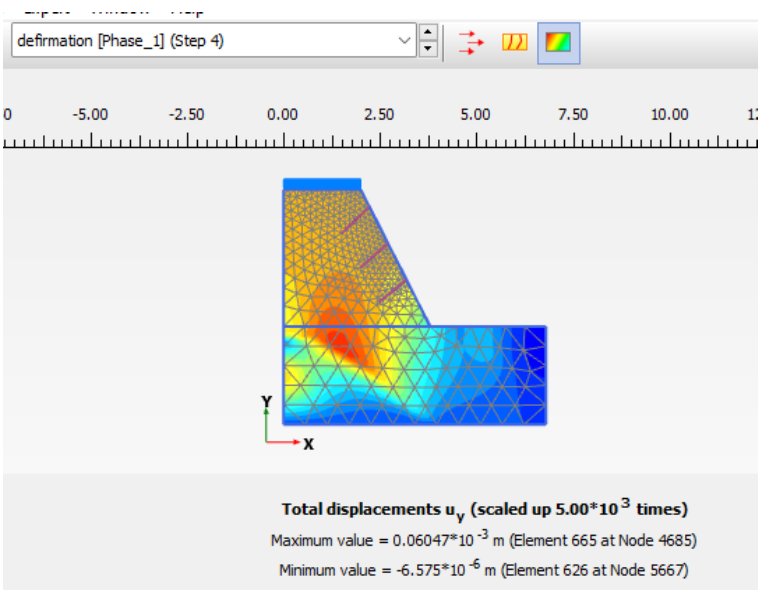

Fig 6 Total Displacement while using mild steel soil nail with 150 mm diameter

3) Mild Steel with 200 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200 mm. Deformation is obtained as shown in fig 7

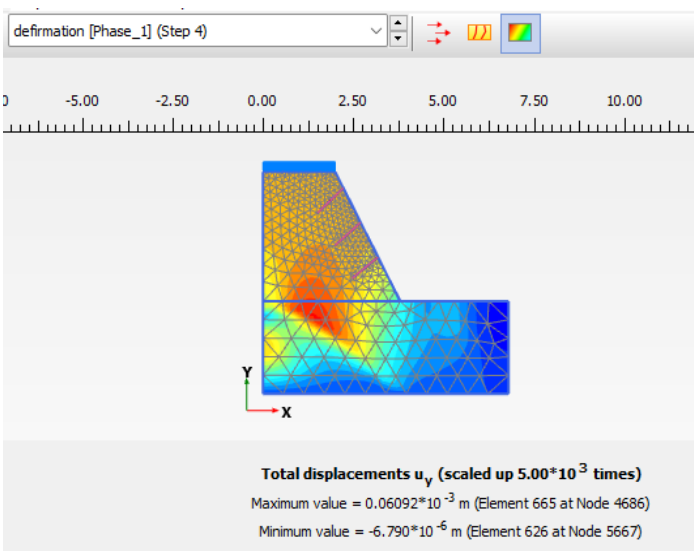

Fig 7 Total Displacement while using mild steel soil nail with 200 mm diameter

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4) Timber soil nail with 100 mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100 mm. Deformation is obtained as shown in fig 8

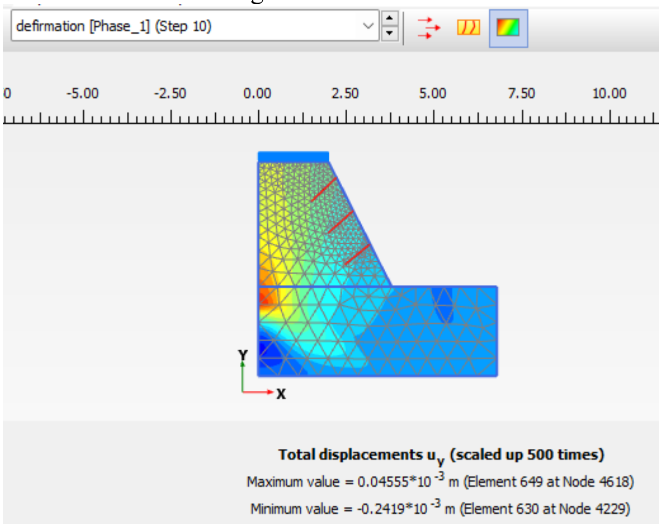

Fig 8 Total Displacement while using timnber soil nail with 100 mm diameter

5) Timber soil nail with 150 mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 9

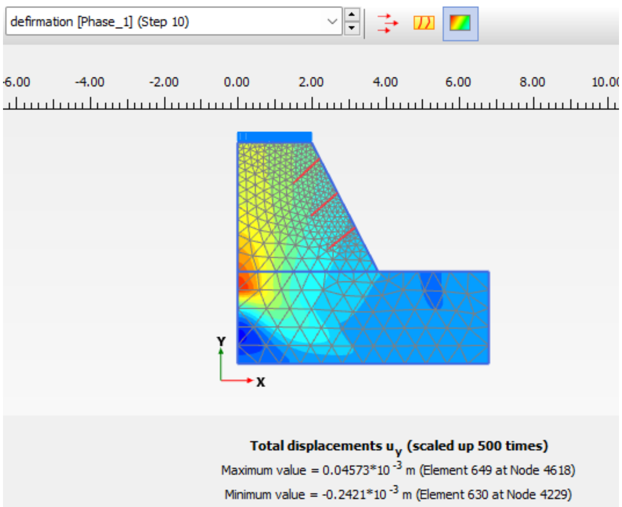

Fig 9 Total Displacement while using timber soil nail with 150 mm diameter

6) Timbersoil nail with 200 mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 10

