CVR COLLEGE OF ENGINEERING

(An Autonomous institution, Affiliated to JNTUH)

DEPARTMENT OF CIVIL ENGINEERING

A MINI PROJECT REVIEW

ON

SLOPE STABILITY ANALYSIS USING PLAXIS 2D

UNDER THE GUIDANCE OF

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BATCH – 14

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Abstract

Slope is the angle, gradient, inclination of straight line. Slopes are very common in civil engineering construction and especially in where we deal with soil. Slope stability analysis is a static or dynamic, analytical or empirical method to evaluate the stability of earth and rock-fill dams, embankments, excavated slopes, and natural slopes in soil. Slope stability refers to the condition of inclined soil or rock slopes to withstand or undergo movement. The stability condition of slopes is a subject of study and research in soil mechanics geo technical engineering and engineering geology. Analyses are generally aimed at understanding the causes of an occurred slope failure, or the factors that can potentially trigger a slope movement, resulting in a landslide, as well as at preventing the initiation of such movement, slowing it down or arresting it through mitigation countermeasures.

PLAXIS 2D, very acceptable and powerful software are created for Analysis of slope stability. PLAXIS 2D software can effectively analyse both simple and complex problems for a variety of slip surface shapes, pore-water pressure conditions, soil properties, and loading conditions.

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CHAPTER -1

1.1 -INTRODUCTION :

A slope is an **inclined ground surface** which can be formed either natural or human-made. Slope stability refers to the condition that an inclined slope can withstand its own weight and external forces without experiencing displacement. Slopes are genetically categorized into primary slopes, formed by processes that advocate for relief, and secondary slopes evolve from erosion and modification of primary slopes. The shape of the slopes are governed by its internal structure and external process, such as slope wash, creep and other mechanism. The material deposited while in transit down is called as colluvium . It's the unsorted mixture of rock and sediment derived from the slope face . The stability of a slope is essentially controlled by the ratio between the available shear strength and the acting shear stress , which can be expressed in terms of a safety factor.

- A slope can be globally stable if the safety factor, computed along any potential sliding surface running from the top of the slope to its toe, is always larger than 1
- The smallest value of the safety factor will be taken as representing the global stability condition of the slope.

- Similarly, a slope can be locally stable if a safety factor larger than 1 is computed along any potential sliding surface running through a limited portion of the slope
- Values of the global or local safety factors close to 1 (typically comprised between 1 and 1.3, depending on regulations)

$$\text{Factor of safety} = \frac{\text{Yield stress}}{\text{Yield strength}}$$

1.2 –**Stability of slope can be affected by**:

- Increase in shear strength of soil.
- Decrease in shear stress of soil.
- Or by the both actions.
- The hydrological events (such as intense or prolonged rainfall, rapid snowmelt, progressive soil saturation, increase of water pressure within the slope),Earthquakes, internal erosion (piping), surface or toe erosion, artificial slope loading (for instance due to the construction of a building), slope cutting (for instance to make space for roadways, railways or buildings), or slope flooding (for instance by filling an artificial lake after damping a river).

LITERATURE REVIEW:

- A. Burman, S. P. Acharya etc. all (2015): “Comparative study of slope stability analysis using traditional limit equilibrium method and finite element method” In that they concluded that present work, limit equilibrium technique (ordinary slice method, Bishop’s method, Spencer’s method, Morgenstern-Price method) and finite element method have been used to the study different slope stability problems. Also, it is observed that ordinary slice method provides most conservative estimation of factor of safety values amongst all the limit equilibrium techniques considered in this paper. Therefore, any design of slopes carried out with ordinary slice method is likely to be always on the safer side. Other limit equilibrium methods like Ordinary Bishop's Method, Spencer's Method and Morgenstern and Price's method attempt to establish a more realistic estimation of interstice forces which may develop in reality. But they lead to somewhat higher estimation of factor of safety. The FOS values obtained using finite element method compare very well with that obtained from limit equilibrium methods. In finite element method, the FOS for critical slip surface is automatically obtained. In case of limit equilibrium methods, several slip surfaces should be analyzed to find the critical slip surface. These types of trial and error calculations are not required with FEM to find out the critical slip surface because the failure occurs through the zone of weakest material properties and automatically the critical slip surface is determined. Furthermore, finite element method satisfies the equations of equilibrium and compatibility equations from theory of elasticity. Therefore, it serves as a more mathematically robust platform. Also, displacements, stress and strains at various nodes in the slope domain are also obtainable from finite element method. These are few of the additional benefits of using finite element method.

Duncan and Wright, 2005 :

- 2.1 A wide range of slope stability analyses are performed using general-purpose computer programs. There are many options and features to be considered such as soil strength, pore water pressure, reinforcement, slip surfaces, and procedure of analysis. Each of these options and features have sub combinations that lead to about thousands probable options and features for a comprehensive slope stability computer program. Obviously, it is not possible to test sophisticated computer programs for every possible combinations of data, or even a reasonably small fraction of the possible combinations (Duncan and Wright, 2005). Consequently, there is a high possibility that many computer programs have not been tested for the exact combination. Moreover, using simple equations can lead to approximations that can cause, in some cases, significant errors. Also, it is possible to make errors in input data due to different program assumption and from human errors. Therefore, independent checks should be made regardless of how slope stability computations are performed.

2.2 Types of Slope Failures and Instability Mechanism There are many conditions that affect slope failures depending on the soil type, soil stratification, ground water, seepage, and the slope geometry (Budhu, 2000). 5 Failure of a slope along a weak zone of soil is called a translational slide Figure 2.1(a). In coarsegrained soils, translational slides are common. In this case, the sliding mass can travel long distances before coming to rest A common type of failure in homogeneous fine-grained soils is a rotational slide that has its point of rotation on an imaginary axis parallel to the slope (Duncan, 2005). Brief descriptions of three types of rotational failure that often occur are given below:

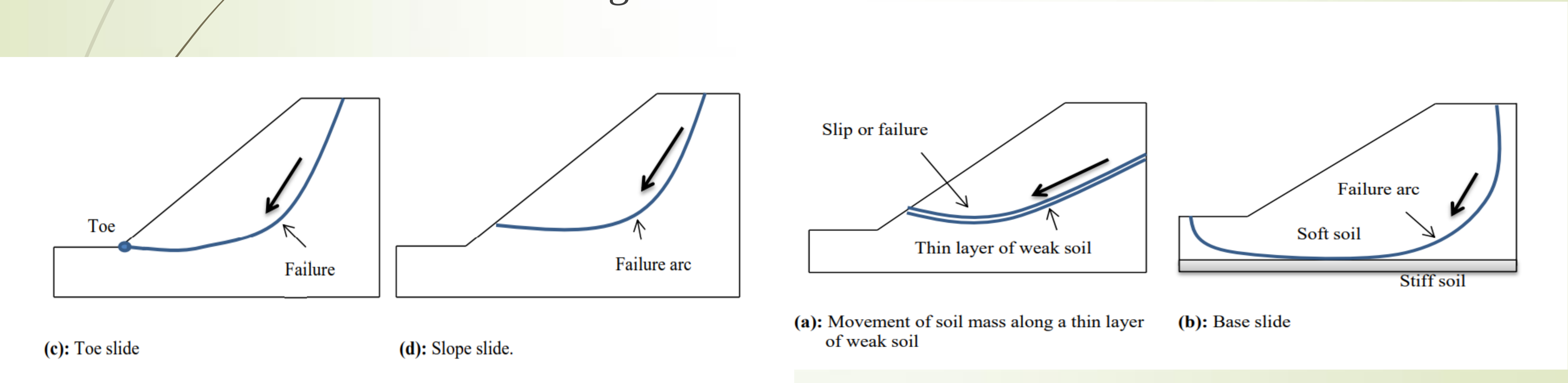


Fig-2.1 2.2 2.3 2.4

Base slide: occurs by an arc engulfing the whole slope. A soft soil layer resting on a stiff layer of soil is prone to base failure and passes below the toe Figure 2.1(b). Toe slide: whereby the failure surface passes through the toe of the slope Figure 2.1(c). Slope slide: whereby the failure surface passes through the slope and above the toe Figure 2.1(d).

Chen, 1995; Budhu;2000 :

Different slope failure modes (Chen, 1995; Budhu;2000). For purpose of designing, constructing, repairing failed and damaged slopes, it is important to understand the causes of instability in slopes.

In most cases, several causes exist simultaneously. For example, water influences affect the slope in many ways, making impossible to isolate one effect. Moreover the behavior of clay soils is complex and unpredictable whether from softening, progressive failure, or a combination. According to Sowers (1979), it is usually not possible to identify the cause that acted alone and resulted in instability, and it is also incorrect technically to isolate one cause.

Attempting to identify which one finally produced the failure is not only difficult, but also technically inaccurate (Duncan and Wright, 2005). Therefore, in designing and constructing new slopes, it is important to consider potential changes in properties and conditions that may affect the structure during its life so that it will remain stable despite these changes.

