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"SETTLEMENT ANALYSIS OF MACHINE FOUNDATION BY USING PLAXIS 2D"

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Abstract - *This study consists of "SETTLEMENT ANALYSIS OF MACHINE FOUNDATION USING PLAXIS" taking into account various soil conditions and conditions of load. While FEM analysis software such as PLAXIS 2D/3D, GEO5, FLAC 2D is fairly new geotechnical engineering software, a lot of work has been done on underground structures, deep excavation, tunneling and tunneling.*

***Key Words*: Machine foundation, Singe pile, Dynamic response, Pile foundation, Soil layers, Displacement**

1. INTRODUCTION

Foundation is a structural part of a building upon which there is a building. The Foundation transmits and distributes its own load and imposes loads on the soil in such a way that the "foundation bed" load-bearing capacity is not exceeded. When a structure cannot be supported by the soil at shallow depth, deep foundations are needed to transfer the loads into deeper strata. When a firm stratum is so deep that open exploration cannot touch it, instead the deep base would be adopted.

1.1PILE FOUNDATION

Piles are columnar elements in a foundation which have the function of transferring load from the superstructure through weak compressible strata or less compressible soils onto rock. Piles used in marine structures are subjected to lateral loads from the impact of berthing ships and from waves. Piles used to support retaining walls, bridge piers and abutments, and machinery foundations carries combinations of vertical and horizontal loads. It is found that at various sites in the coastal region, the top layer soil is soft clay with varying thickness of 5.0 to 25m and most of the structures which are constructed on soft clay . Lateral load tests were conducted on single pile and pile groups. The load deflection curves were found to be non-linear and were flatter at higher load levels showing loss of soil resistance.

1.2 MACHINE FOUNDATION

The behaviour of machine foundation on saturated porous medium can be considered as a complicated geotechnical problem due to nature of dynamic loads and plasticity of soil which make the analysis and design of foundation subjected to dynamic loads more complex. The main criteria for safe performance of machine foundations subjected to dynamic loads are to control excessive displacements. Machine foundations require a special consideration because they transmit dynamic loads to soil in addition to static loads due to weight of foundation, machine and accessories. The dynamic load due to operation of the machine is generally small compared to the static weight of machine and the supporting foundation. All foundations in practice are placed at a certain depth below the ground surface.

1.3 DYNAMIC RESPONSE OF FOUNDATIONS

Dynamic response of foundations depends on several factors such as the shape, size, flexibility and mass of foundation, the finite depth of stratum over bedrock, the influence of inhomogeneity, anisotropy and nonlinearity of soil and the depth of embedment of the foundation.

2. METHODOLOGY

2.1 PLAXIS 2D

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 behaviour, 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 modelling 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