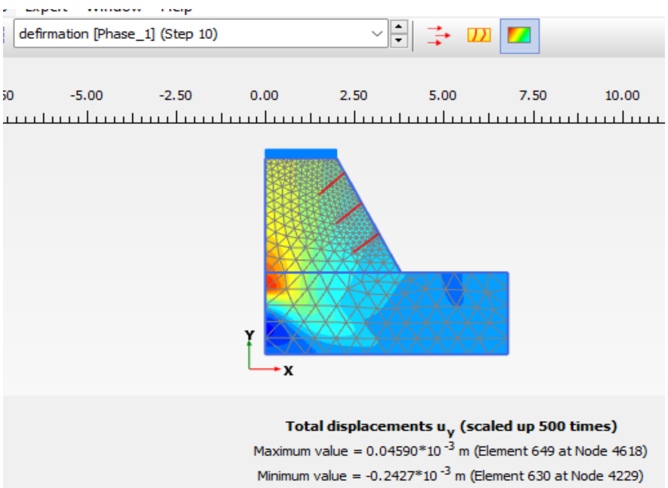

Fig 10 Total Displacement while using timber soil nail with 200 mm diameter

7) Aluminium soil nail with 100 mm daimeter

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 11

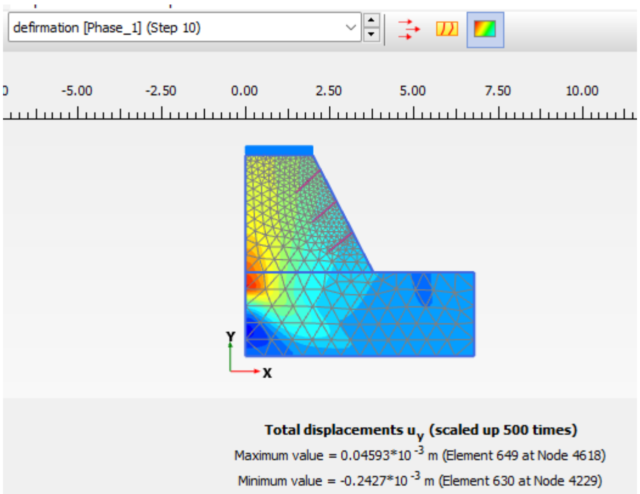

Fig 11 Total Displacement while using aluminium soil nail with 100 mm diameter

8) Aluminium soil nail with 150 mm diameter

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 12

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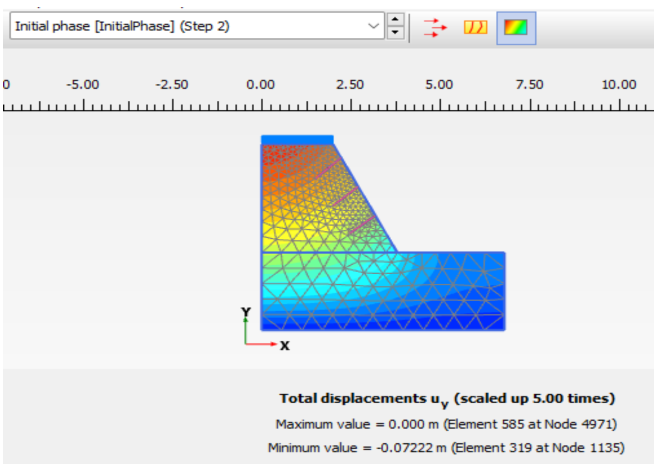

Fig 12 Total Displacement while using aluminium soil nail with 150 mm diameter

9) Aluminium soil nail with 200 mm diameter

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 13

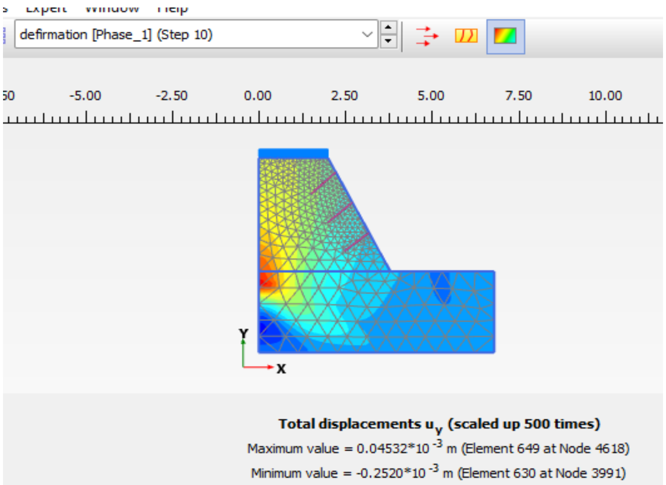

Fig 13 Total Displacement while using aluminium soil nail with 200 mm diameter

B. With 1.25m spacing

During soil nailing method mild steel, aluminium or timber nail is used. Soil nail is of diameter 100 mm, 150 mm or 200 mm. The nails are spaced at a distance of 1.25m from each other.

1) Mild Steel soil nail with 100 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 14

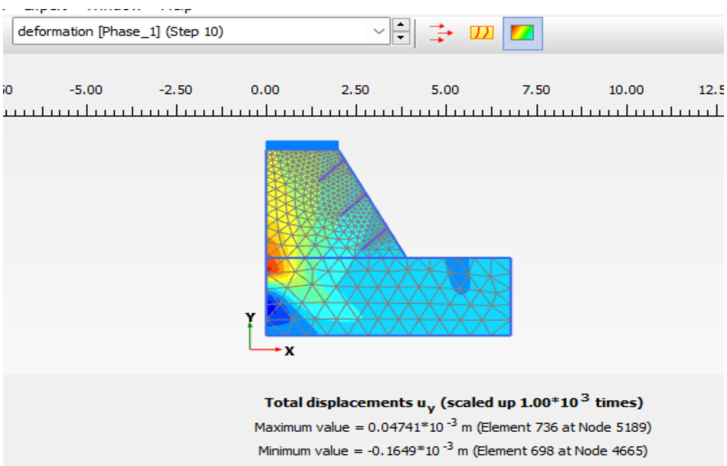

Fig 14 Total Displacement while using mild steel soil nail with 100 mm diameter

2) Mild Steel soil nail with 150 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 15

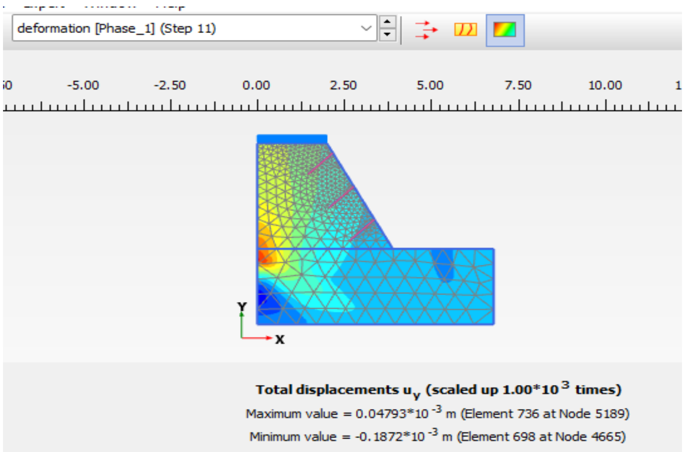

Fig 15 Total Displacement while using mild steel soil nail with 150 mm diameter

3) Mild Steel soil nail with 200 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 16

