Analysis of soil profile using Plaxis 2D

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Abstract : ***The proneness to implement software programs into the civil engineering industry began as pedagogical concerns for the future as civil engineer. Land surveying, a specialized subdivision of civil engineering, depends heavily on the computerization of the industry. PLAXIS is a program that has been developed specifically for the analysis of deformation, stability, and stress in geotechnical engineering. Shahpur is a town in Burhanpur district in the Indian state of Madhya Pradesh. Shahpur is located at 21.23°N 76.22°E. The land used for study of soil behavior and soil investigation for proposed construction for improvement to water supply services in Nagar Parishad Shahpur, district Burhanpur (MP). The test result obtained from the MNTRL is studied using Plaxis 2D (BENTLEY). The first 9 meters of soil layer consists of Yellowish stiff to hard silty sandy clay, next 11 meters consists of very dense medium coarse grain clayey silty sand with fine gravel. The bore hole terminates at a depth of 20 meters. The modeling of mentioned site is going to be done by Plaxis 2D Software. The FEM analysis of 15 nodes element will be carried out by using Mohr-Coulomb model. The generated mess of borehole will be analysed with different phase condition of staged construction using various soil input parameters provided. The result obtained will be analysed using deformed mess, effective stress, void ratio, plastic points, tension cut-off points and cohesion on different node points of element.***

IndexTerms - Borehole, Plaxis 2D, FEM, mess, Element, Phase, staged construction.

I. Introduction

Plaxis 2D is a finite element software, specifically used for stability and deformation analysis in geotechnical applications. The program uses a suitable and friendly graphical user interface that enables users to straightway generate a geometry model and FEM (finite element mesh) based on a representative vertical cross section of the terrain. PLAXIS 2D is a powerful and user friendly finite element package that has been developed specifically for the analysis of deformation, stability and flow in geotechnical engineering. The input parameters enable the enhanced output facilities provide a detailed output(presentation) of computational results. PLAXIS enables new users to work with the tools after only a few hours of proper training. It provides the user friendly interface to work with.

Xiaoyun Yang, Yan Zhang, and Zhuhan Li, 2020, In this study the investigation of the displacement of coal gangue filling material in road construction and microstructural behavior of treated coal gangue by taking the environmental factors of aqueous solutions with different acidity. The displacement analysis of the coal gangue embankment model has been done by means of the finite element method(FEM) PLAXIS. The displacement of the coal gangue subgrade is obtained by PLAXIS numerical simulation method. The displacement settlement of the coal gangue subgrade is gradually reduced from the top of the roadbed to the underside of the clay. [1]

Ika Puji Hastuty and Rizky Prambudi, 2020, Unstable slopes are very dangerous to the surroundings; therefore, an analysis of slope stability is highly needed. In this research, Plaxis are used to planning cantilever retaining wall reinforcement with the aim to determine the safety factor value of the slope condition before and after was given reinforcement. The safety factor value in the slope condition with cantilever retaining wall reinforcement was 1,567 > 1,3 (Safe). The safety factor value in the condition of slope with cantilever retaining wall reinforcement by Plaxis was 1.57, the value showed that the slope condition became safe with the application of cantilever retaining wall reinforcement.[2]

K. U. Arun, P. Jisna, Rose Simon, Oshin Ann Mathews, E. M. Anju, (2020), The study was undertaken to investigate the stability of slopes in landslide prone area using GEO5 and PLAXIS 2D software. The determination of index properties using geotechnical investigations are carried out first and hence the values to be assigned to corresponding software.[3]

II. Data Collection

a) Site Location:

Shahpur is a town in Burhanpur district in the Indian state of Madhya Pradesh. Shahpur is located at 21.23°N 76.22°E as shown in fig:2.1. The average elevation of shahpur is about 238 metres (780 feet). The land used for study of soil behavior and soil investigation for proposed construction for improvement to water supply services in Nagar Parishad Shahpur district Burhanpur (MP). The soil near the intake well consists of various layers of clay and gravel. The first 9 meters of soil layer consists of Yellowish stiff to hard silty sandy clay, next 11 meters consists of very dense medium coarse grain clayey silty sand with fine gravel. The bore hole terminates at a depth of 20 meters.

Site Location

Collected Sample

The three borehole 1 (BH1), borehole 2 (BH2) and borehole 3 (BH3) terminates at a depth of 20m with different layer of soil strata as stated in table below with: Layer -I Brownish -Yellowish stiff to hard silty sandy clay and Layer –II Brownish-Yellowish very dense medium coarse grain clayey silty sand with fine gravel.