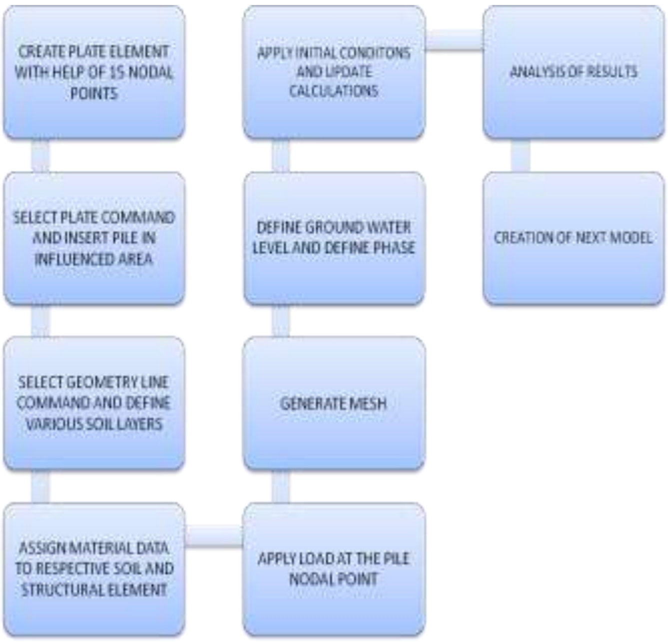


Fig -1: Flow chart showing procedure used for simulation and analysis of pile

3. PROBLEM STATEMENT 1

- A 3 m wide strip foundation with multiple thicknesses is placed at the middle of the top surface of two layers: the top layer is sand of different densities underlying by medium sand.
- The analysis is performed numerically using the finite element software, PLAXIS 2D version 8.2.
- 15-noded triangular isoperimetric elements are used to discretize the soil medium under the plane strain condition. The boundaries of the soil are taken as (30 m) wide and (20 m) deep far away from the foundation to minimize the boundary effect.
- To investigate the excess pore water pressure build up under machine foundation due to harmonic excitation, the soil is assumed to be saturated with water table coincides with the ground surface.
- Maximum amplitude of dynamic force = 25 kPa $\omega = 2\pi f$ with f = operating frequency = 5 Hz

3.1 ANALYSIS OF PILE IN PLAXIS 2D

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

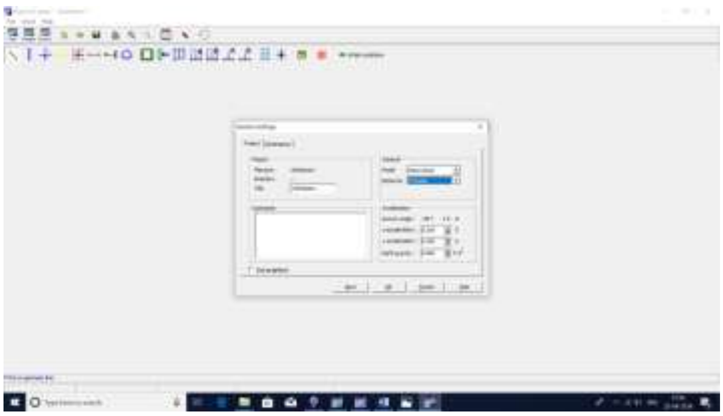


Fig -2.1: Select 15 Nodal points

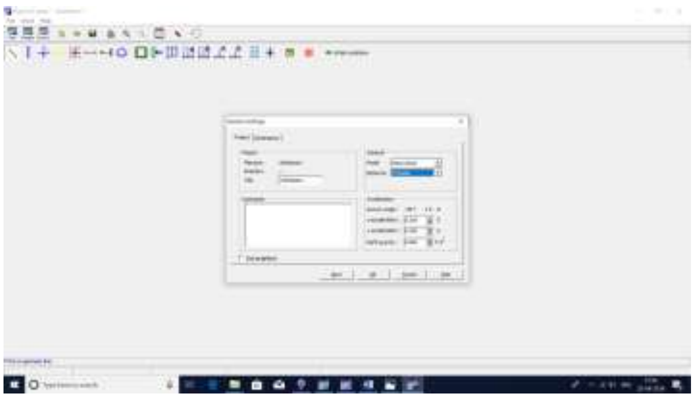
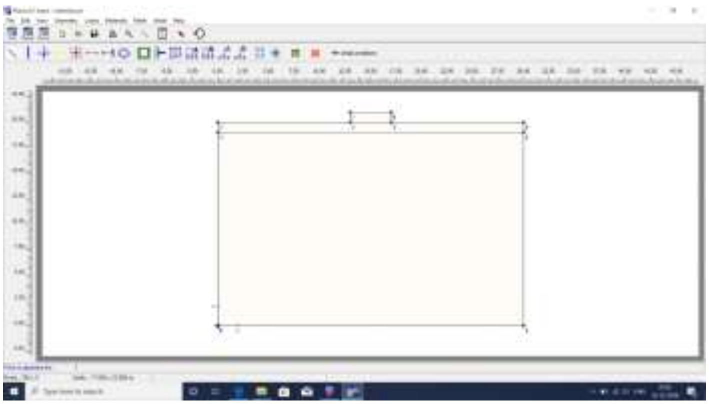


Fig -2.2: Select dimension of influence area

Step 2: Draw the geometry of the model.