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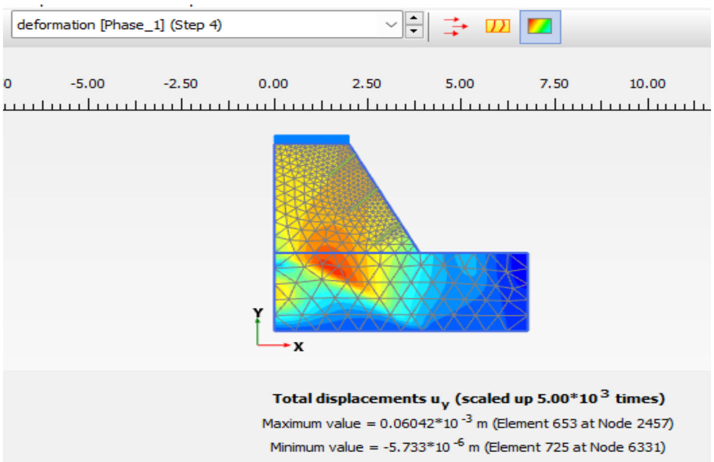

Fig 16 Total Displacement while using timber soil nail with 200 mm diameter

4) Timber soil nail with 100 mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 17

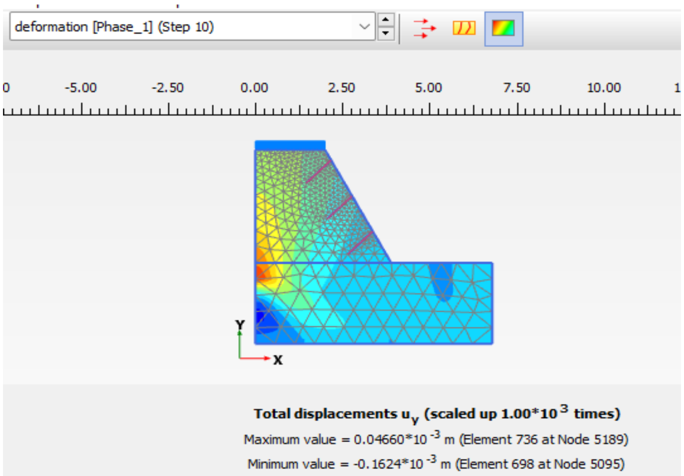

Fig 17 Total Displacement while using timberl soil nail with 100 mm diameter

5) Timber soi nail with 100 mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 18

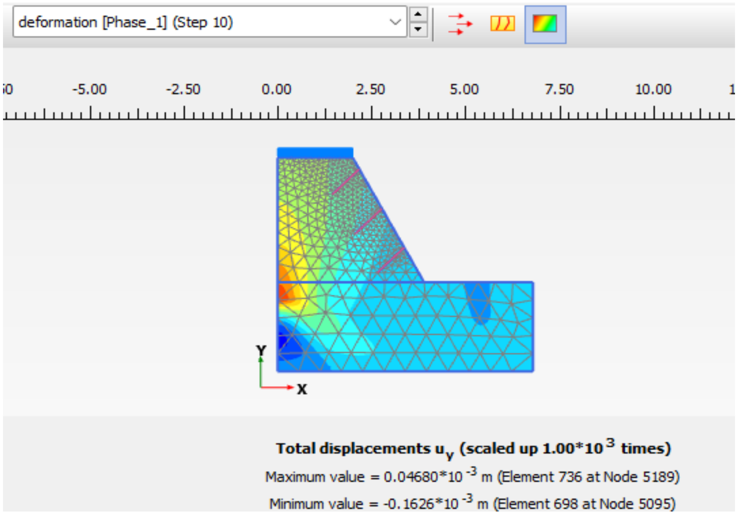

Fig 18 Total Displacement while using timber soil nail with 150 mm diameter

6) Timber soil nail with 200 mm daimeter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 19

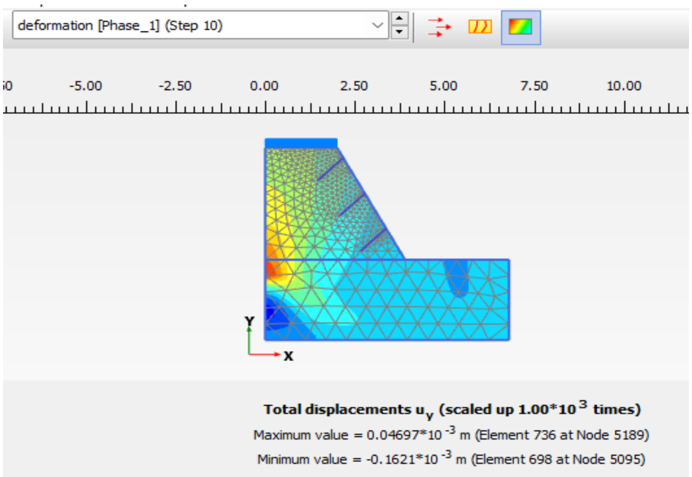

Fig 19 Total Displacement while using timberl soil nail with 200 mm diameter

7) Aluminium soil nail with 100 mm spacing

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 20

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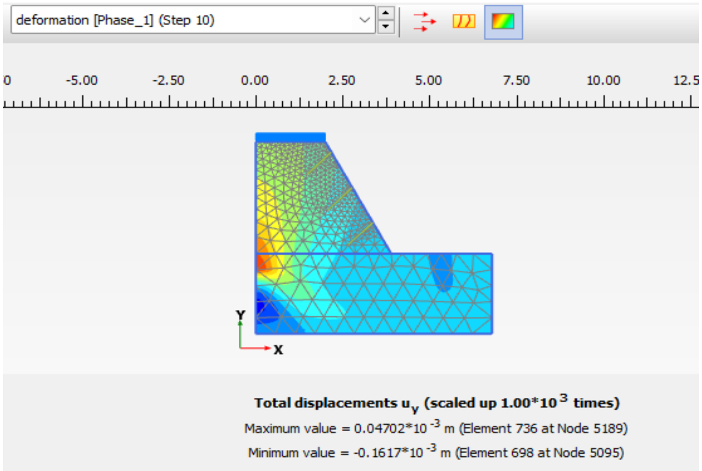

Fig 20 Total Displacement while using aluminum soil nail with 100 mm diameter

8) Aluminium soil nail with 150 mm diameter

For the soil nail method, the nail used is aluminum. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 21.

