International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Settlement Analysis of Pile Foundation Using Plaxis 2D

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Abstract: ***In the recent years, there are many construction projects which are constructed on soft soil. Because of the characteristics of soft soil, the structures which are built on it are subject to differential settlements. Foundation is one of the methods for reducing differential settlement.To reduce the settlements to an acceptable amount, the piles are added. The aim of this study is to analyse the settlements of the pile foundation by increasing the number piles, as the pile foundation, under the same loading, with or without considering the water table below the top surface. The numerical analysis has been done by finite element method using PLAXIS 2D by considering the various number of piles. As a result, the addition of piles could reduce the settlement. It is necessary to consider the optimum number of piles in pile foundation system based on the allowable settlements, for its economical design. This analysis has been undertaken to study the behavior of pile foundation under different number of piles. This analysis has been done using PLAXIS 2D software.***

Keywords: PLAXIS 2D, Settlements, Pile Foundation

1. Introduction

1.1 General

Foundation is a structural part of a building on which a building stands. Foundation transmits and distributes its own load and imposed loads to the soil in such a way that the load bearing capacity of the “foundation bed” is not exceeded. When the soil at shallow depth is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata. If a firm stratum is so deep that it cannot be reached by open excavation, the deep foundation will be adopted.

1.2 Types of Foundation

The most common types of deep foundations are Piles, Piers and Caissons. The mechanism of transfer of the load to the soil is essentially the same in these types of foundations. When piles and raft are both equal in cost, then piles are preferable to rafts as the settlement for piles is considerably less than that of a raft. Economy in pile foundation is achieved by designing the piles of suitable diameters such that the sum of safe capacity of piles under a column should be almost equal to the load coming on the column. In one pile group there should be preferably only one diameter of piles. In a building, diameter of piles may vary under various columns depending on the magnitude of load being carried by the columns.This paper presents the Comparison results between analytical and also by using PLAXIS 2D.

Recent years, a lot of urbanization is taking place as a result many high rise buildings are constructed and due to scarcity of land, structures are built on soft soils using pile foundation. So apart from conventional method now geotechnical engineers are going for piled foundation in which load from super structure is shared by pile.Pile has adequate bearing capacity and reduces differential settlement but undergo excessive settlement.It is also an economical method as compared to conventional pile foundation. The results proved that ultimate load has increased and the settlement has reduced. Parametric study showed that reduction in settlement takes place due to increase in pile length as well as with increase in number of piles. This study is useful to decide various parameters required to design pilefoundation economically.

1.3 Need of Pile

An insufficient bearing capacity of the soil to bear a structure will demand for pile foundation. The pile foundation will be chosen based on theSoil Condition, Types of Loads acting on the Foundation,Bottom layers of the soil,Site Conditions,Operational conditions.

When the plan of the structure is not regular the load distribution also will not be uniform in nature. Employing a shallow foundation in these cases will result in the differential settlement. In order to eliminate differential settlement and such a cases, the pile foundation become necessary. Pile foundation is necessary for areas where the structure surrounding has chances for soil erosion. This might not be resisted by the shallow foundation. Pile foundation is needed near the drainage and canal lines. The adjacent soil can be confined by means of sheet pile foundation.

In some situations, the sub soil water table at the site will be so high that the use of other foundation will be affected badly. In such a situation, pile foundation can be easily penetrated through the water and extended until a hard strata can be reached.Structures might be subjected to horizontal forces that will bring effect to the foundation. The use of pile foundation help in resisting this bending action along with supporting the vertical load coming over the foundation. The pile foundation is needed for the construction of earth water retaining structures and building structures highly subjected to lateral (Earthquake and wind) forces.

2. Methodology

2.1 Finite Element Method

The finite element method (FEM) is a numerical method for finding fairly accurate solutions of partial differential equations as well as integral equations. The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method. For carrying out elasto-plastic analysis in this project, commercially available geotechnical software PLAXIS 2D is being used which uses Finite Element Analysis (FEA) for simulation of model.

2.1.1 Plaxis 2D

PLAXIS 2D is a powerful user-friendly finite element package intended for two dimensional analysis of deformation and stability in geotechnical engineering and rock mechanics. It is used worldwide by top engineering companies and institutions in the civil engineering and geotechnical engineering industries.Applications range from excavation,embankment and foundation to tunneling,mining and reservoir geo-mechanics. PLAXIS is equipped with broad range of advanced feature in model a diverse range of geotechnical problems, all from within a single integrated software package.

PLAXIS uses predefined structural elements and loading types in a CAD-like environment. This empowers the user with the fast and efficient model creation, allowing more time to interpret the results. The user-friendly interface guides the user the efficiency create model with the logical geotechnical workflow in cont. The versatile output programme offers various ways to display forces, displacements, stresses and flow data in contour, vector and copied from tables or via python based scripting for further processing purposes outside of PLAXIS. The curve manager enables graph creation, plotting various results type from available calculation data.