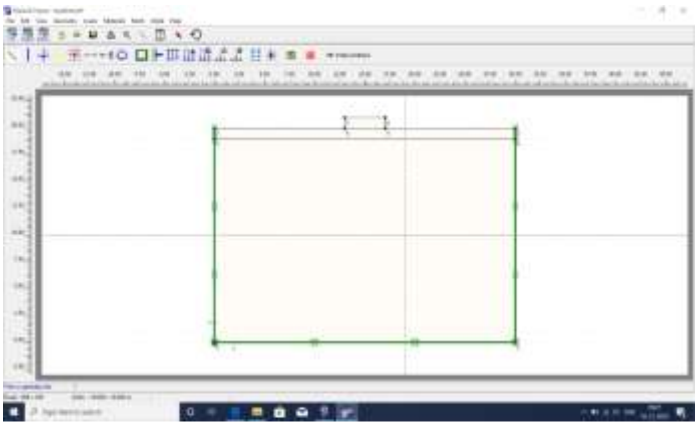


Fig -2.3: Assign the fixities

Step 3: After making complete geometry, next step to assign soil property to model.

Table .(1) Material properties.

Material	Material properties	Unit	Sand
Soil	Unit weight, γ	(kN/m³)	18.5
	Young's modulus, E	(kN/m²)	35000
	Poisson's ratio, ν	-	0.32
	Friction angle, φ	(°)	35
	Cohesion, c	(kN/m²)	1
	Dilatancy angle, ψ	(°)	5
	Horizontal permeability, k_x	(m /sec)	10^{-4}
	Vertical permeability, k_y	(m /sec)	10^{-4}
Foundation	Young's modulus of concrete, $E_{concrete}$	(kN/m²)	2×10^7
	Unit weight of concrete, $\gamma_{concrete}$	(kN/m³)	24
	Poisson's ratio of concrete, $\nu_{concrete}$	-	0.15
Machine	Weight of machine, W_{mach}	(kN/m²)	10

Table -1: Properties of material

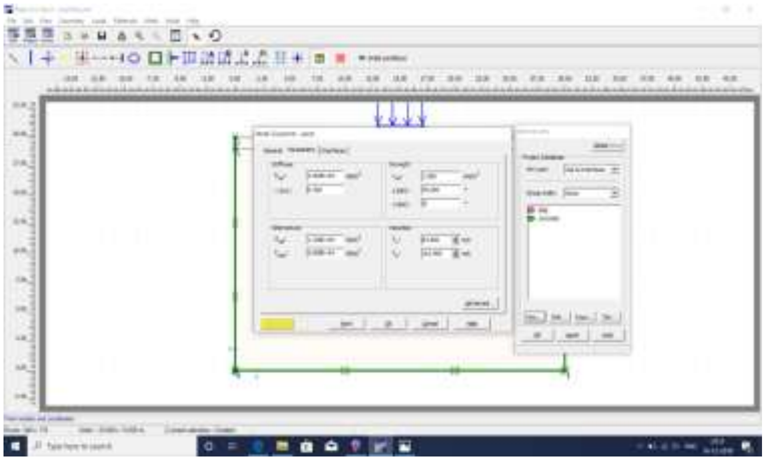


Fig -2.4: Assign the material properties(concrete footing, soil, sand)