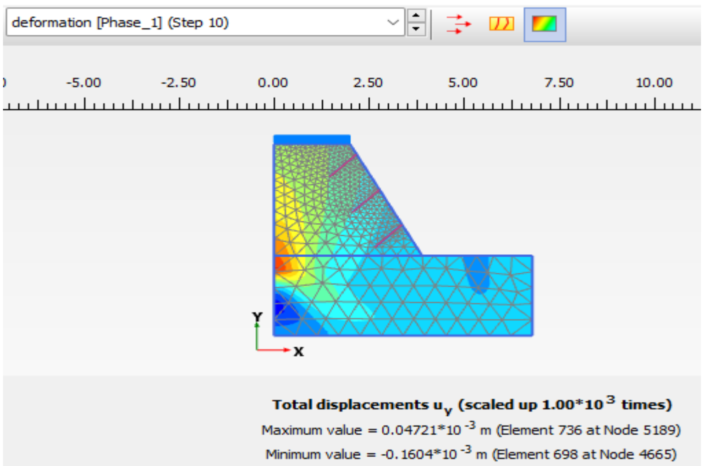

Fig 21 Total Displacement while using aluminium soil nail with 150 mm diameter

9) Aluminium soil nail with 200 mm spacing

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1.25m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm.Deformation is obtained as shown in fig 22

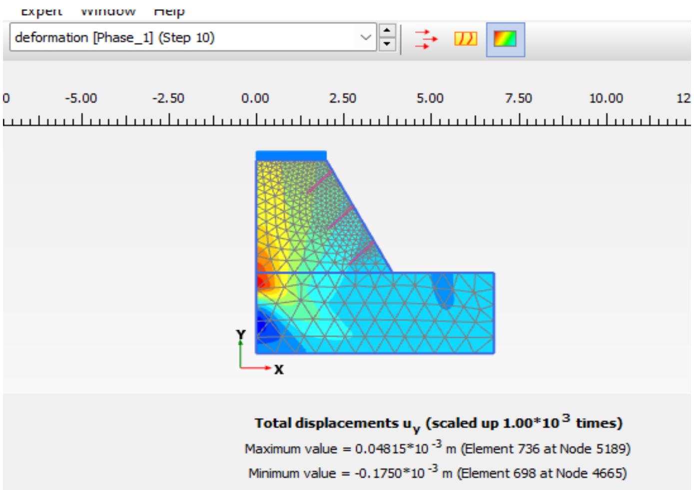

Fig 22 Total Displacement while using aluminium soil nail with 200 mm diameter

C. With 1.5 spacing

1) Mild Steel soil nail with 100 mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 23

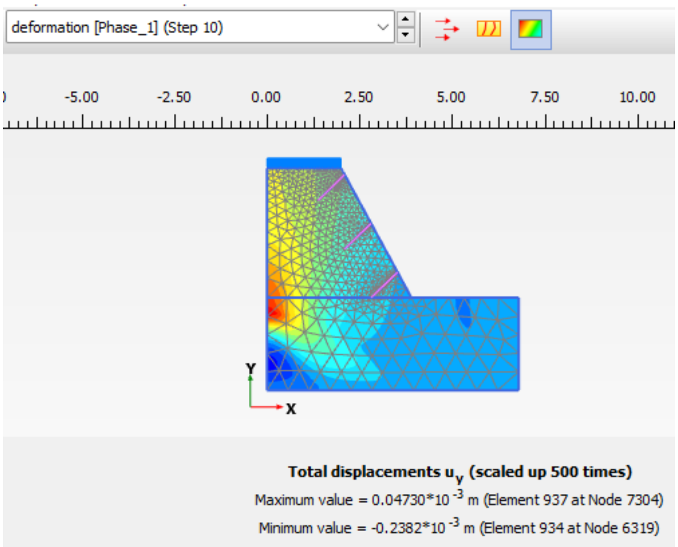

Fig 23 Total Displacement while using mildsteel soil nail with 100 mm diameter

2) Mild steel soil nail with 150mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 24

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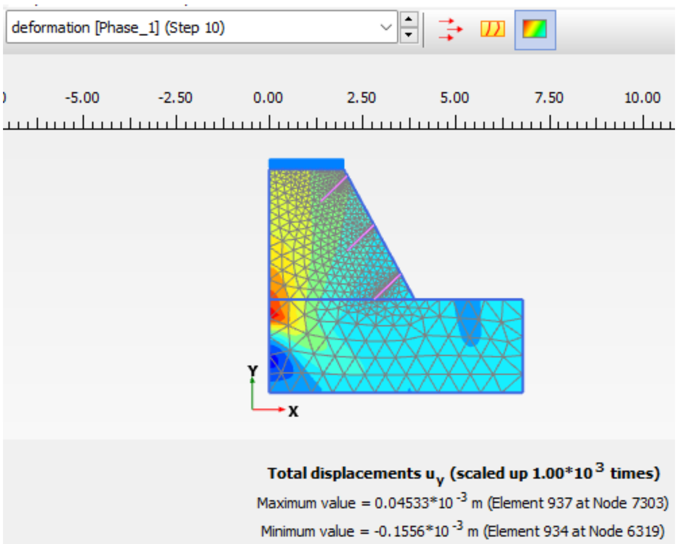

Fig 24 Total Displacement while using mildsteel soil nail with 150 mm diameter

3) Mild steel soil nail with 200mm diameter

For the soil nail method, the nail used is mild steel. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 25