To prevent slope failure, the shear strength of the soil must be greater than the shear stress requirement for equilibrium. The instability condition can be obtained through two mechanisms (Duncan and Wright, 2005): Toe Failure arc Failure arc .

The first mechanism a decrease in the shear strength, the maximum shear stress that the soil can withstand, may occur due to an increase in void ratio (swelling), increase in moisture content, increase in pore water pressure, development of slickenside, creep under sustained loads, and weathering. The second mechanism an increase in the shear stress may occur due to water pressure causing saturation of soils, drop in water level, load at the top of the slope, and earthquake.

Spencer’s Method Description,1967 :

Spencer developed a complete equilibrium method known as Spencer’s method, which satisfies both force and moment equilibrium. Spencer’s Method used for circular slip surface and can also be adapted for use with non-circular slip surface (see Figure 2.1a), which is useful because many slides do not have circular failure surface (Spencer, 1967). 9 Spencer’s procedure is based on the assumption that the interslice forces are parallel and have the same inclination. The inclination is unknown and is computed as one of the unknowns in solution of the equilibrium equations. The other assumption is that the normal force acts at the center of the base of each slice. However, this assumption has negligible influence on the Computed values for the unknowns provided that a reasonably large number of slices are used (Duncan and Wright, 2005).`

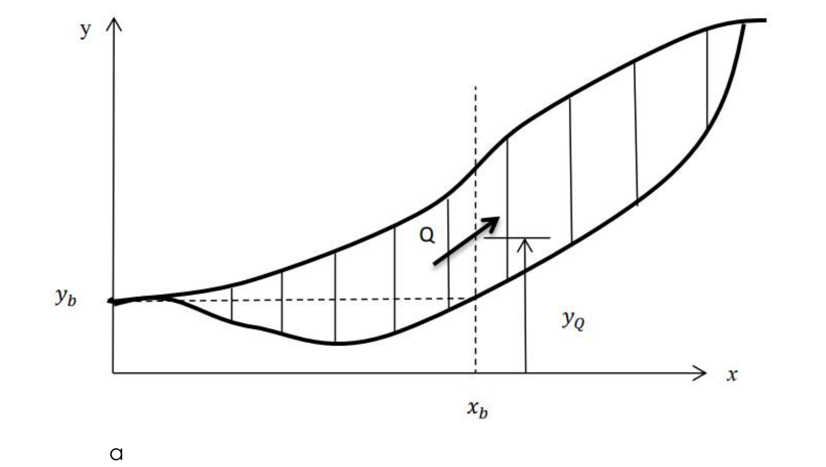
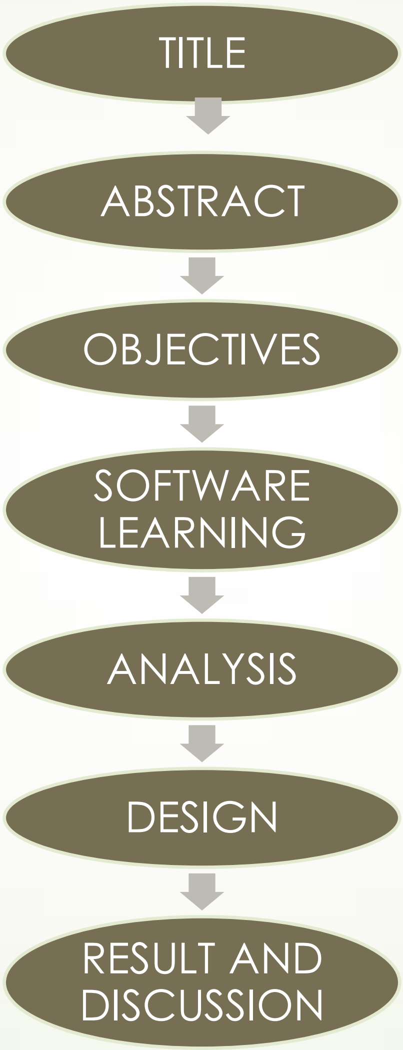


Figure 2.2 Coordinates for noncircular slip surface used in Spencer’s procedure.

Morgenstern and Price’s Method, 1965 :

- Morgenstern and Price’s Method Description Morgenstern and Price’s (1965) procedure is similar to Spencer’s procedure. The only major difference between Morgenstern and Price’s and Spencer’s procedures in terms of unknowns is that Spencer’s procedure involves a single interslice shear force inclination whereas Morgenstern and Price’s procedure involves different interslice shear force inclination that function on x direction (Duncan and Wright, 2005).

METHODOLOGY



OBJECTIVES:

- To model the geometry of an embankment in the plaxis 2D
- To assign the properties of different fill materials for the embankment portion.
- To run the software and analyse the slope stability at different conditions (Ex: Presence of Water table)
- To analyse the variation of different parameters such as factor of safety and Possible slope failures of the embankment.

CHAPTER - 2

➢ Inputs given to software

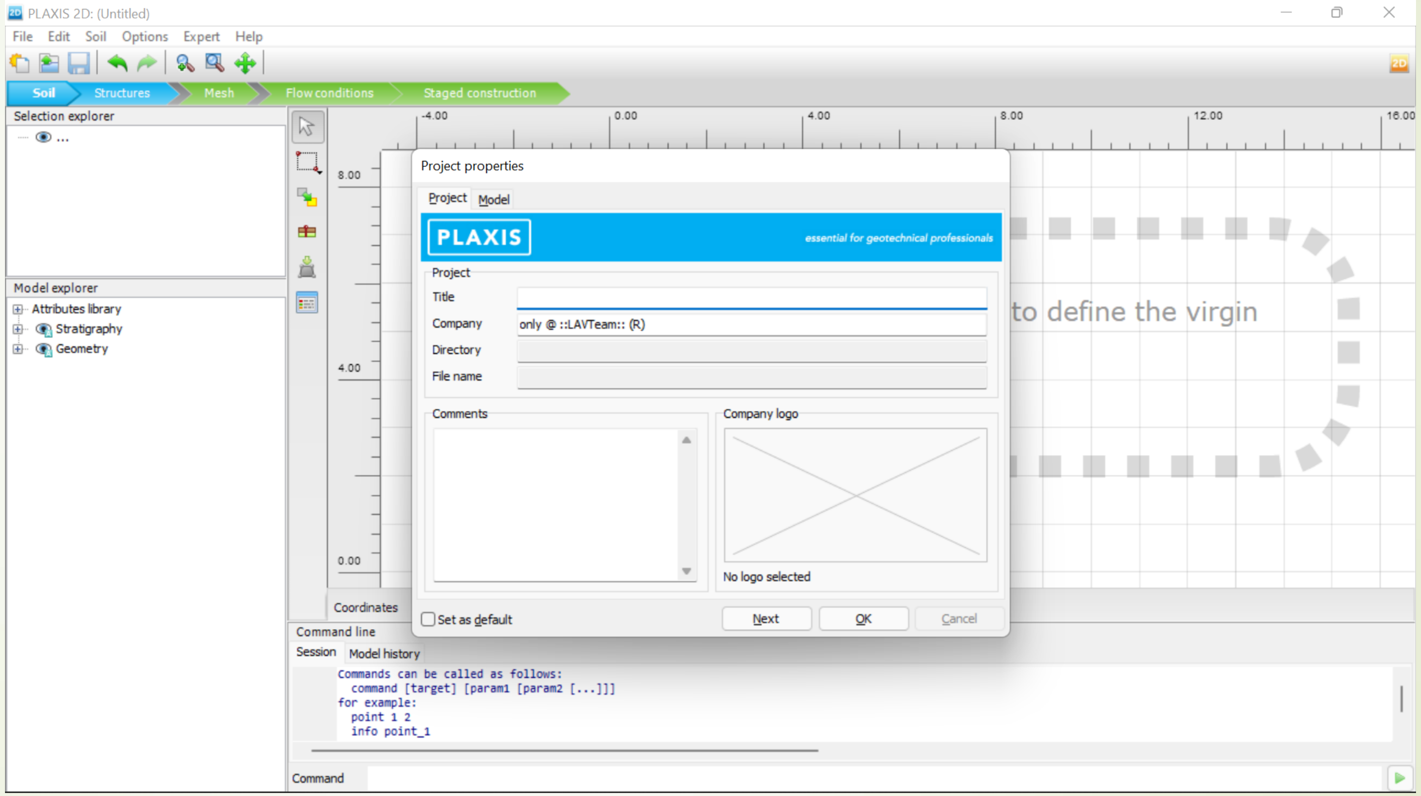
- The Youngs Modulus (e'), Poisons ratio (v) , cohesion (c), Angle of internal friction , density has to be provided as Shown in the table.