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

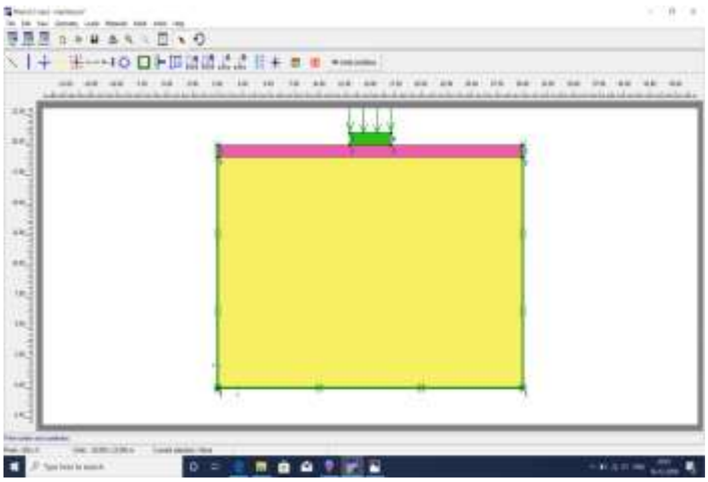


Fig -2.5: Material property assigning to soil

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

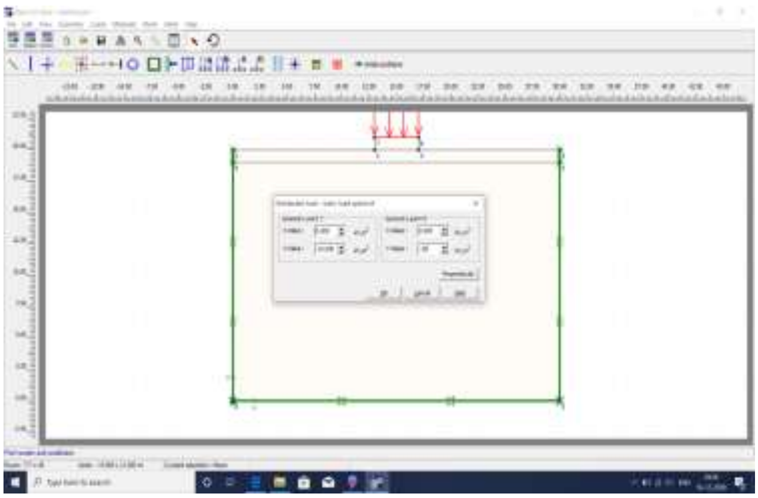


Fig -2.6: Assign distributed load on footing

Step 6: Mesh is generated

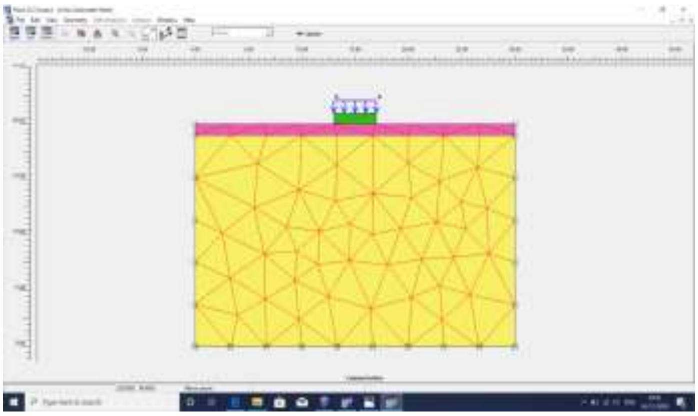


Fig -2.7: Generation of mesh

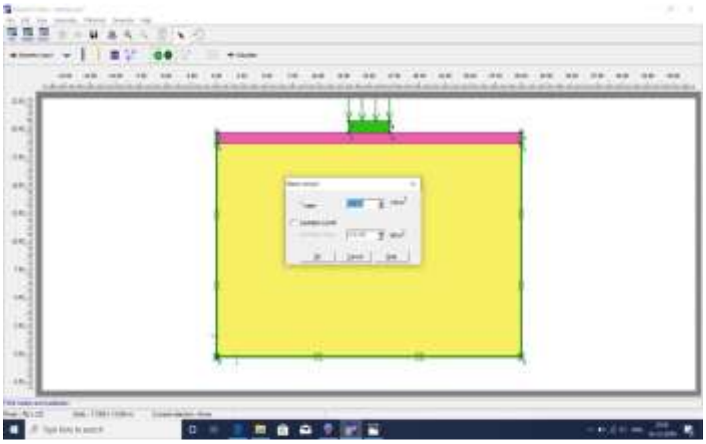


Fig -2.8: assign ground water table properties

Step 7: Ground water table is assigned.