2.2 Soil Layer and Structural Elements

Current model of this problem consist of a pile having diameter 40cm and length 10m which is ultimately loaded to 800KN. The pile is placed at the centre of excavation with the depth of 1.2m.The subsoil is divided into 4 layers.
The details of this elements are as follows,

1) **Soil Layers**
   The soil stratigraphy can be defined in the soil mode using the borehole feature of the programme. Boreholes are located in draw area at which the information on the positions of soil layer and the water table is given. If multiple boreholes are defined the programme will automatically interpolate between borehole and derived the position of the soil layer from the borehole information. Groundwater and pore pressure play an important role in the soil behavior, so this requires proper definition of water conditions. This definition of water condition can also be done with the creation of borehole. A fixed end anchor is a point element that is attached to a structure at one side and fixed to the world at other side. Fixed end anchors can be used to simulate piles in a simplified way, that is without taking into account pile soil interaction. Alternatively, fixed end anchors can be used to simulate anchors or props to support retaining walls.
2) **Embedded piles:**
   An embedded pile is a pile composed of beam elements that can be placed in arbitary direction in the subsoil and that interacts with the subsoil by means of special interface elements. The interaction may involve a skin resistance as well as a foot resistance. The skin friction and the tip force are determined by the relative.
3) **Interfaces:**
   Interfaces are joined elements to be added to plates or geo-grids to allow for a proper modulling of soil structure in the action. Interfaces may be used to simulate, for example the thin zone of intensely sharing material at the contact between a plate and the surrounding soil. Interfaces can be created next to plate or geo-grid element of between to soil volumes.

2.3 Procedure used for Simulation and Analysis of Project:

Following flow chart expresses the procedure adopted for the simulation of each model having unique position of pile:

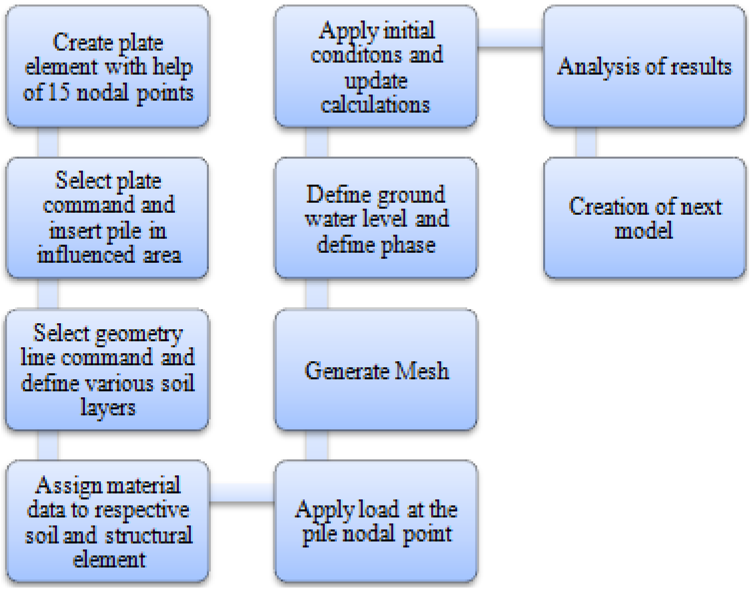

Figure 1: Flow chart showing procedure used for simulation and analysis of pile

2.4 Problem Statement

1) Pile is placed at the center of small excavation with the depth of 1.2m . The subsoil can be divided into 4 layers.
2) The water table is in level with the top of deep sand layer which starts below pile toe.
3) The pile diameter is 40cm length is 10m which is ultimately loaded to failure in compression.

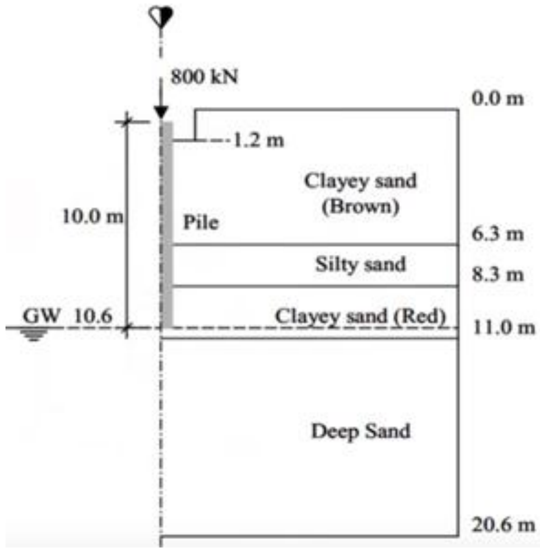

Figure 1: Numerical structure

2.5 Analysis of Pile in Plaxis 2D

Step 1: In this step, we selected 15 nodal points and decided the dimension of influence area.