LAYER :	FINE GRAIN	COARSE SAND	LOOSE GRAVEL
POISON'S RATIO (V) (nu)	0.25	0.15	0.35
YOUNGS MODULUS (e') (KN/m2)	30,000	43,000	50,000
COHESION (C) (KN/m2)	4	8	7
ANGLE OF INTERNAL FRICTION (ϕ)	32°	34°	32°

Table 3.1

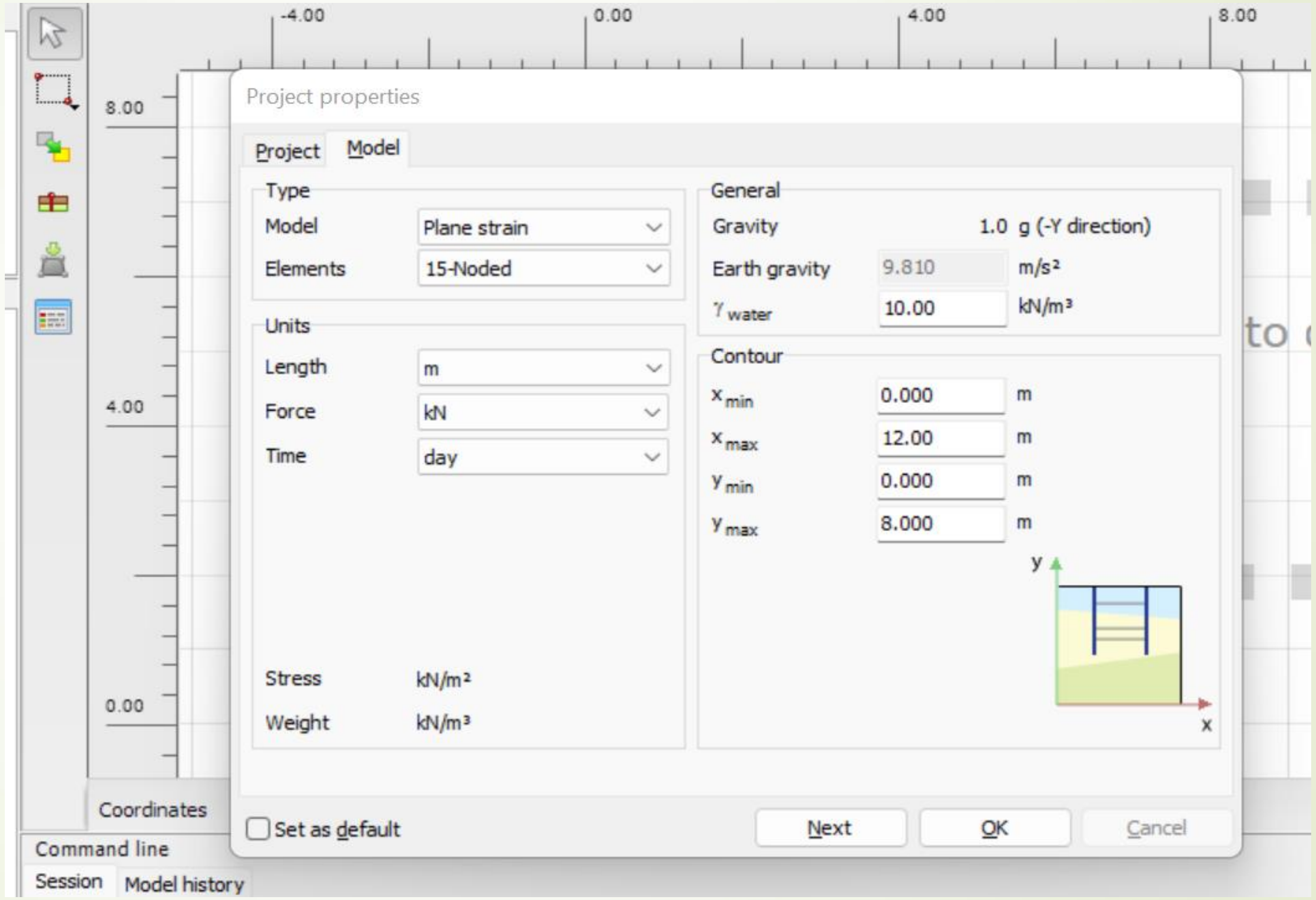
Interphase of plaxis 2D

The interphase of plaxis 2D contains
Title box.



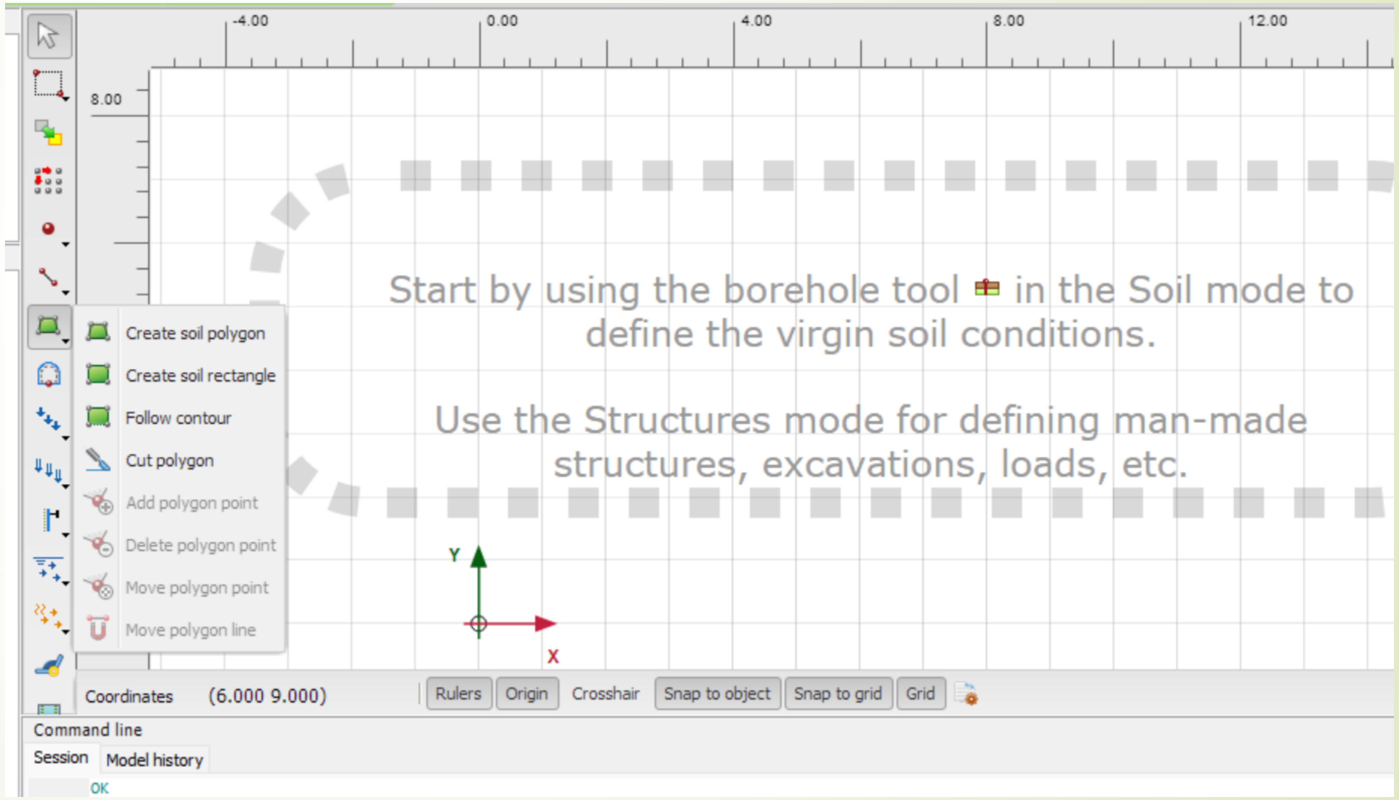
Dimensions and limits

The units and limits are to be fixed in the MODEL of the software

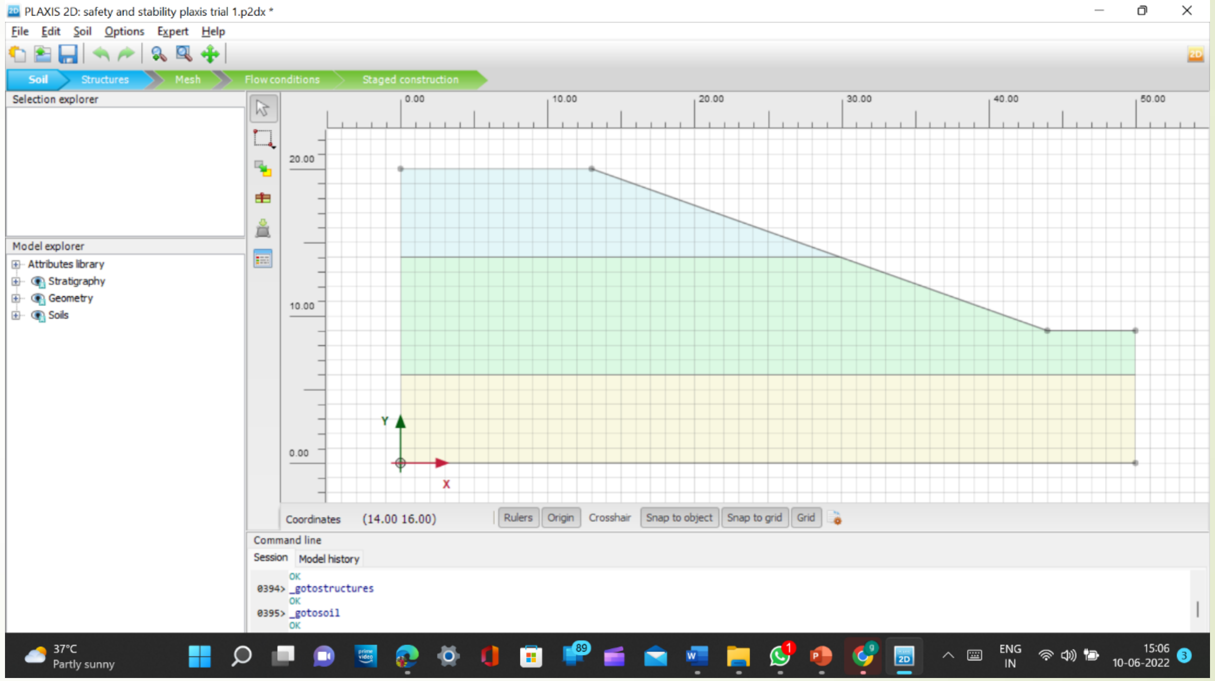


Structural view of the soil system (Slope)