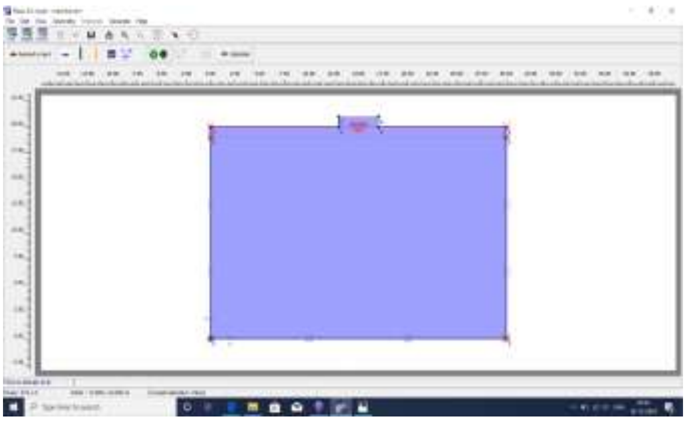


Fig -2.9: Generation of ground water table

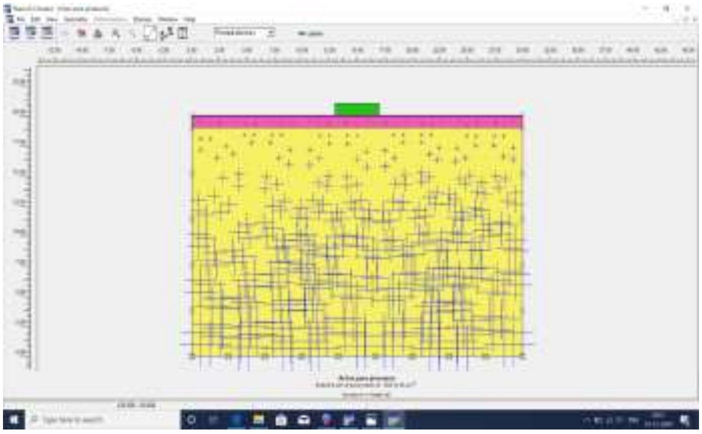


Fig -2.10: Generation of active pore pressure

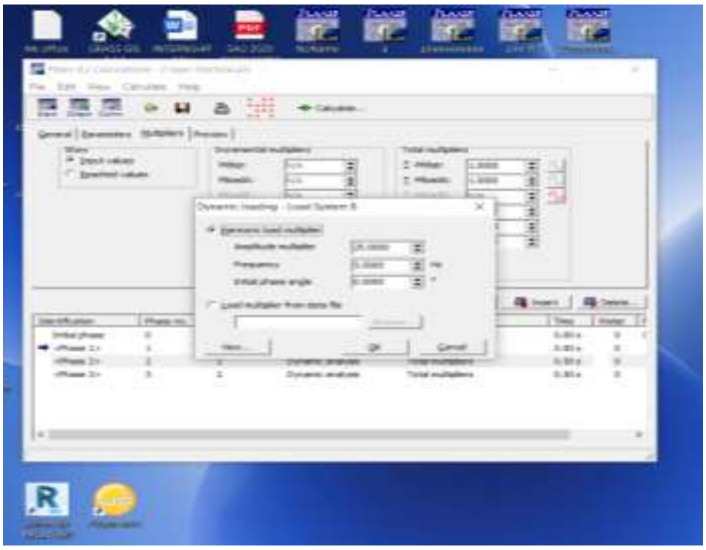


Fig -2.11: Calculation tab, assign amplitude and frequency values

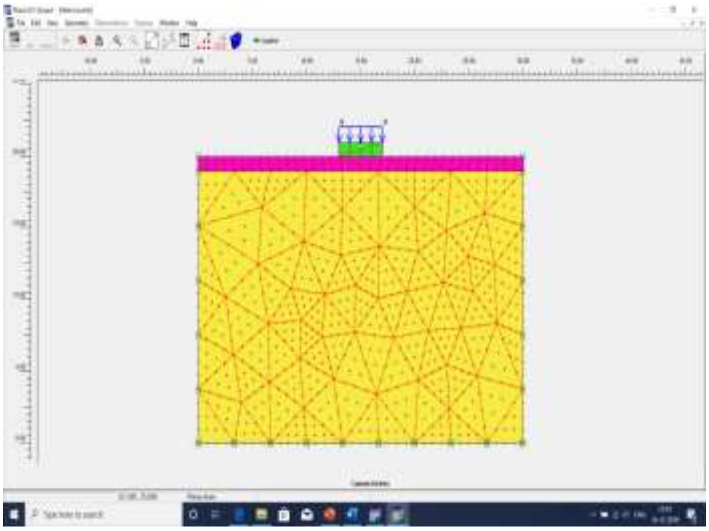