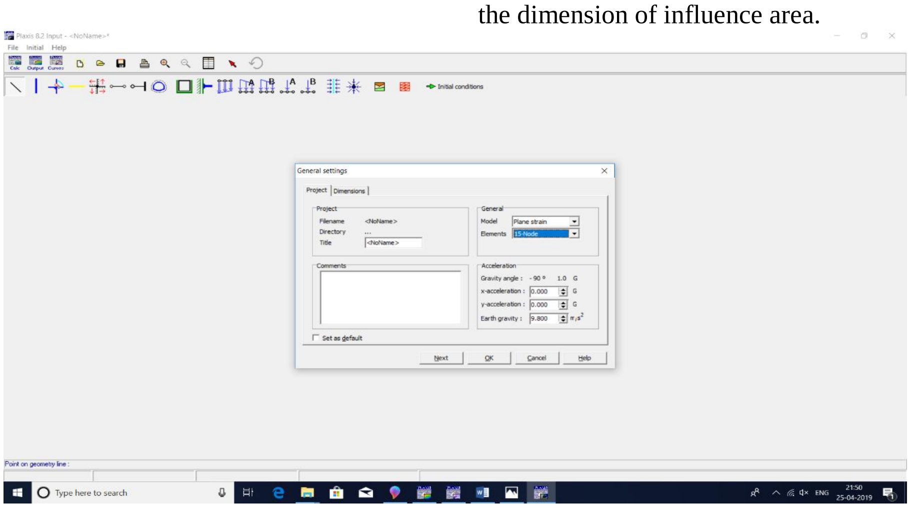

Figure 2.1: Select15 Nodal points

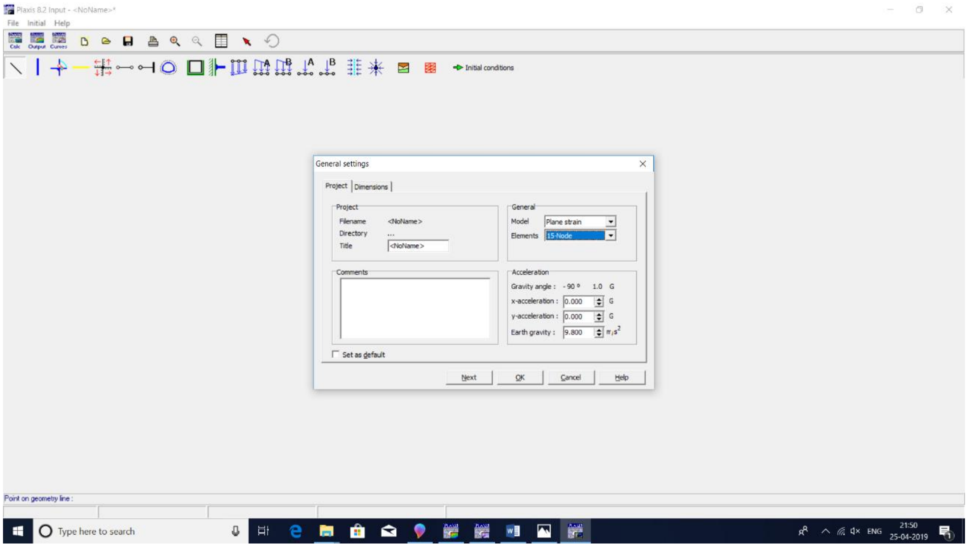

Figure 2.2: Select dimension of influence area

STEP 2: Select plate command to insert pile of given dimensions.

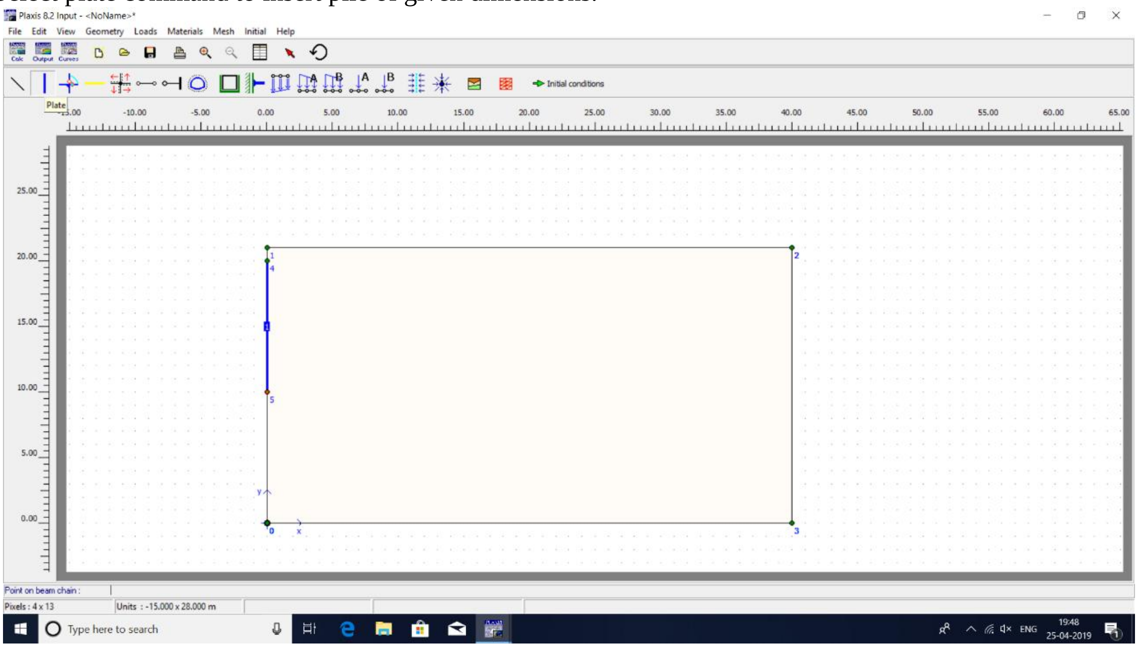

Figure2.3: Pile in influenced area

STEP 3: After making complete geometry of pile, next step to assign soil property to model.

Table1: Properties of soil

PARAMETER	NAME	CALYEY SAND (brown)	SILTY SAND	Clayey sand (red)	DEEP SAND	PILE	UNIT
MATERIAL MODEL	MODEL	Mohr coulomb	Mohr coulomb	Mohr coulomb	Mohr coulomb	Linear elastic	-
MATERIAL BEHAVIOUR	TYPE	Drained	Drained	Drained	Drained	Non porous	-
UNSATURAT ED SOIL WEIGHT	Yunsat	16.7	18.8	19.8	17.6	24	KN/m^3
SATURATED SOIL WEIGHT	Ysat	16.7	18.8	19.8	20	-	KN/m^3
YOUNGS MODULUS	E	9150	13000	13500	19000	29.2X10^6	kPa
POISSIONS CONSTANT	µ	0.3	0.3	0.3	0.3	0.3	-
COHESION	c	13	12	14	17	-	kPa
FRICTION ANGLE	ø	26	23	23	23	-	-
DILATANCY ANGLE	ψ	0	0	0	0	-	-
INTERFACE REDUCTION FACTOR	R	1	1	1	1	1	-