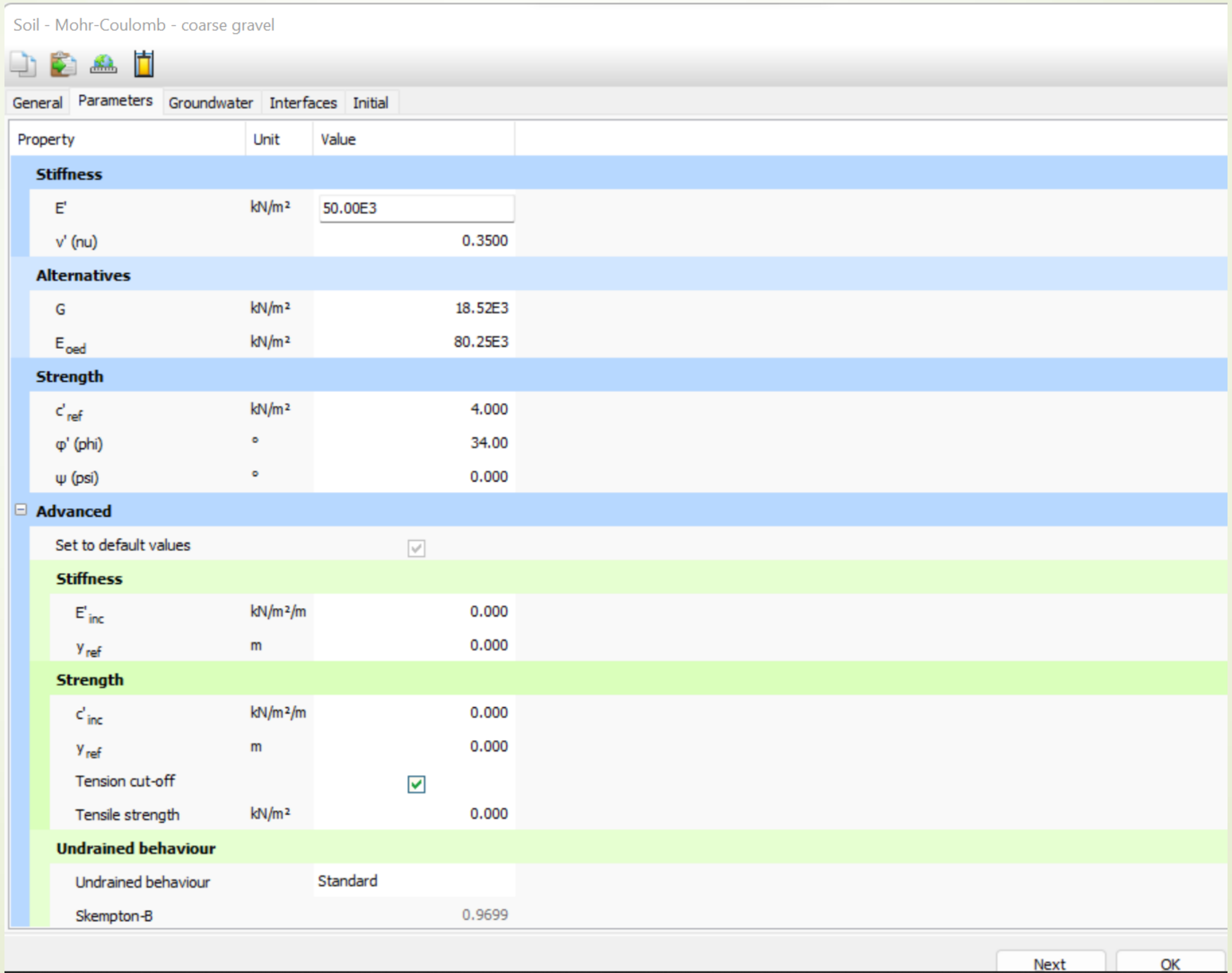
- The software contains different types of stages to give the inputs
- In the first stage the soil is designed with the help of polygon command



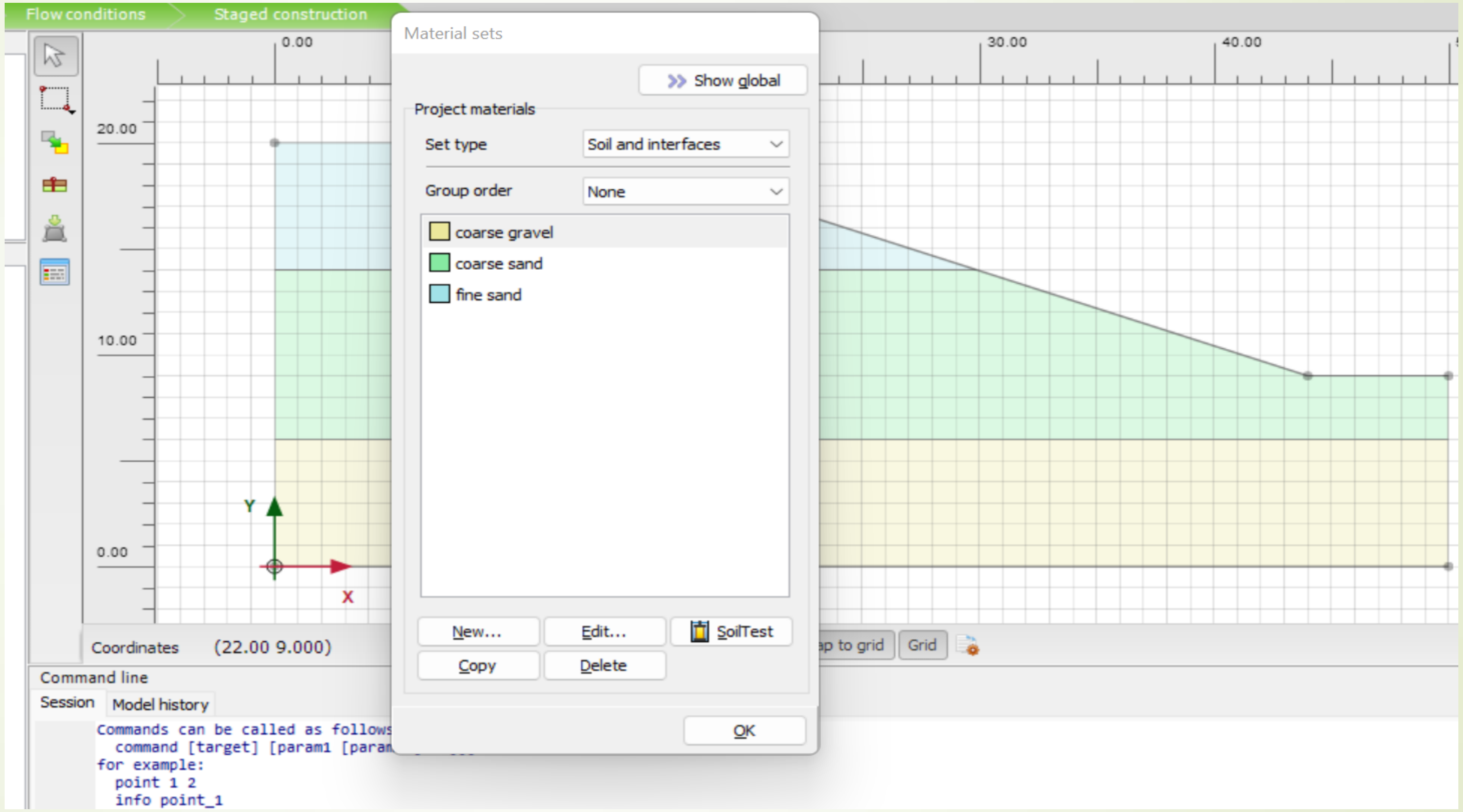
- The 2 dimensional view (sectional view) of the slope is drawn by plotting the points .
- The section looks like the figure