Fig -2.12: Select the nodal point

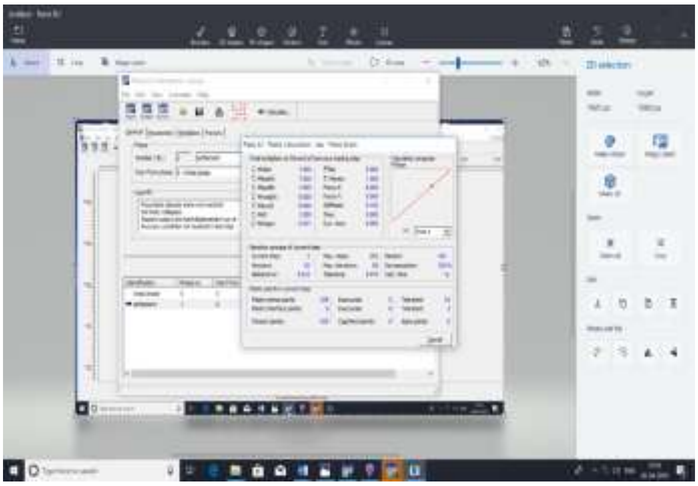


Fig -2.13 : Output calculations

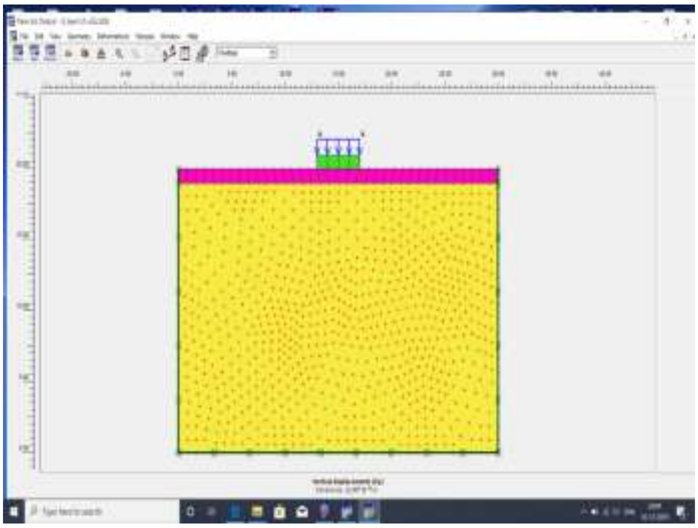


Fig -2.14: Displacement when E1=E2

(-15.09x10'-3m)

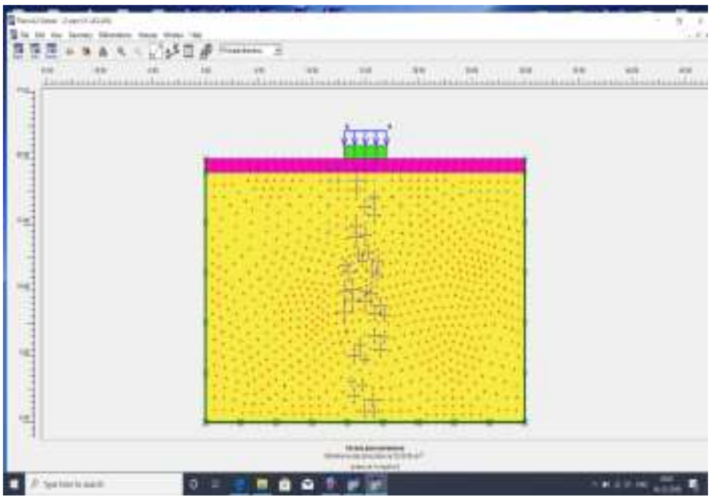


Fig -2.15: Excess pore water pressure when

E1=E2 (15.22 KN/m2)