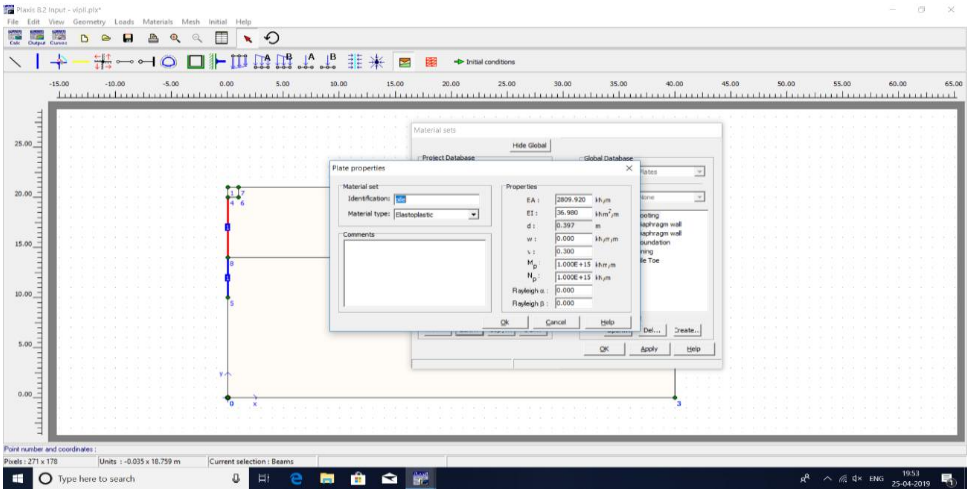

Figure2.4: Assign properties to structural element (pile)

STEP 4: After giving input to soil layer, there properties were assigned.