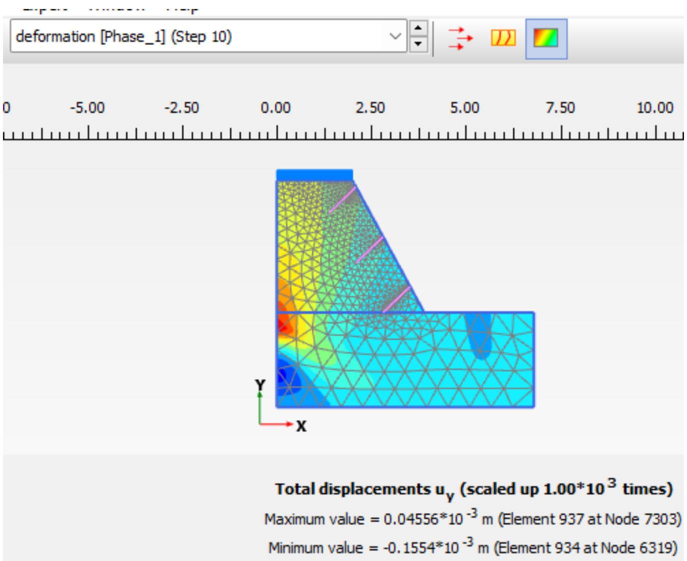

Fig 25 Total Displacement while using mildsteel soil nail with 200 mm diameter

4) Timber soil nail with 100mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1 m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 26

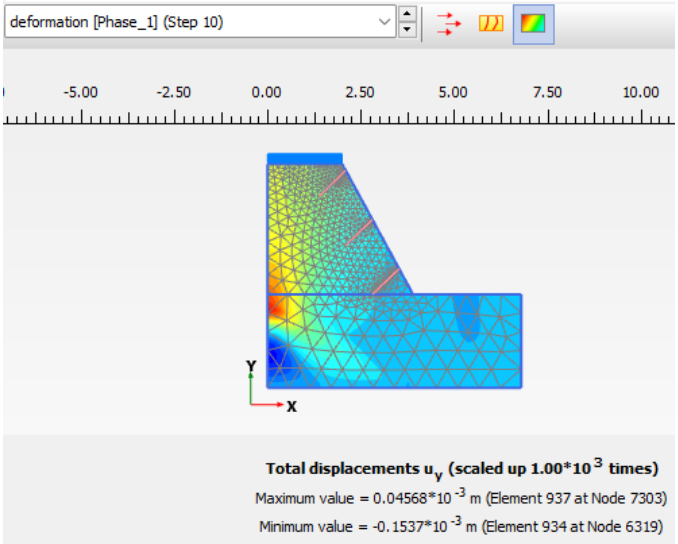

Fig 26 Total Displacement while using timber soil nail with 100 mm diameter

5) Timber soil nail with 150mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1 m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 27

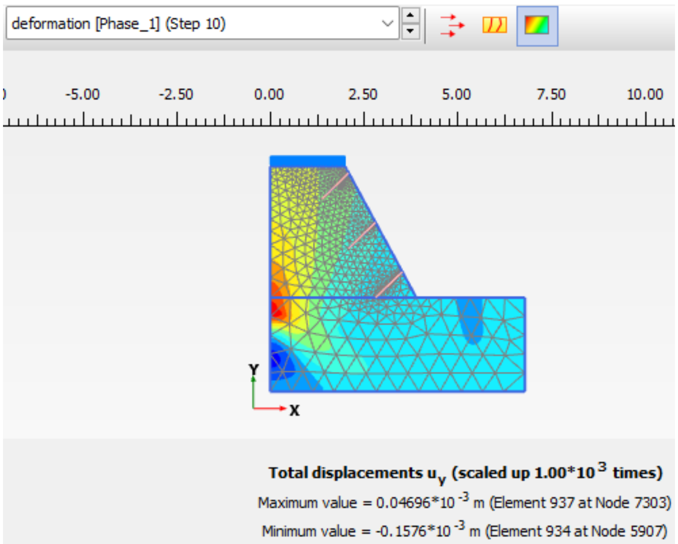

Fig 27 Total Displacement while using timber soil nail with 150 mm diameter

6) Timber soil nail with 200mm diameter

For the soil nail method, the nail used is timber. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm. Deformation is obtained as shown in fig 28

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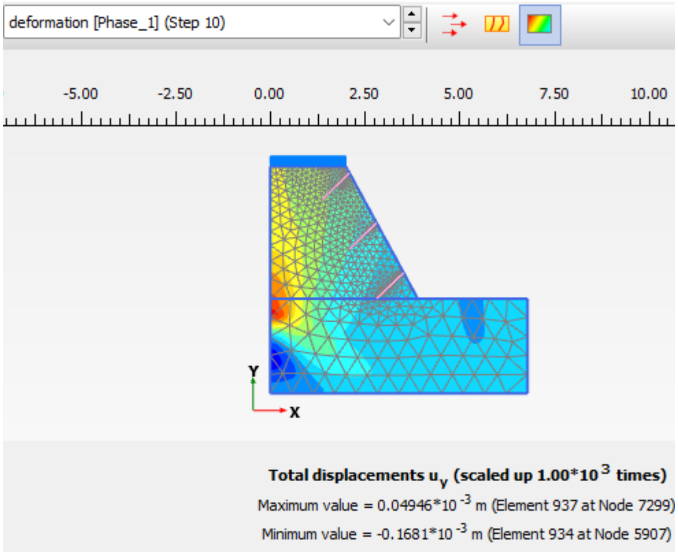

Fig 28 Total Displacement while using timber soil nail with 200 mm diameter

7) Aluminium soil nail with 100mm diameter

For the soil nail method, the nail used is aluminum. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1m. Diameter of soil nail selected is 100mm. Deformation is obtained as shown in fig 29

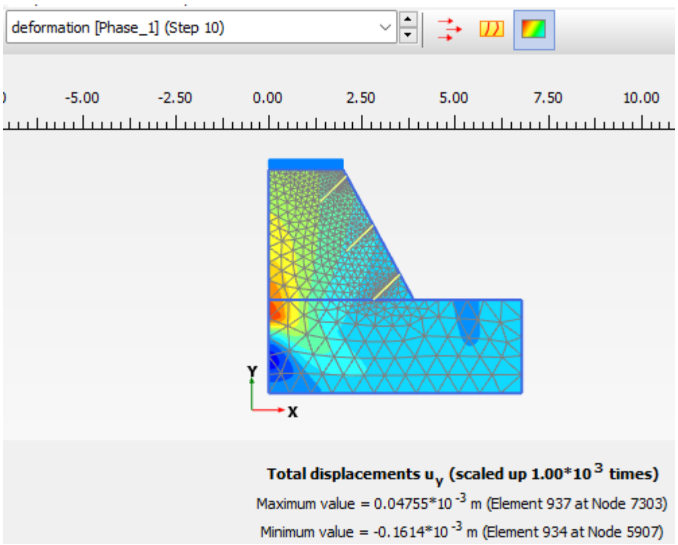

Fig 29 Total Displacement while using aluminum soil nail with 100 mm diameter

8) Aluminium soil nail with 150mm diameter

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1m. Diameter of soil nail selected is 150mm. Deformation is obtained as shown in fig 30