S.NO	Location	Bore hole depth	Layer -I	Layer -II	Remark
1	BH-1	20.00 m	9.00 m	11.00 m	Depth is as per the existing ground level
2	BH-2	20.00 m	4.00 m	16.00 m	
3	BH-3	5.00 m	5.00 m	-	

Layer Description

III Methodology:

The finite element method:

The problem can be modeled either by a plane strain or an axisymmetric model. The program has advantageous feature that enable user to choose different soil model which is dependent on mechanical deformation behavior of soil for the simulation. The models include Mohr-Coulomb, joint rock, hardening soil, soft soil and modified cam-clay model. Standard boundary conditions are automatically generated by the program.

Mohr-Coulomb:

The content about the Mohr-Coulomb model is collected from Bringreve et al. (2013).

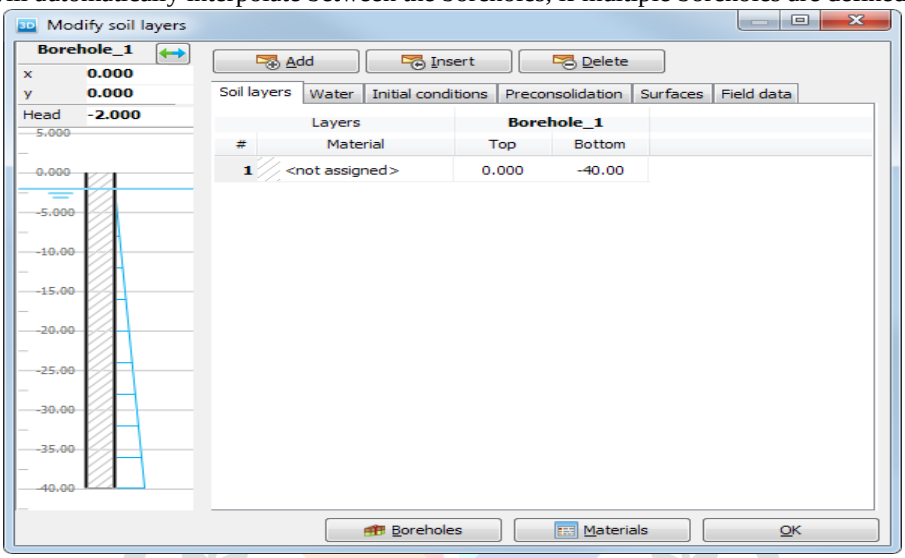
Soil behaviour is highly non-linear and irreversible. The Mohr-Coulomb model assumes a linear elastic perfectly plastic behaviour of the soil, which implies a linear unloading and reloading. The strains are decomposed into an elastic and a plastic part. To model the soil behaviour, the following five parameters are used in the Mohr-Coloumb model:

E : Young's modulus [kN/m2]
ν : Poisson's ratio [-]
c : Cohesion [kN/m2]
φ : Friction angle [°]
ψ : Dilatancy angle [°]

The various steps involved in the modeling of the sample are disscussed below:

Step1: Defination of soil stratigraphy:

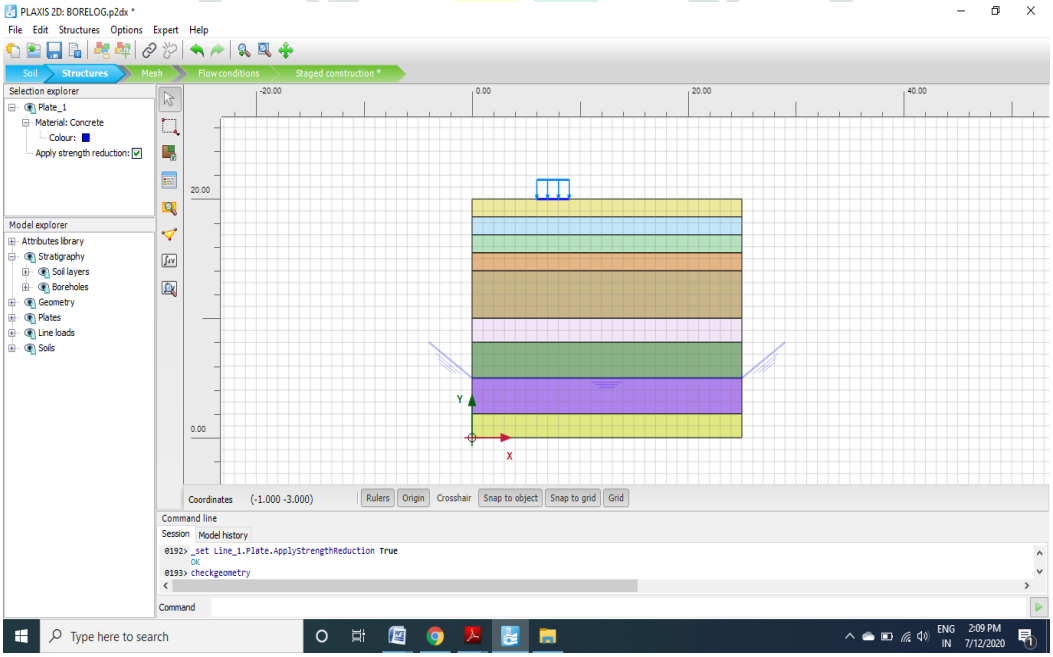
Boreholes are locations within the drawing area at which the knowledge on the position of soil layers and therefore the water level is given. PLAXIS 3D will automatically interpolate between the boreholes, if multiple boreholes are defined.