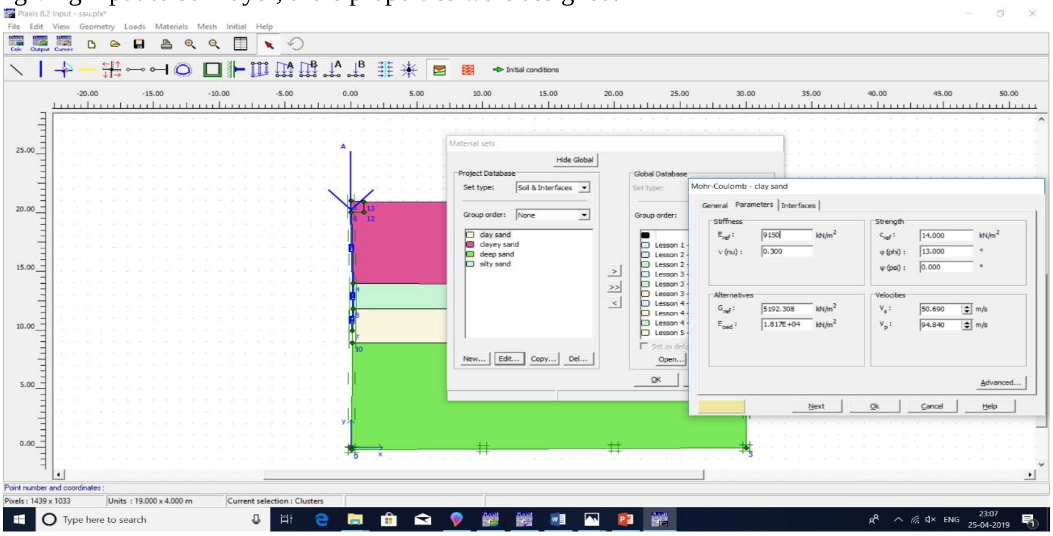

Figure2.5: Material property assigning to soil

STEP 5: Next step is to assign load at pile nodal point

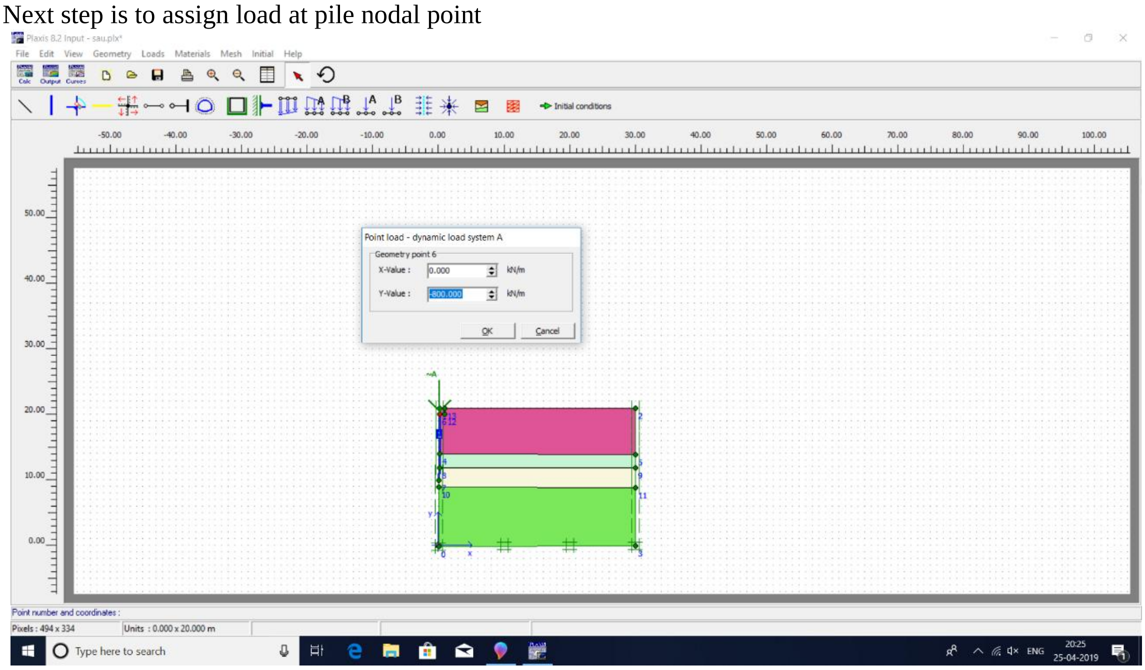

Figure2.6: Assign point load on nodal point

STEP 6: MESH IS GENERATED

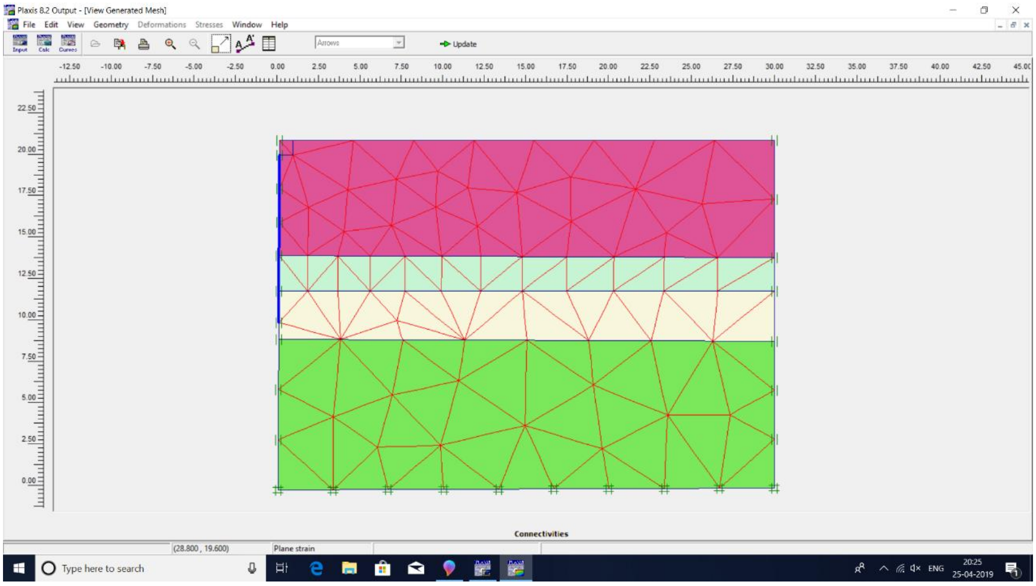

Figure2.7: Generation of mesh

STEP 7: Ground water table is assigned.