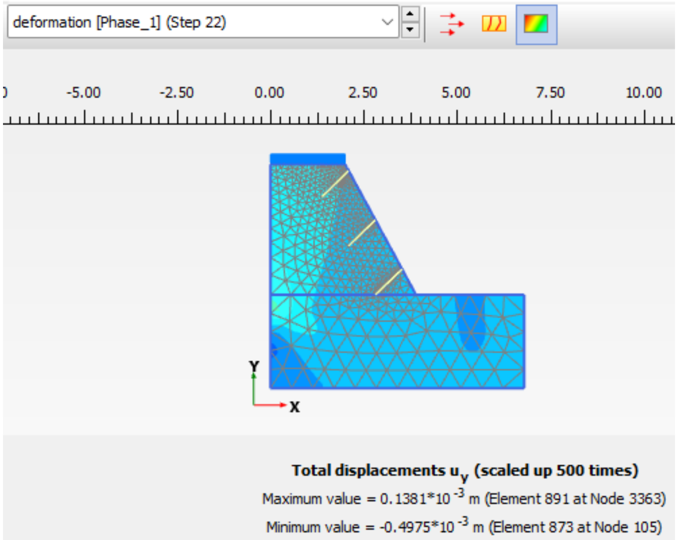

Fig 30 Total Displacement while using aluminum soil nail with 150 mm diameter

9) Aluminium soil nail with 200mm diameter

For the soil nail method, the nail used is aluminium. The nails are spaced at a distance of 1.5m. The length of soil nail length is 1 m. Diameter of soil nail selected is 200mm.Deformation is obtained as shown in fig 31.

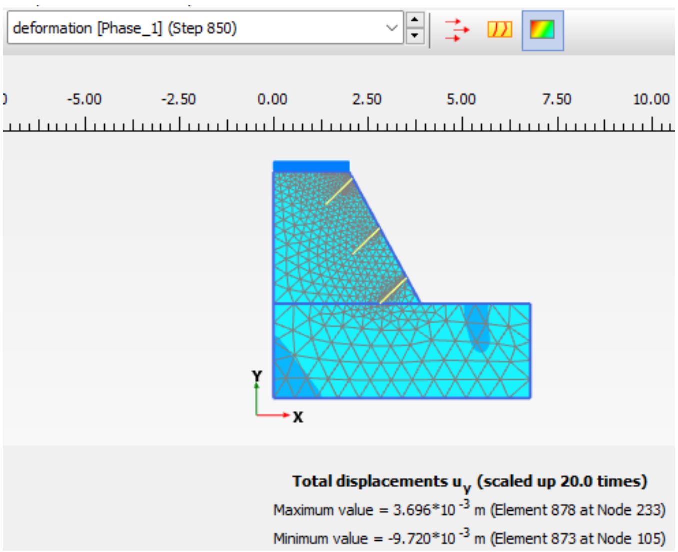

Fig 31 Total Displacement while using aluminum soil nail with 200 mm diameter

XII. DEFORMATION AT REFERENCE POINT

A. GENERAL

Node selected is at the top edge of slope. The deformation occurred at the node at varying diameter of soil nail (100 mm,150 mm,200 mm) is recorded.

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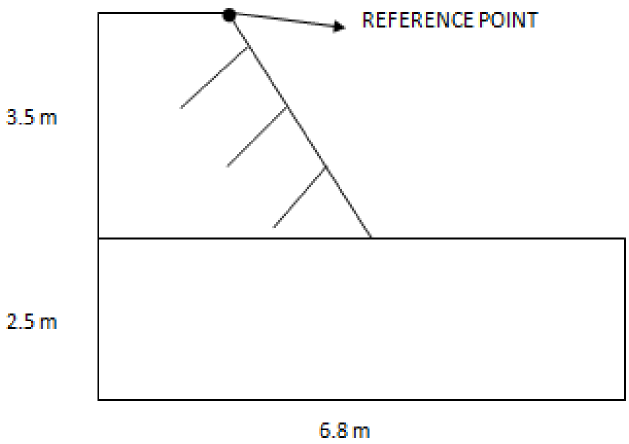

Fig 32 Point considered for total settlement in the software study

1) Mild steel-1m spacing

The settlement/deformation obtained during soil nailing of slope using mild steel nail with 200mm diameter and 1m spacing between nails is 64.106 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 33

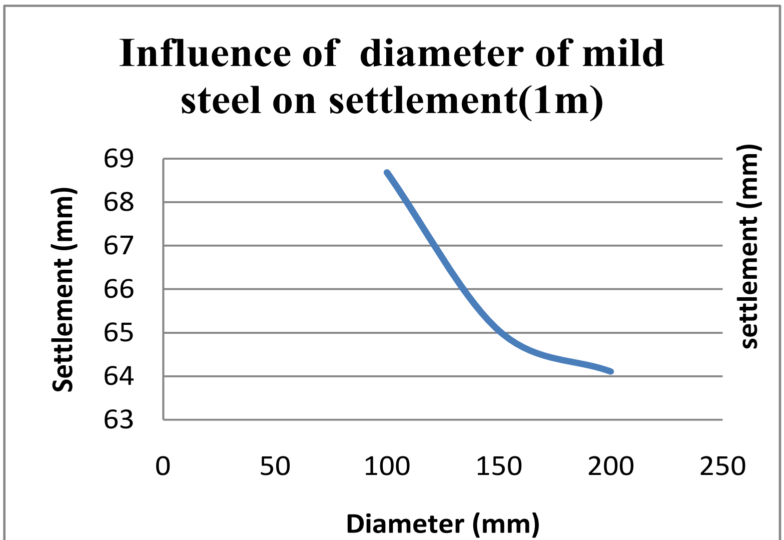

Fig 33 – Influence of diameter of mild steel on settlement (1m)

2) Timber-1m spacing

The settlement/deformation obtained during soil nailing of slope using timber nail with 150 mm diameter and 1m spacing between nails is 65.65 mm, which is comparatively less with respect to the settlement at 100 mm and 200 mm diameter as shown below in fig 34.