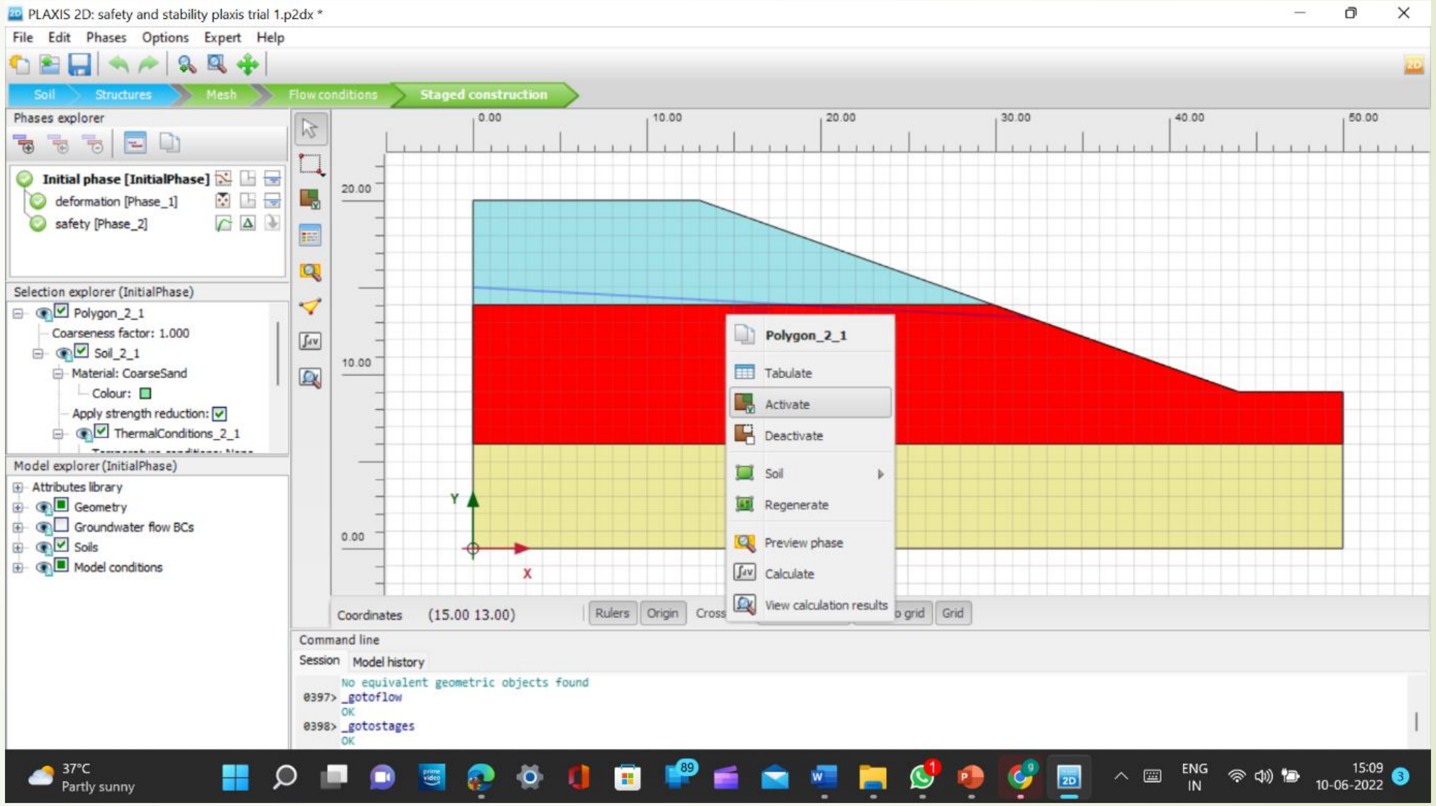
The parameters for the soil layers are given with a borehole option in which the details of The Youngs Modulus (e'),Poisons ratio (v),cohesion (c) ,Angle of internal friction , density are assigned for the layers of soil



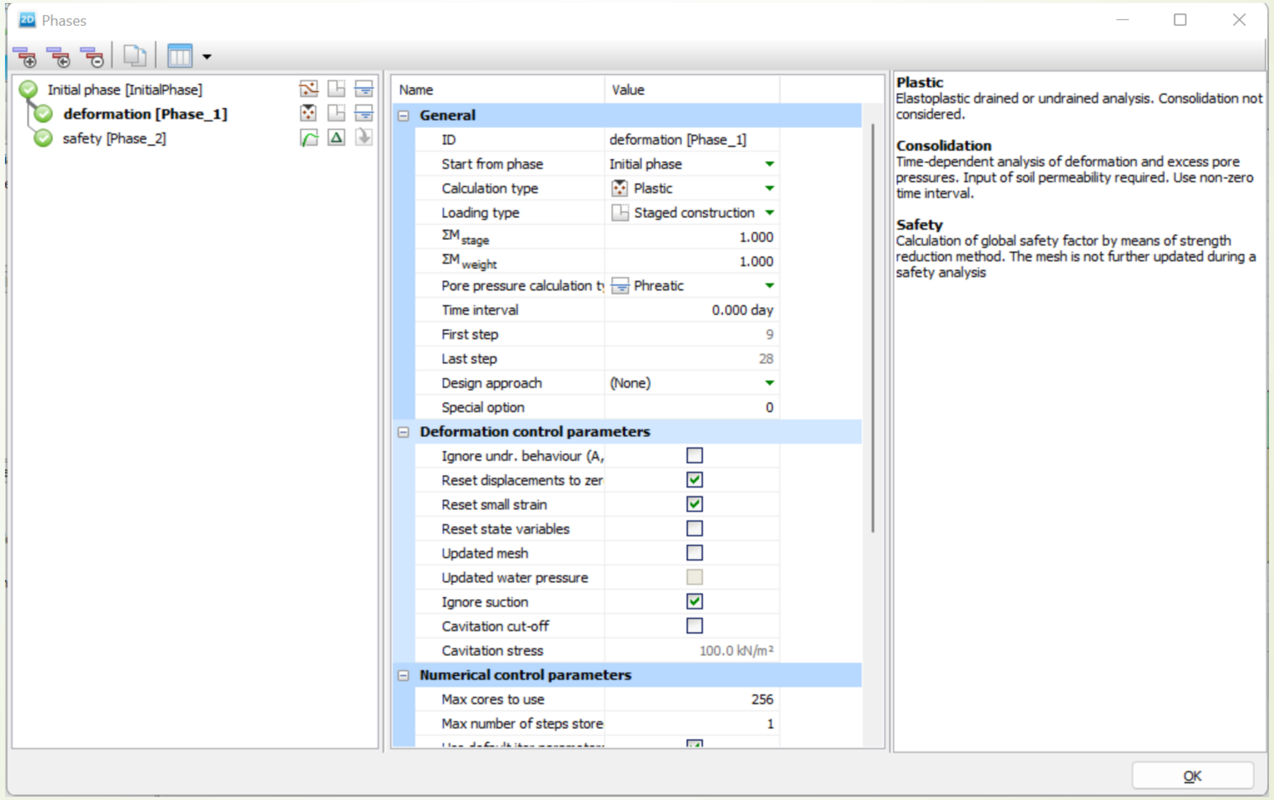
The material sets are dragged and placed at their designed layers