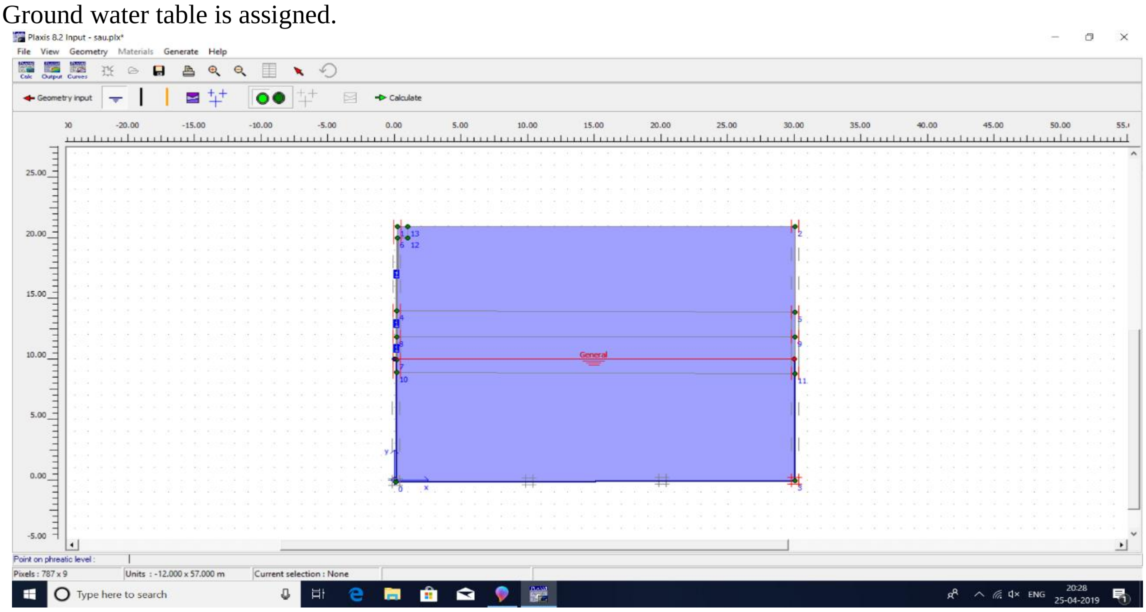

Figure2.8: Generation ground water table

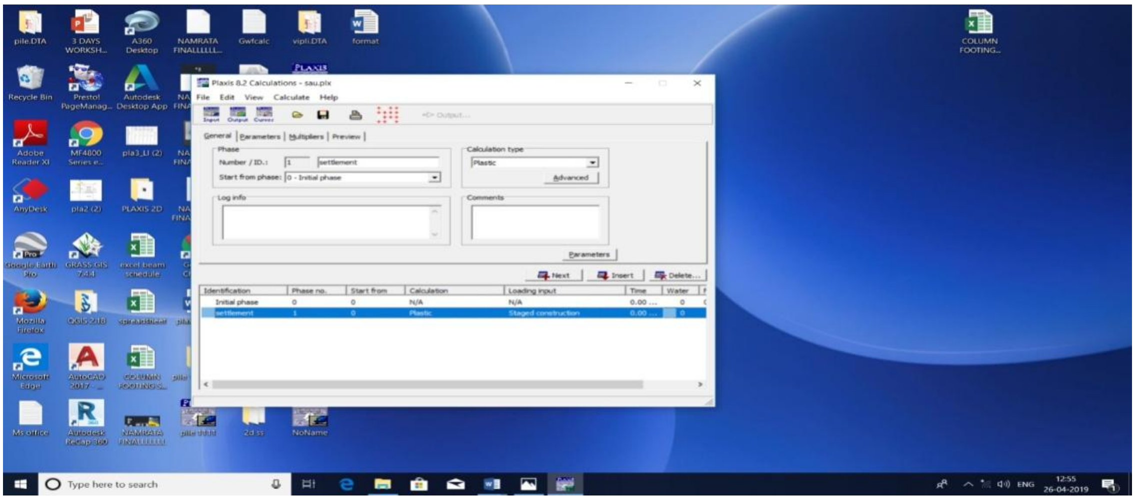

Figure 2.9: Settlement calculation

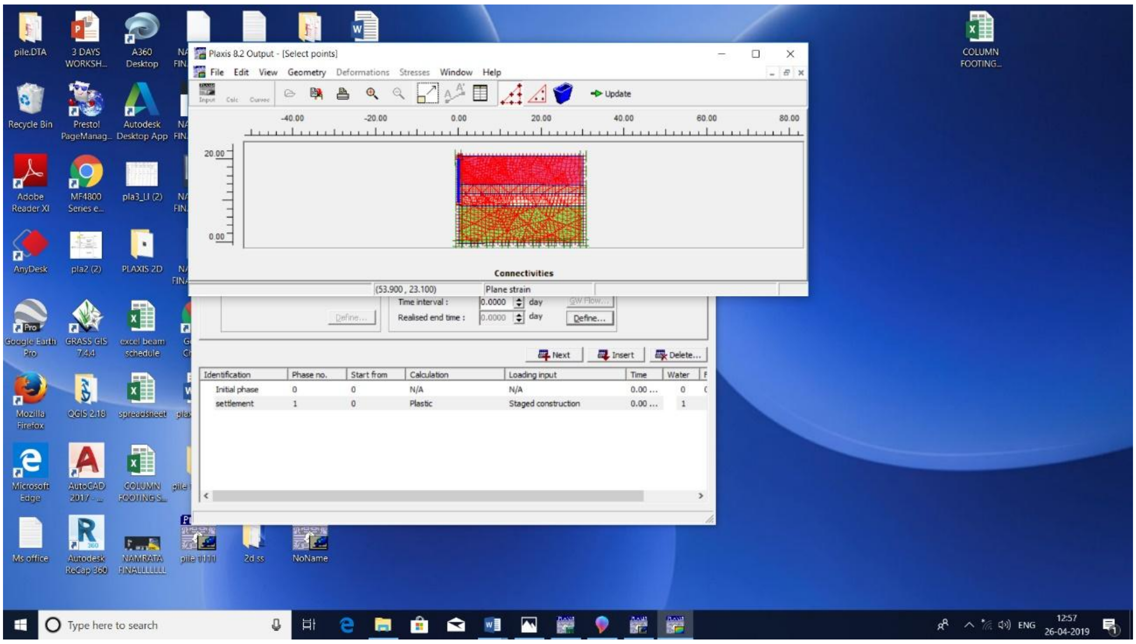

Figure 3.0: Define point load

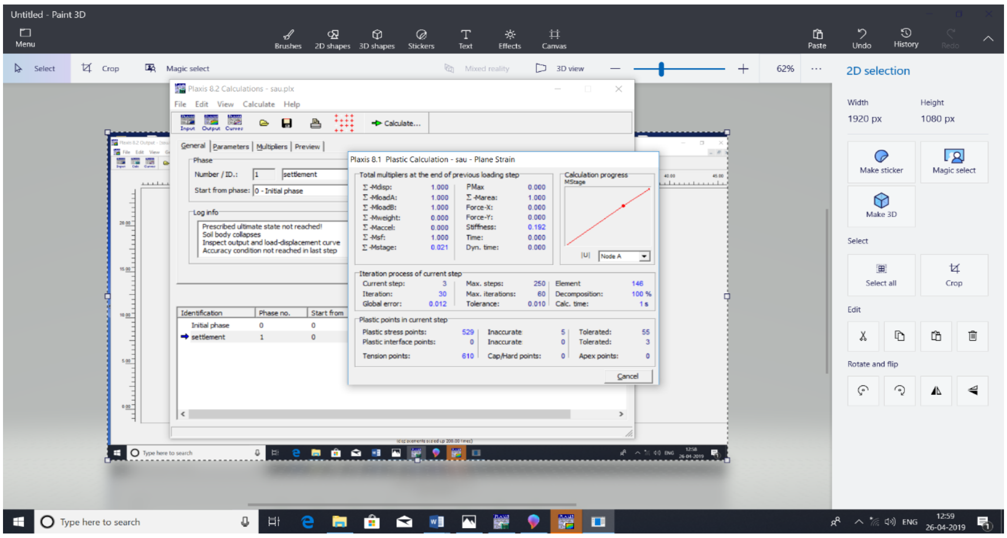

Figure 3.1: Output calculations

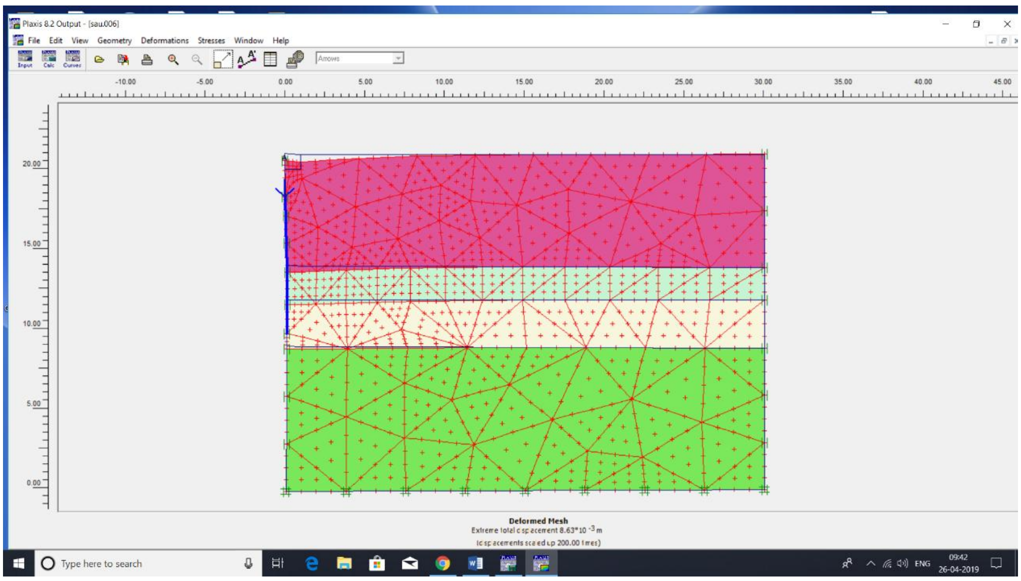

Figure 3.2: Settlement of deformed pile

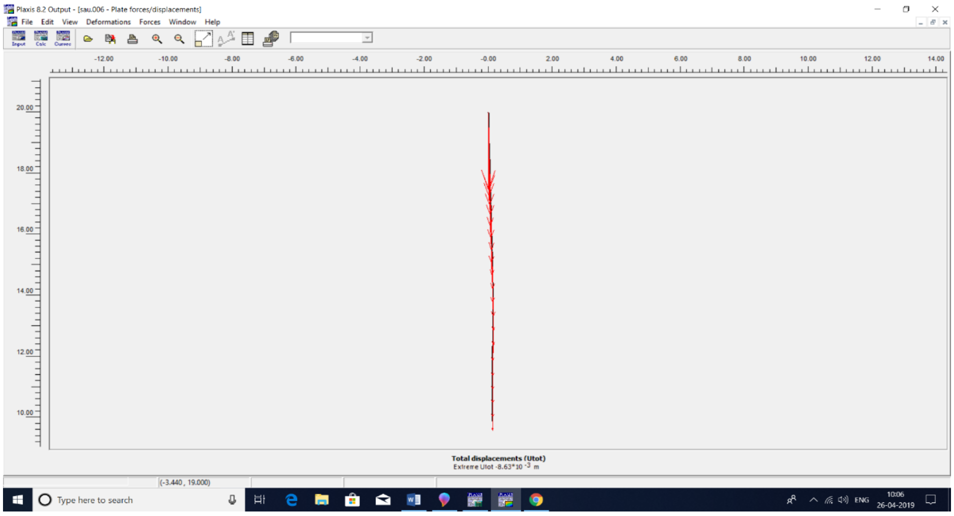

Figure 3.3: Total settlement graph

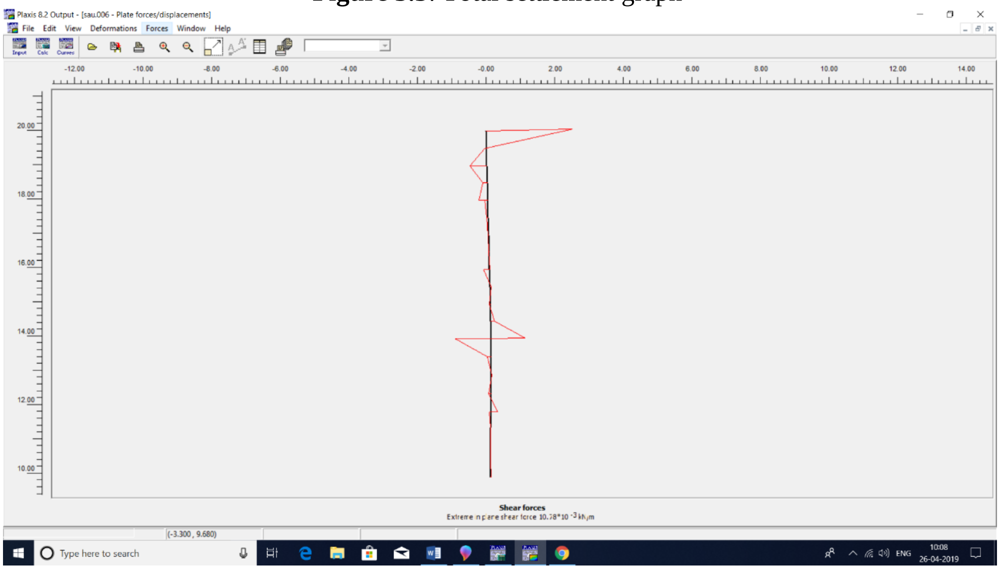

Figure3.4: Graph of axial forces

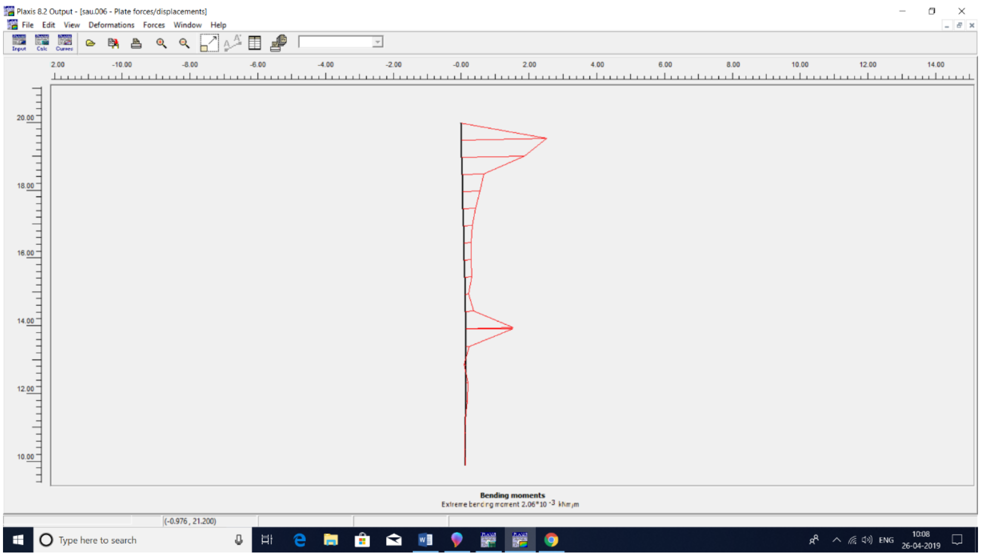

Figure 3.5: Graph of bending moments

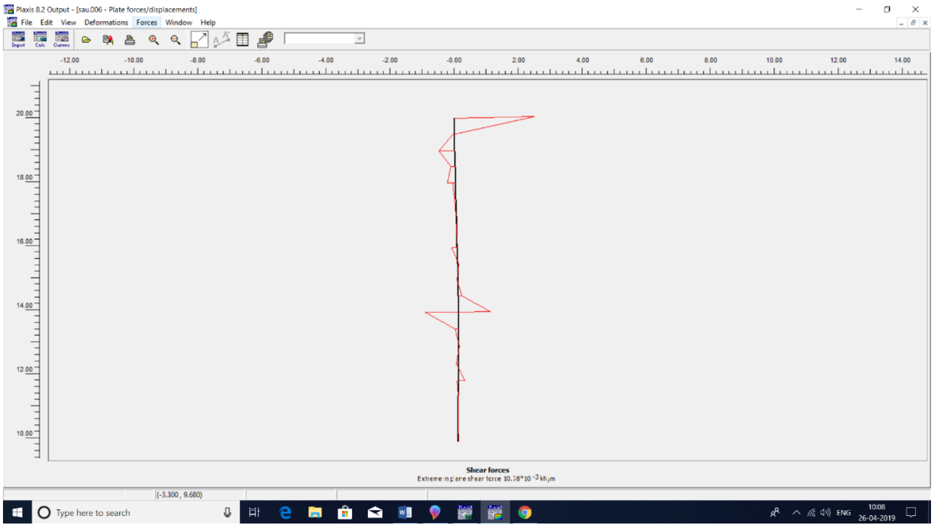

Figure 3.6: Shear force graph