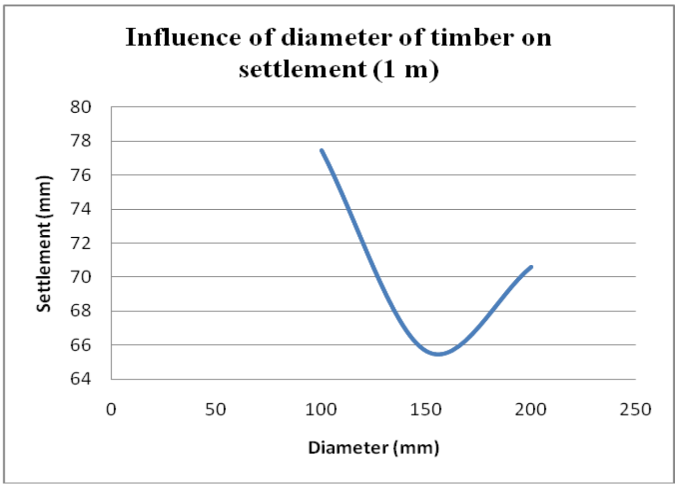

Fig 34 – Influence of diameter of timber on settlement (1m)

3) Aluminium-1m spacing

The settlement/deformation obtained during soil nailing of slope using aluminium nail with 200mm diameter and 1m spacing between nails is 65.38 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 35.

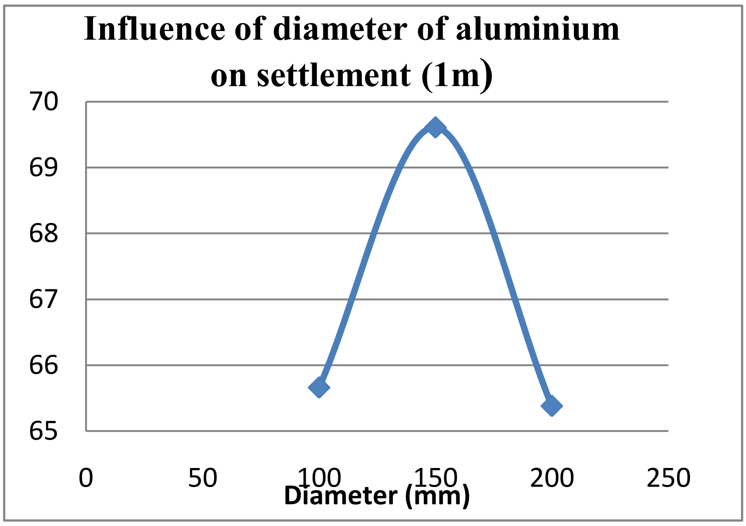

Fig 35– Influence of diameter of aluminium on settlement (1m)

4) Mild steel-1.25m spacing

The settlement/deformation obtained during soil nailing of slope using mild steel nail with 200mm diameter and 1.25m spacing between nails is 64.055 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 36

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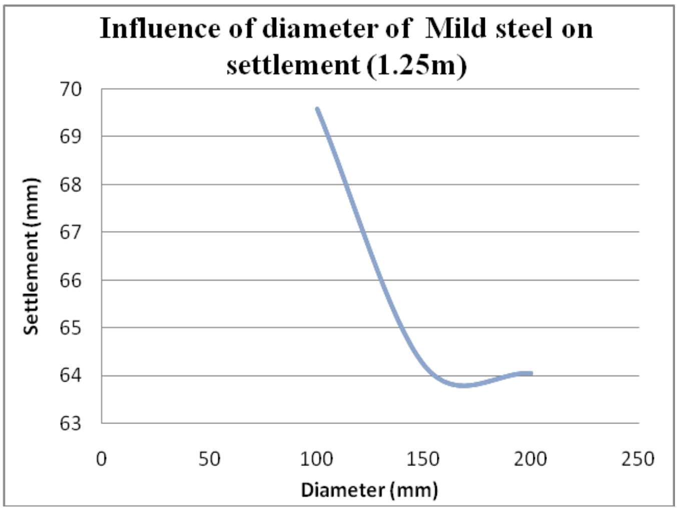

Fig 36 – Influence of diameter of mild steel on settlement (1.25m)

5) Timber-1.25m spacing

The settlement/deformation obtained during soil nailing of slope using timber nail with 200mm diameter and 1.25m spacing between nails is 61.483 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 37

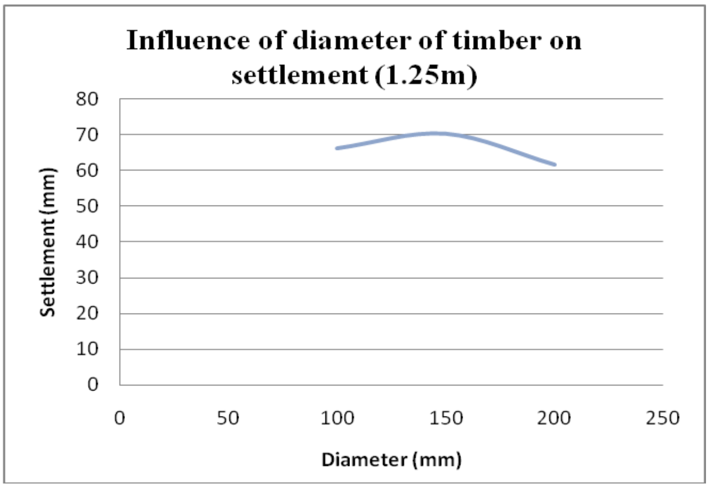

Fig 37 – Influence of diameter of timber on settlement (1.25m)

6) Aluminium-1.25m spacing

The settlement/deformation obtained during soil nailing of slope using aluminium nail with 100mm diameter and 1.25m spacing between nails is 61.508 mm, which is comparatively less with respect to the settlement at 150 mm and 200 mm diameter as shown below in fig 38.