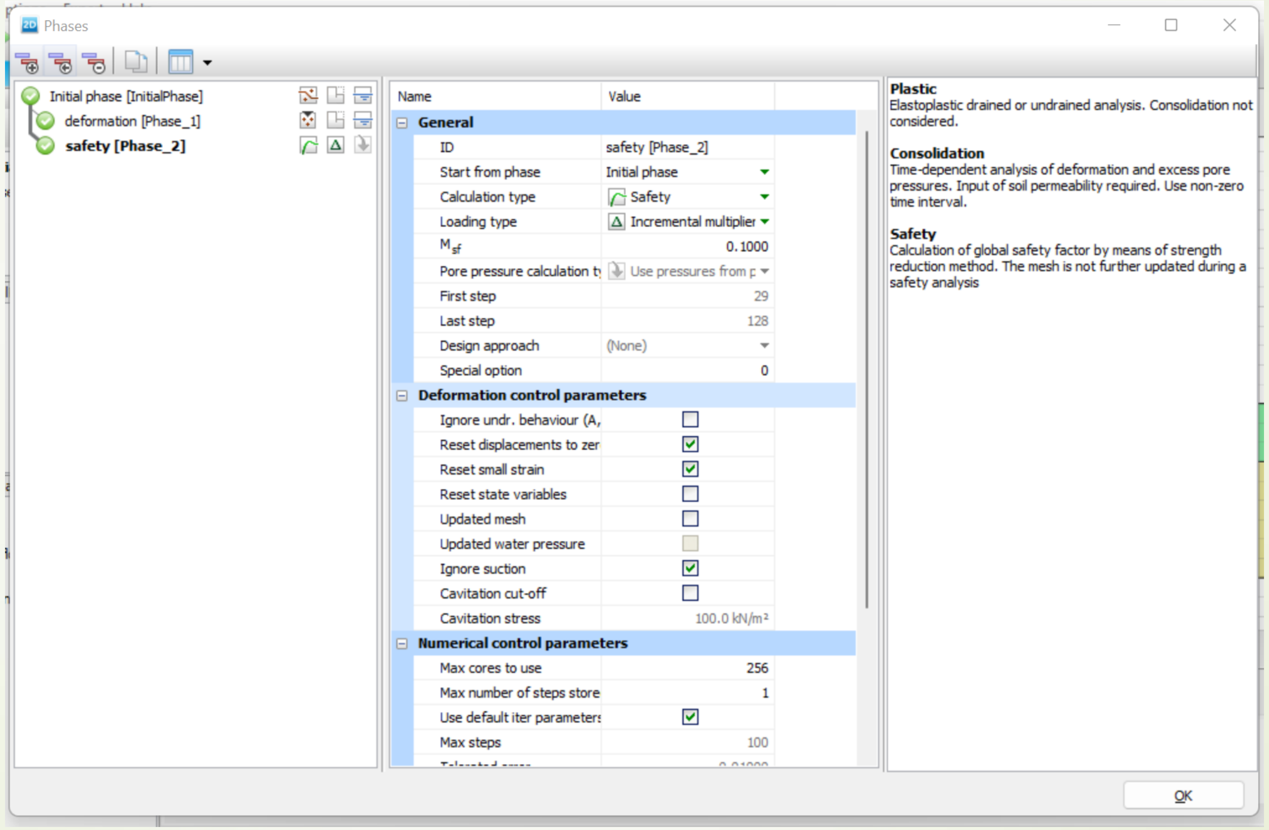
- The structure then activated for calculating the factor of safety and deformation as shown .
- Now in the staged construction the calculation of deformation and factor of safety is calculated



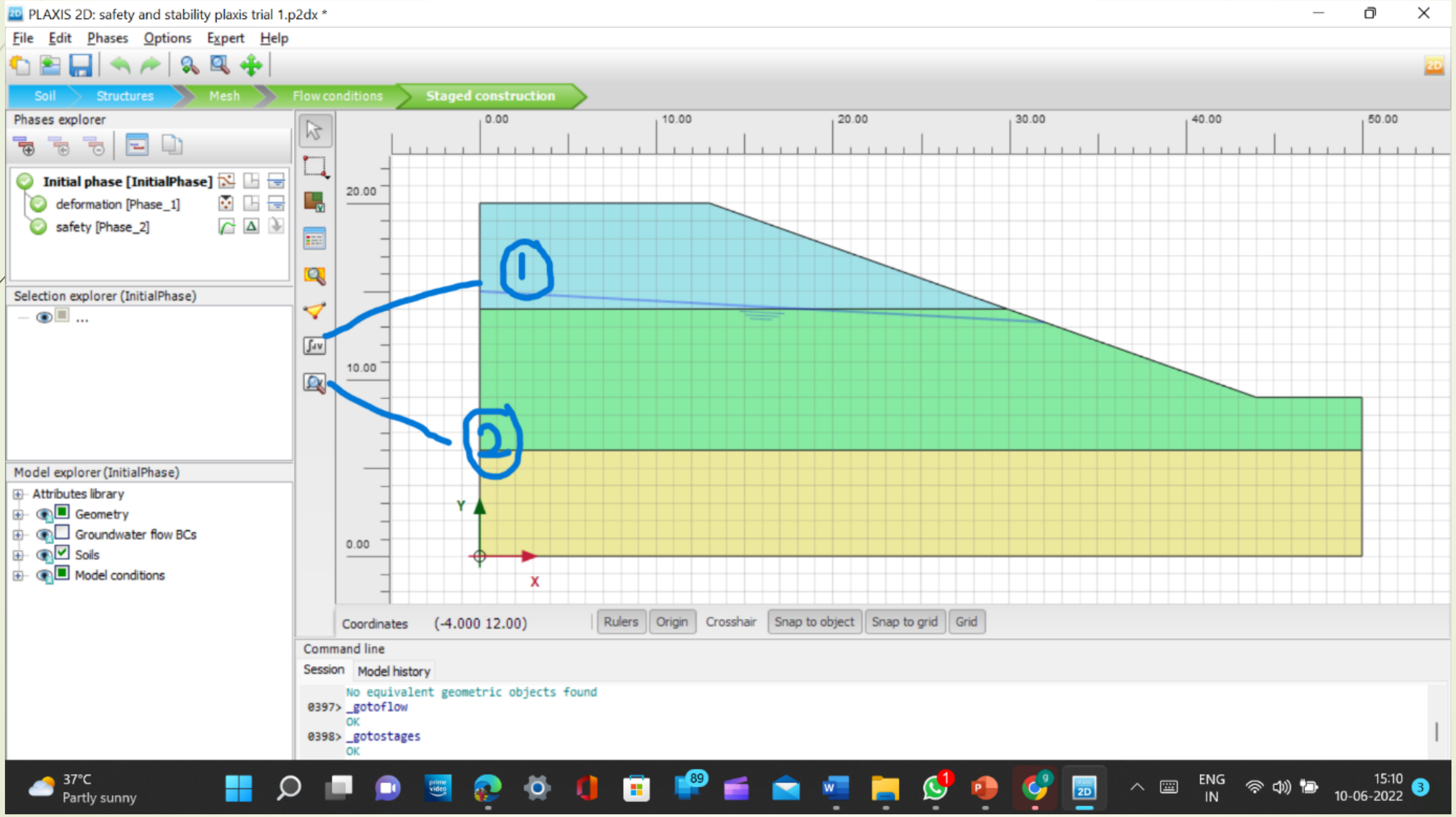
By adding new phases in staged construction , For the verification of deformation the calculation type is fixed as plastic



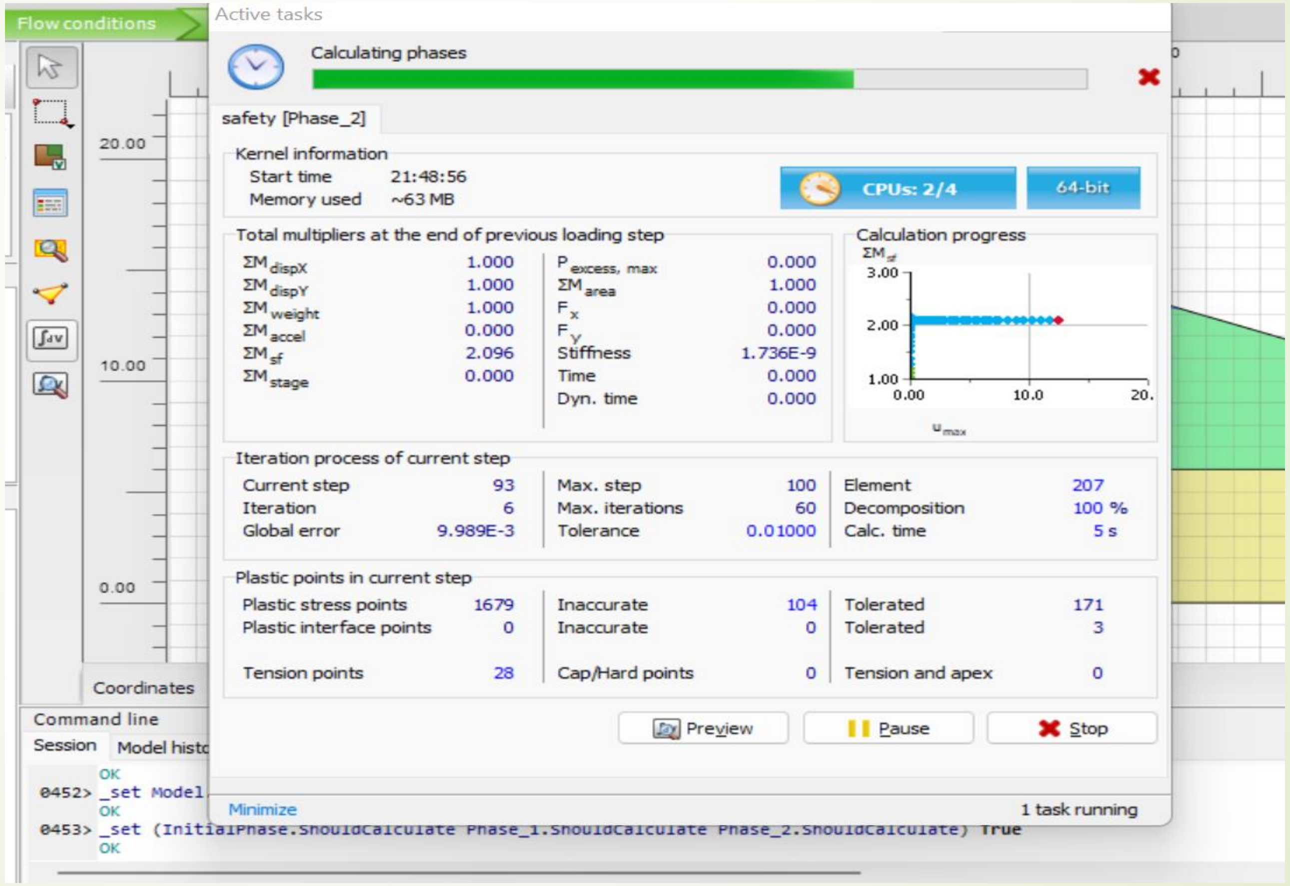
By adding another new phases in staged construction , For the verification of factor of safety the calculation type is fixed as safety as shown.