Material data set

Step 2: Definition Of Structural Elements

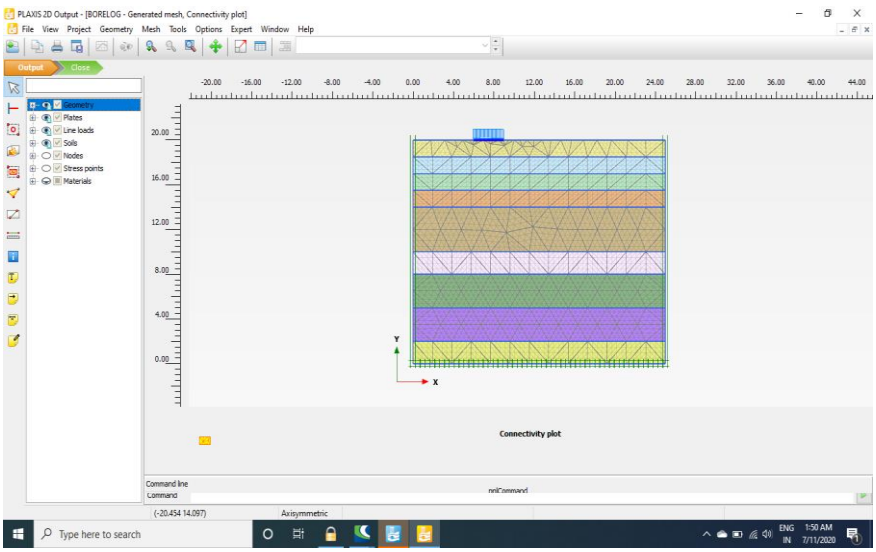
For structures (like beams, plates, etc.) the system is similar, but different types of structures have different parameters and therefore different types of data sets.The structural elements are created in the Structures mode of the program.



Parameter details

Step 3: Mesh Generation

The model is complete. In order to generate the Mesh mode click the Mesh tab. PLAXIS 2D generate automatic mesh generation procedure, during which the geometry is split into volume elements and compatible structure elements, if applicable.



Mesh Generation

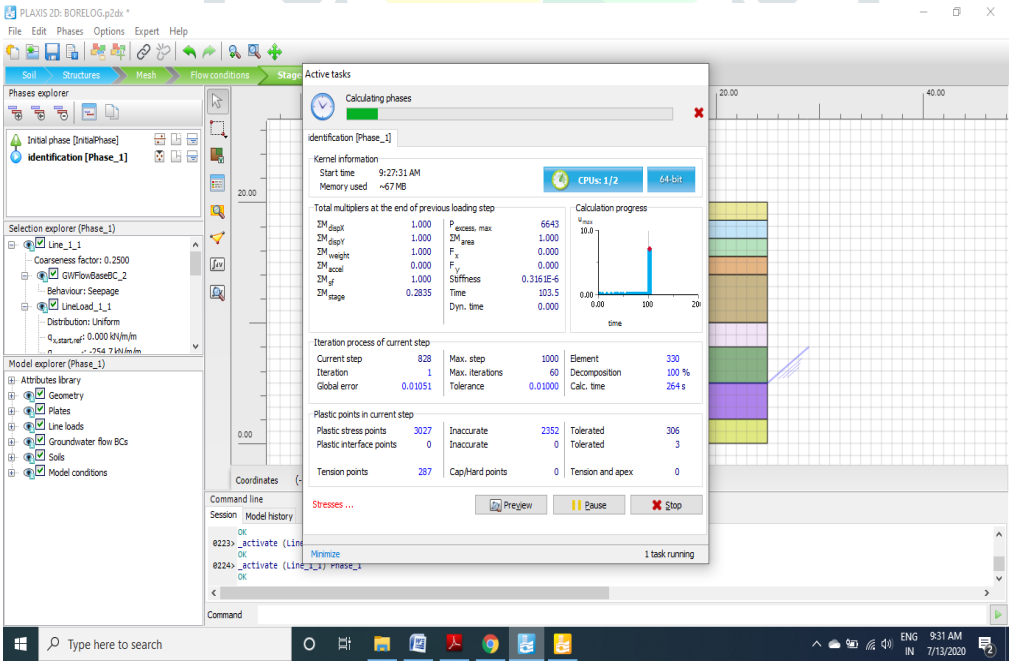
Step 4: Flow condition

Interface element are treated specially in groundwater calculations. The interface elements have an active setting for the deformation calculation (soil structure interaction) and an independent settings for flow calculation. When the interface elements are active in flow conditions, there is a full coupling of the pore pressure degrees of freedom and the interface permeability is taken into account.