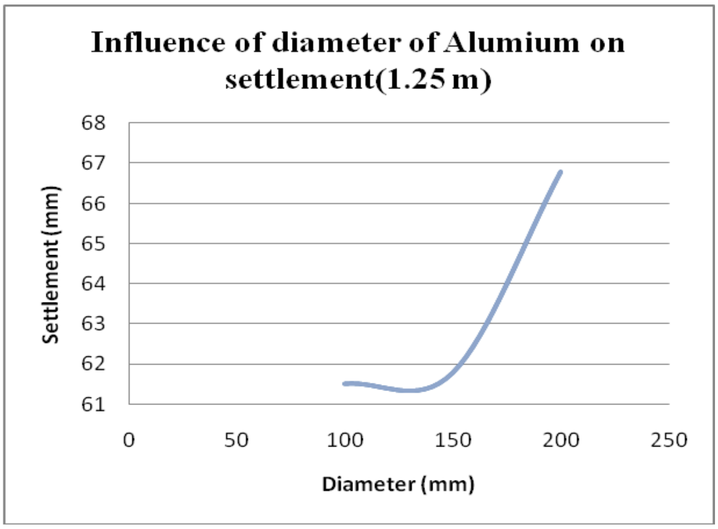

Fig 38 – Influence of diameter of aluminium on settlement (1.25m)

7) Mild steel-1.5m spacing

The settlement/deformation obtained during soil nailing of slope using timber nail with 150mm diameter and 1.5m spacing between nails is 62.775 mm, which is comparatively less with respect to the settlement at 100 mm and 200 mm diameter as shown below in fig 39

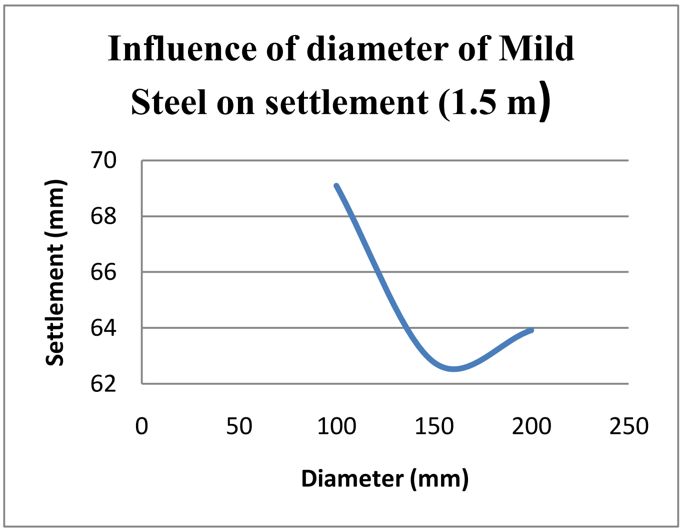

Fig 39 – Influence of diameter of mild steel on settlement (1.5m)

8) Timber-1.5m spacing

The settlement/deformation obtained during soil nailing of slope using timber nail with 200mm diameter and 1.5m spacing between nails is 67.984 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 40

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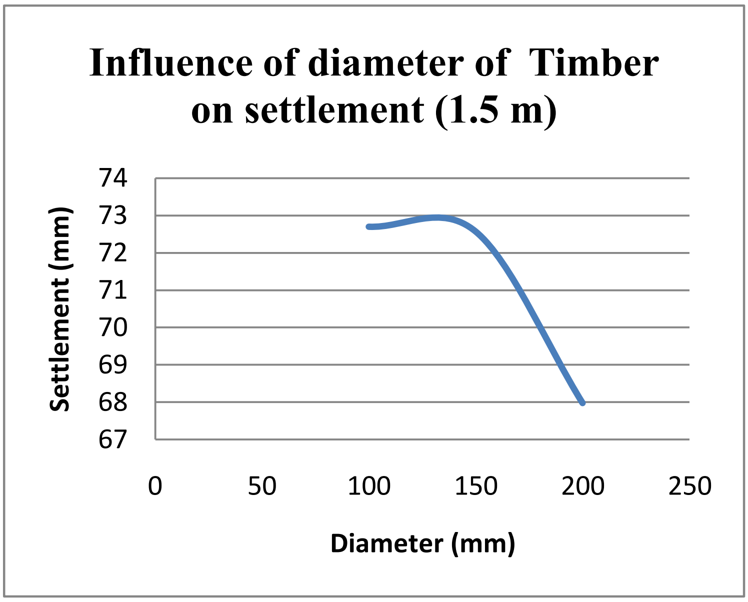
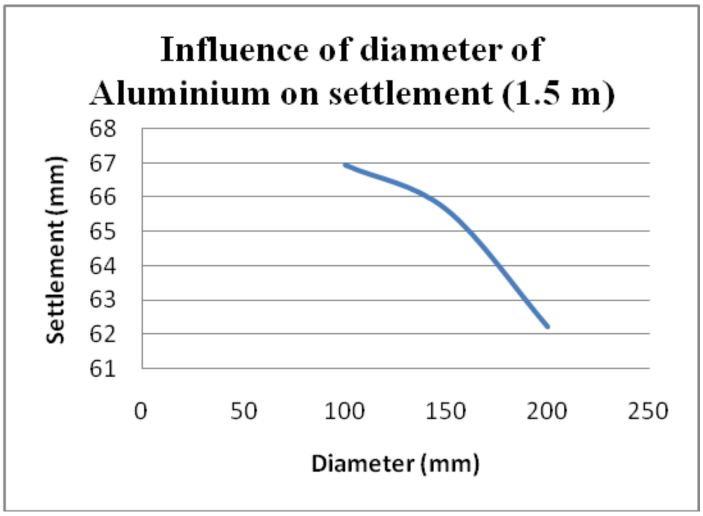


Fig 40 – Influence of diameter of timber on settlement (1.5m)

9) Aluminium-1.5m spacing

The settlement/deformation obtained during soil nailing of slope using aluminium nail with 200mm diameter and 1.5m spacing between nails is 62.205 mm, which is comparatively less with respect to the settlement at 100 mm and 150 mm diameter as shown below in fig 41.



S Fig 41 – Influence of diameter of aluminium on settlement (1.5m)

XIII. CONCLUSION

By Analysing the output and deformation obtained, after the running data, we can identify the soil nail which would cause least amount of deformation to the slope surface (based on varying diameter and spacing of nails). As per the output, here we select soil nail of material timber of 200 mm diameter and 1.5 m spacing between the nails.

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