3. Results and Discussion

1) The present work was carried out to study the load-settlement behavior of model pile on sand. The length of the pile, diameter of the pile was kept constant for all the trial. Load varied as 500KN, 800KN, 1500KN, 2000KN.
2) Discussions were made on the effect of load on the pile as well as settlement of the pile. Increasing amount of settlement is taking place as we increase the prescribed load for this analysis.

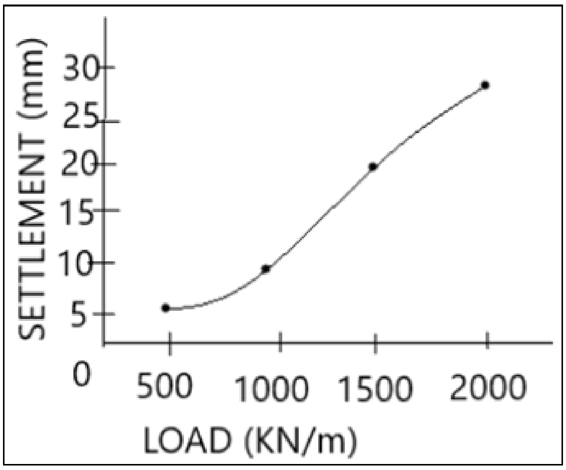

Figure 4: Load- settlement graph

From the above graph, it was found that as load increases, settlement increases and if load goes higher then settlement goes on increasing further.

4. Conclusion

1) As we increase the load from 500KN to 800KN, settlement is increased about 8.63mm. Load is applied upto 2000KN, settlement is 27.01mm which is within allowable settlement limit.
2) The addition of small number of piles increases the ultimate load of pile, and this enhancement effect increases with increase in number of piles as well as with increase in l/d ratio.
3) From above study it can be concluded that the Numerical analysis of piles by using software like PLAXIS are more economical and accurate. In this computer age use of software like PLAXIS give better and faster results and approach of analysis represents actual soil conditions.

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