Step 5: Staged Construction

The calculation has to be defined in phases before the actual calculation can be performed in the staged construction explorer. The 'Initial phase' comprises of the generation of initial conditions. In staged construction, the initial conditions comprise the initial geometry configuration and the initial stress state, i.e. effective stresses, pore pressures and other state parameters.

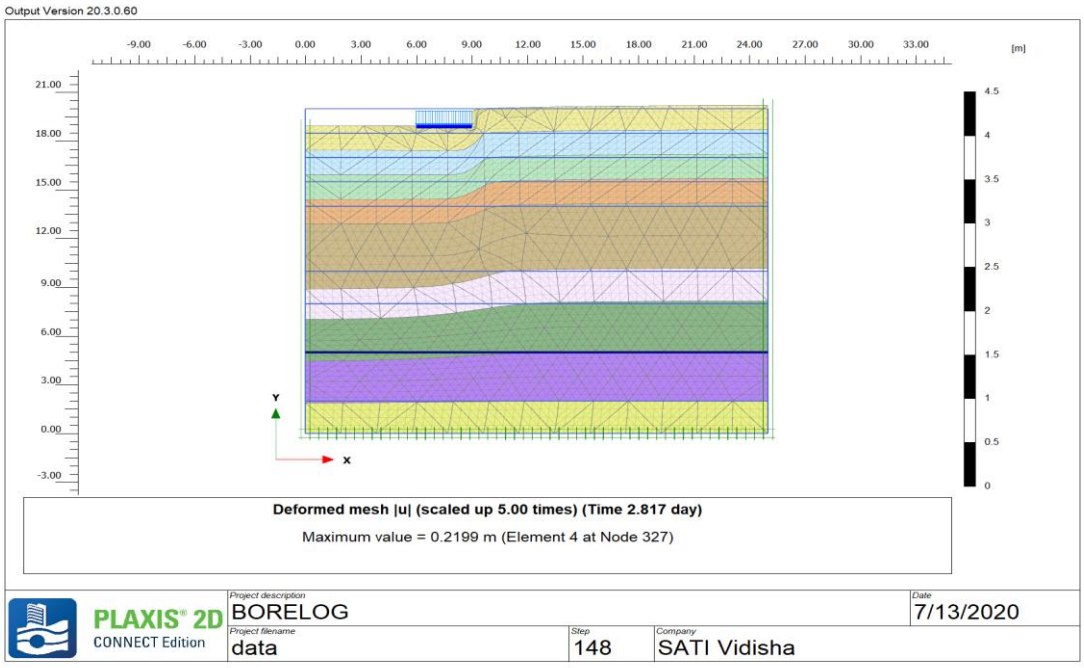
- Loading type option is available for the Staged construction.
- By default for Pore pressure calculation type Phreatic option is selected.
- The temperature option is ignored (by default) for the Thermal calculation type.



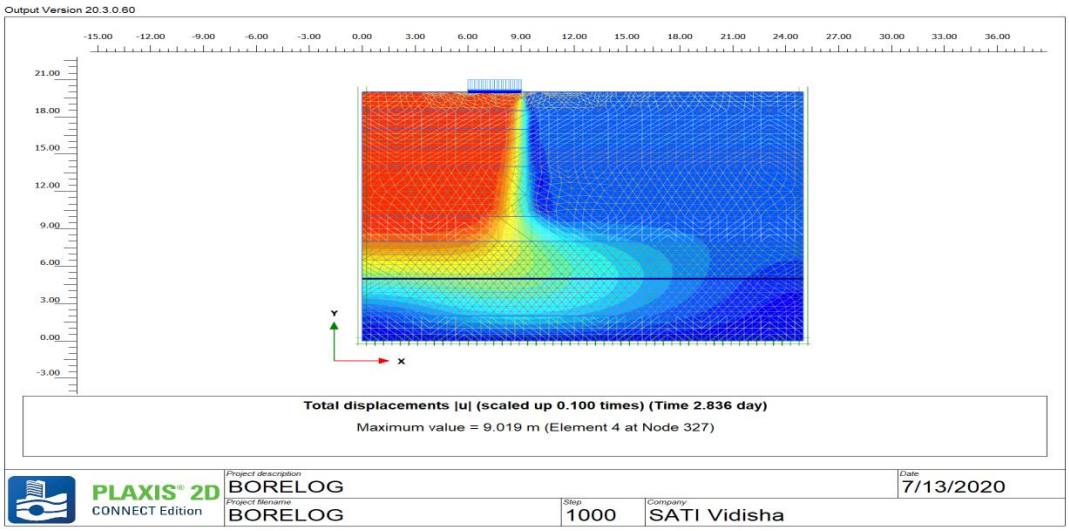
Calculation of Identification Phase(Starting from initial phase)