By using **calculating input** and **view calculation input**



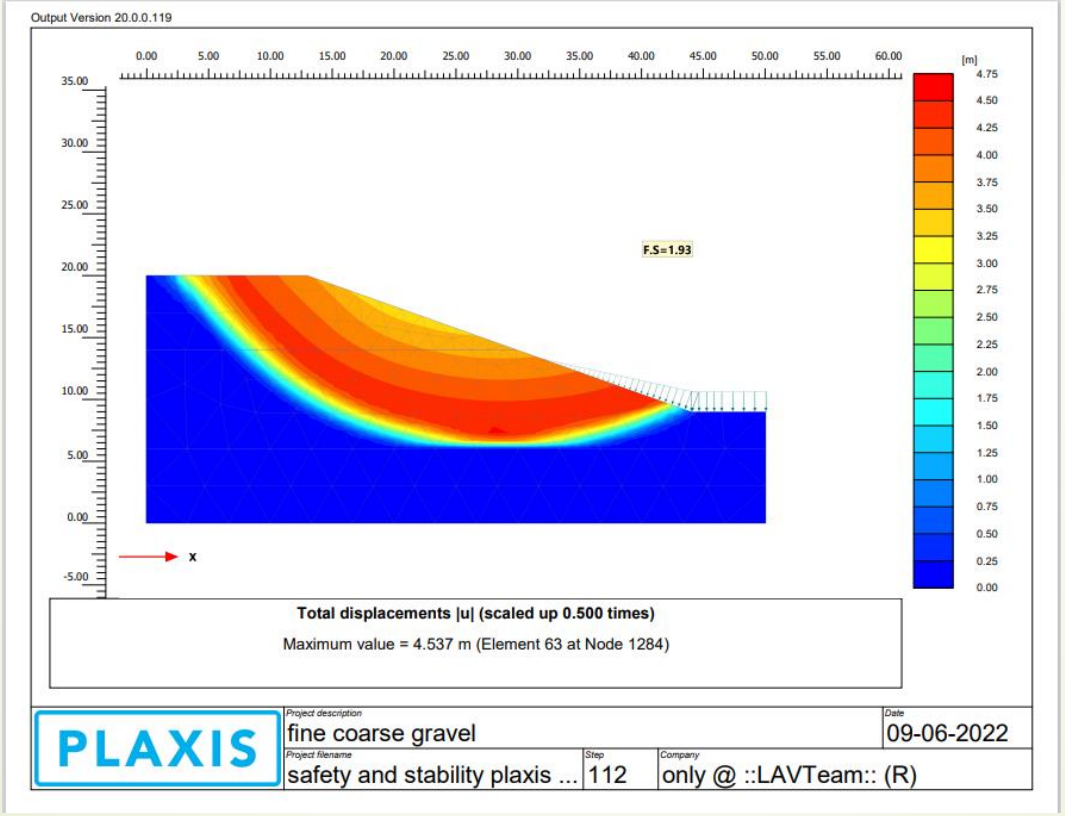
The calculation will work as shown



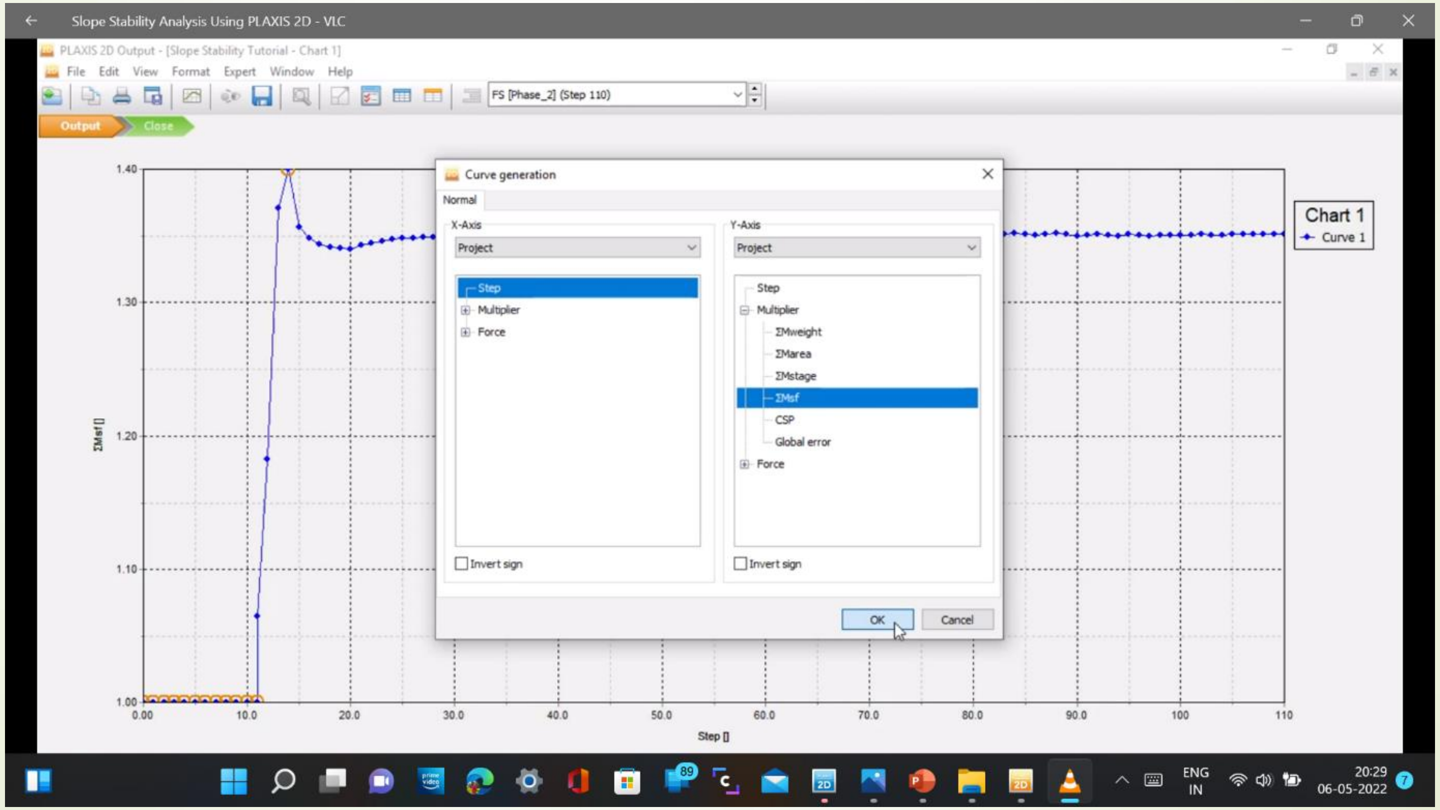
UNIT -3

Result And Conclusion

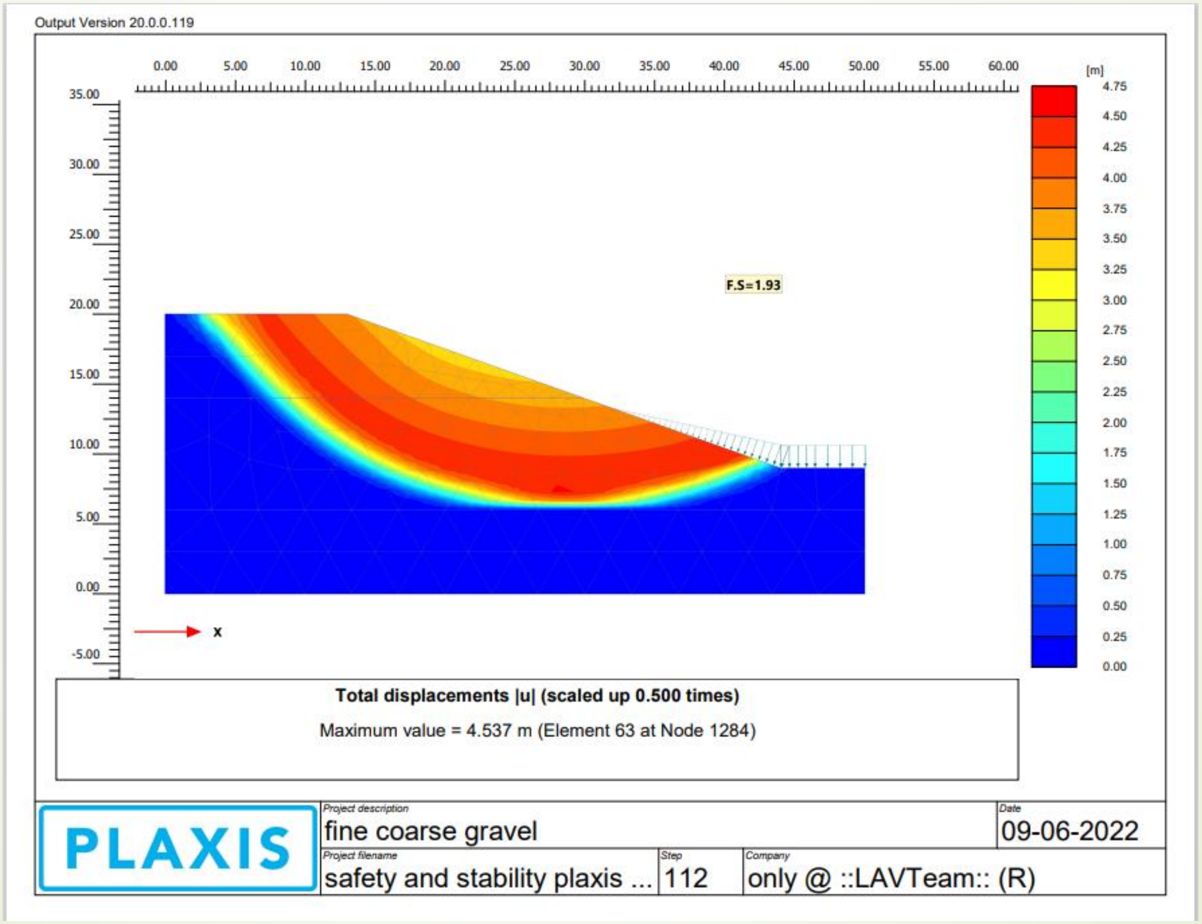
By selecting stability option the possible failure of slope is determined



The graph for the factor of safety is hence calculated by selecting factor of safety on y-axis



Factor of safety is hence calculated as :1.93 from the graph

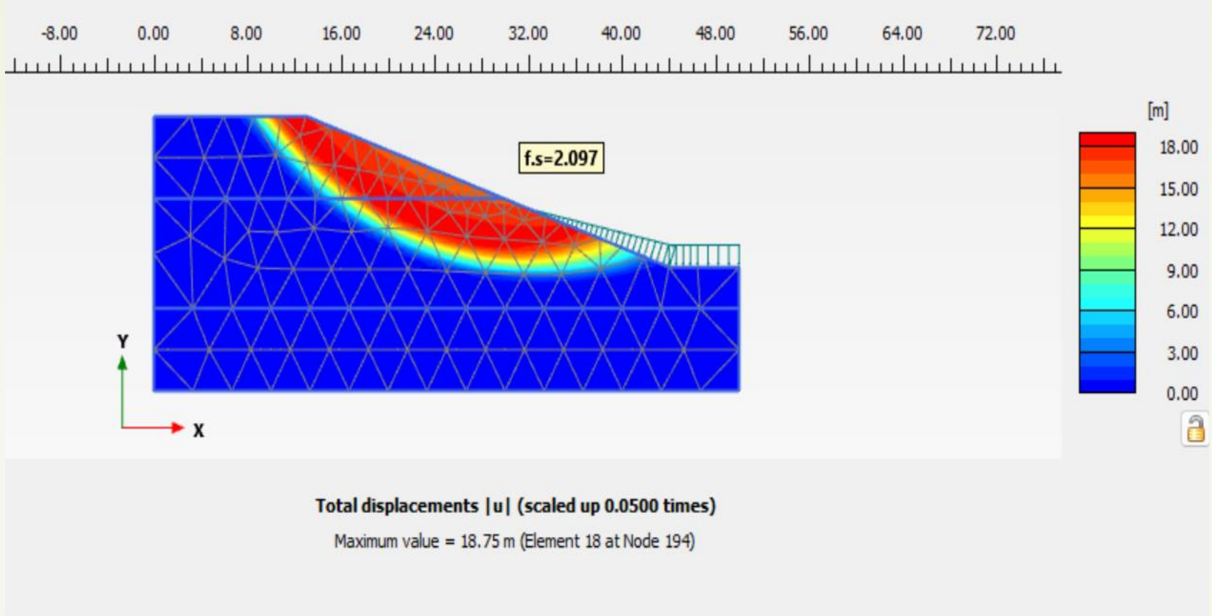


By using the biopolymers (Xanthan gum and Guar gum) the soil properties are changes as shown in the table 2