IV SOFTWARE RESULT

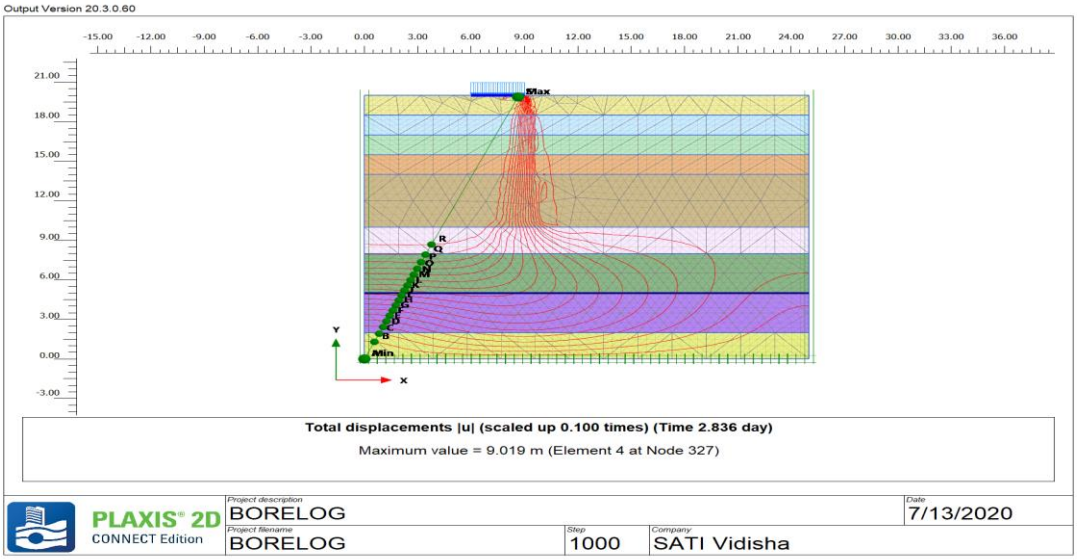
The result of Initial phase and Indicated phase staged construction are listed below. All the output of each phase is generated in a separate output screen.



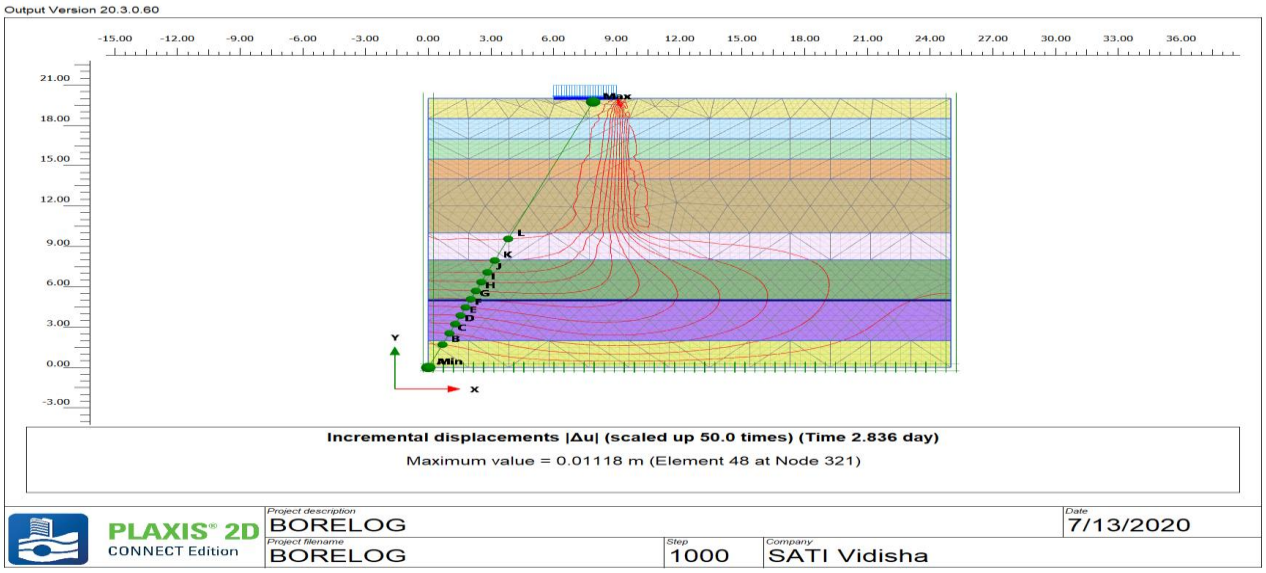
Deformed mesh after indication phase calculation upto 5 times



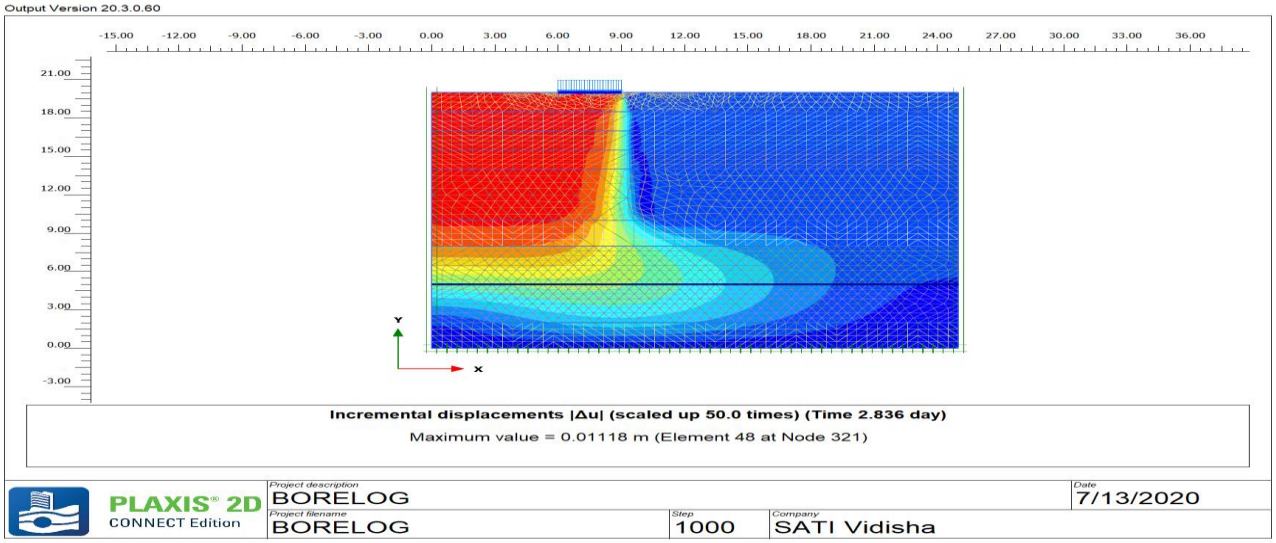
Total displacement in shaded area in time interval of 2.836 days



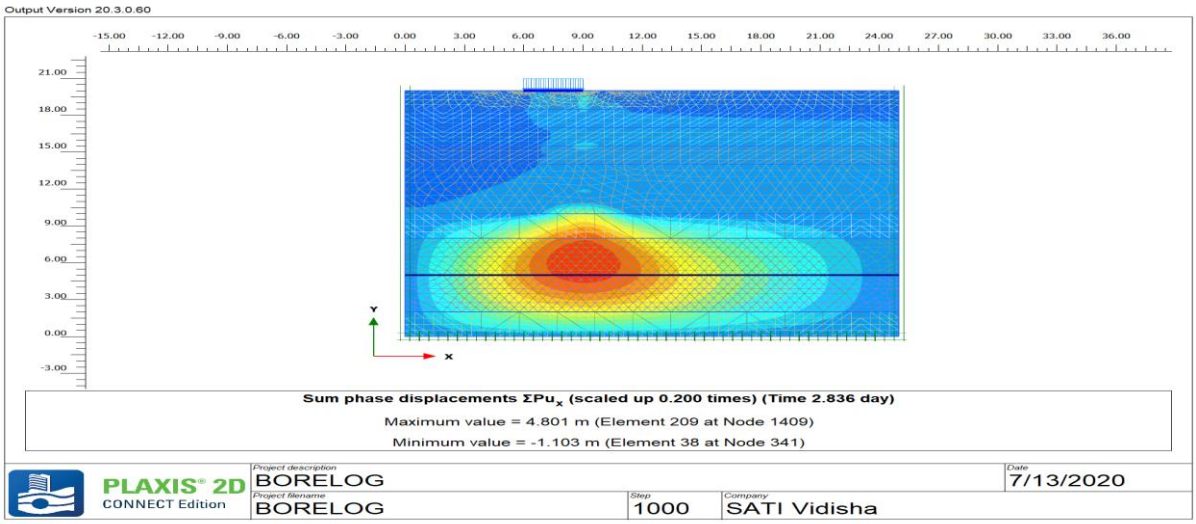
Total displacement upto 9.019m length at node 327, element 4