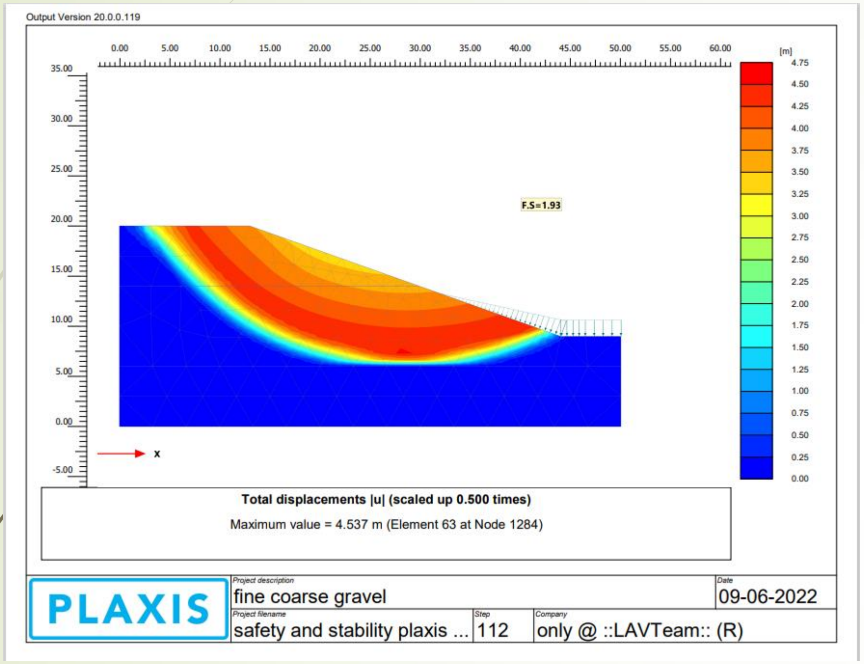
LAYER:	FINE GRAIN	COARSE SAND	LOOSE GRAVEL
POISON'S RATIO (V) (nu)	0.25	0.15	0.35
YOUNGS MODULUS (e') (KN/m2)	30,000	43,000	50,000
COHESION (C) (KN/m2)	2	5	4
ANGLE OF INTERNAL FRICTION (ϕ)	35°	36°	34°

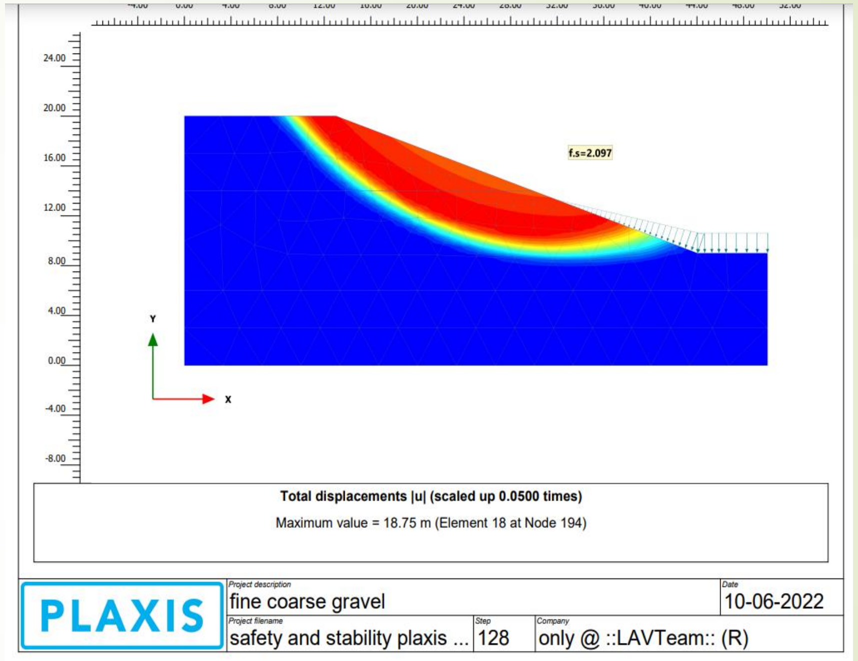
Table 2

By giving the parameters of the soil (Experimental results for 1% XG + 2% GG) the output is as follows:



Factor of safety : 2.097





The stability of natural soil

The stability of soil with 1% XG + 2% GG

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THANK YOU.