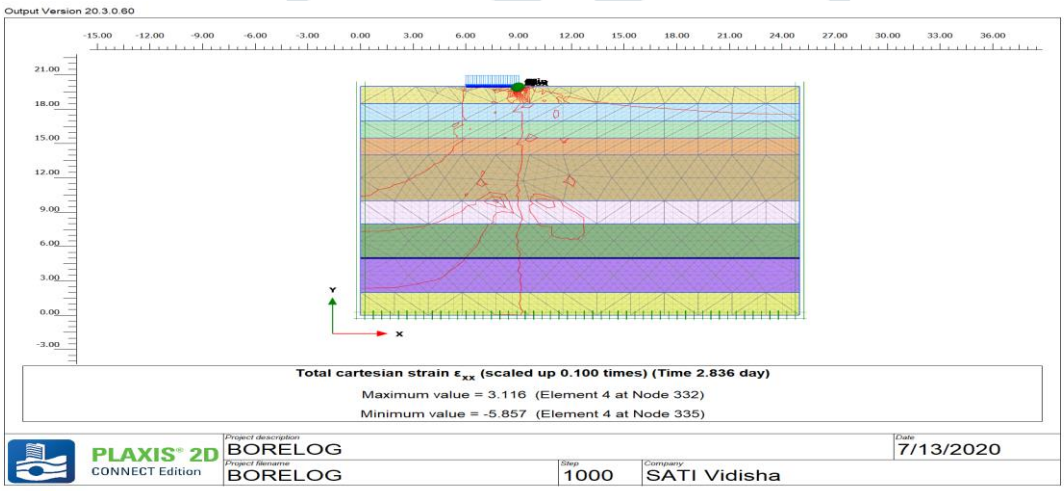
Incremental displacement (max value 0.01118m at node 321)



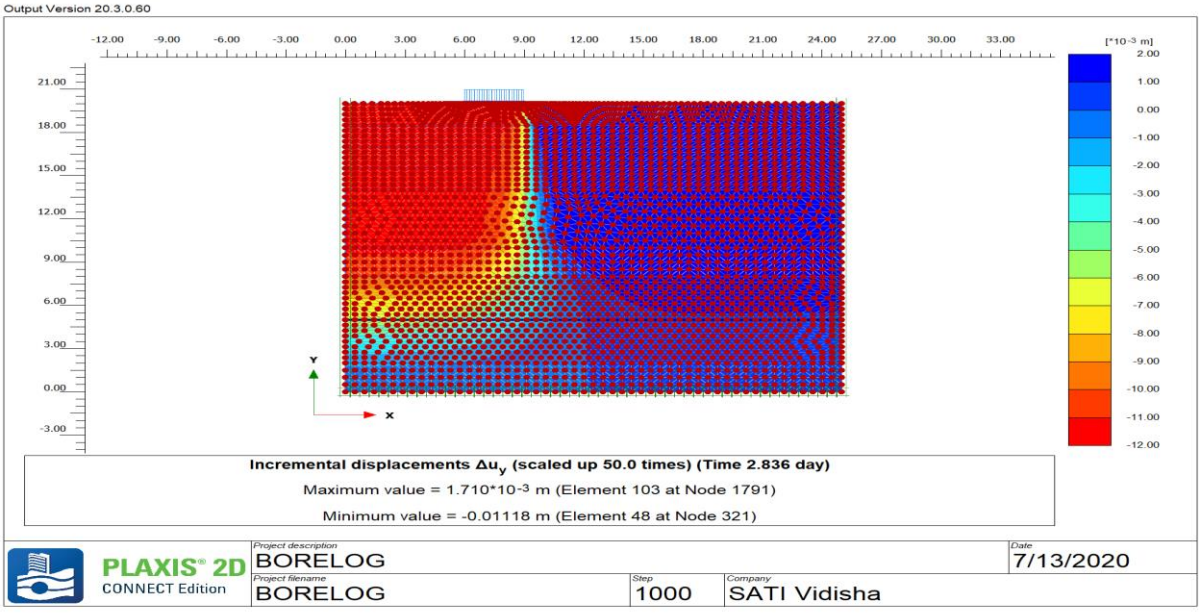
Incremental displacement (shaded area)



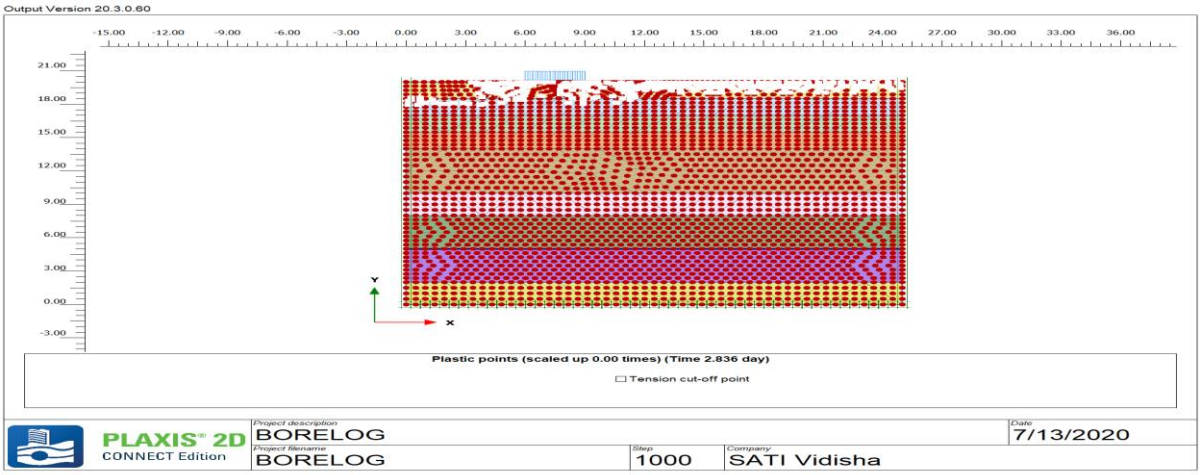
Sum phase displacements (max 4.801m, min -1.103m)



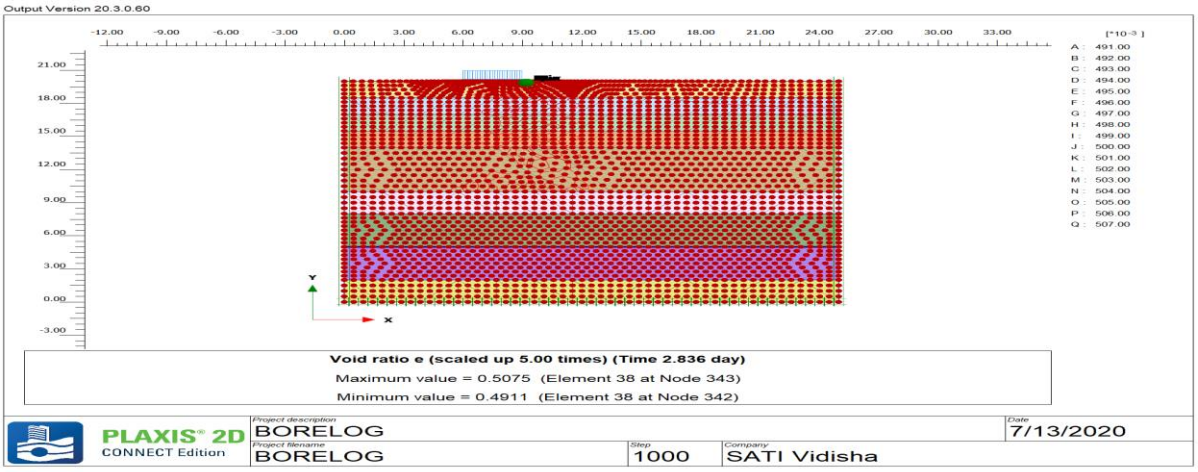
Total cartesian starin ɛxx max and min value



Incremental displacement



Plastic points with tension cut-off point



Void ratio e

V) Conclusion

The study of borehole data obtained is analysed through Plaxis 2D. The various input parameters gives the desired result which shows the behaiour of soil on loading. The result obtained through software analysis are stated below:

- The Mohr-Coulomb model is used for analysis of linear elastic perfectly plastic behaviour of the soil.
- 15 element node points are generated instead of 6 nodes points for stress analysis.
- 3960 stress ponits are generated with 15 element node points (all cluster point).
- Deformed mess is genrated scaled upto 5 times with maximum value of 0.2195m at element 4 node 327.
- Total displacement of soil stratigrapgy is 0.019m at element 4 same obtained by the borelog details
- Incremental displacement of mess is 0.0118m at node 321, element 48.
- Sum phase(initial and independent phase) displacement is occurred at element 209 at node 1409
- Total cartesian starin ɛxx max and min value are 3.116 and -5.857 at node point 332 and node 335 respectively.
- The void ratio emax=0.5075 and emin= 0.4911 at element 38 node point 343 and 342 respectively.
- The systematic plastic failure points and tension cut-off point on soil layer are shown in figure.

VI) References

[1] Xiaoyun Yang, Yan Zhang, and Zhuhan Li, 2020, Embankment Displacement PLAXIS Simulation and Microstructural Behavior of Treated-Coal Gangue, Volume 10 Issue 3, 218 MDPI.

[2] Ika Puji Hastuty and Rizky Prambudi, 2020, A Comparison Study on Stability of Kuranchery Slopes Using GEO5 and PLAXIS 2D Software, Volume-3, Issue-3, March-2020 IJRESM, pp323-326.

[3] K. U. Arun, P. Jisna, Rose Simon, Oshin Ann Mathews, E. M. Anju, (2020), Analysis of slope stability by the planning of cantilever retaining wall reinforcement using the application of Plaxis, IOP Science.