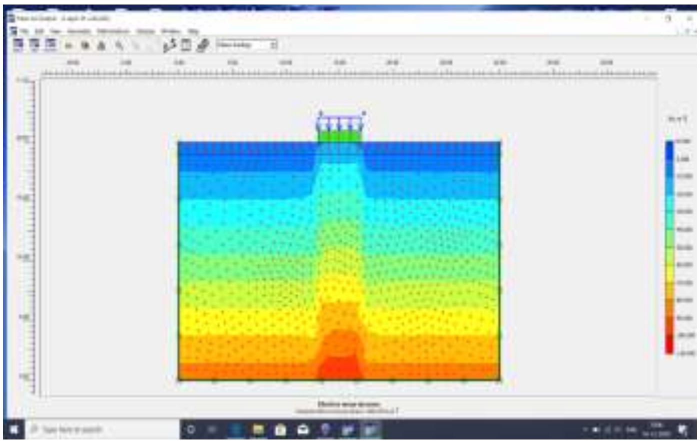


Fig -2.16: Effective stresses when E1=E2 (100.23 KN/m2)

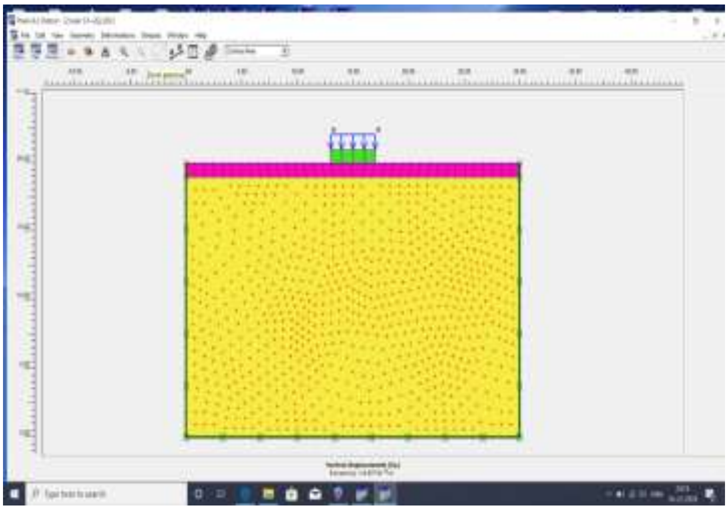


Fig -2.17: Displacement when E1=2E2

(-14.93x10'-3m)

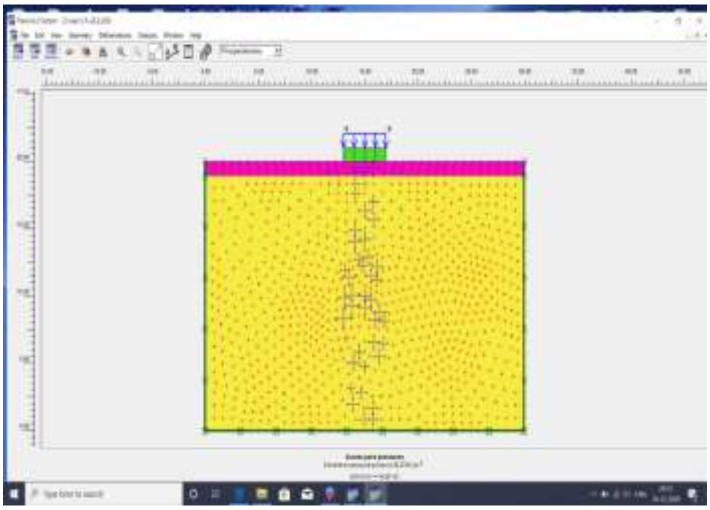


Fig -2.18: Excess pore water pressure when E1=2E2 (20.07KN/m2)

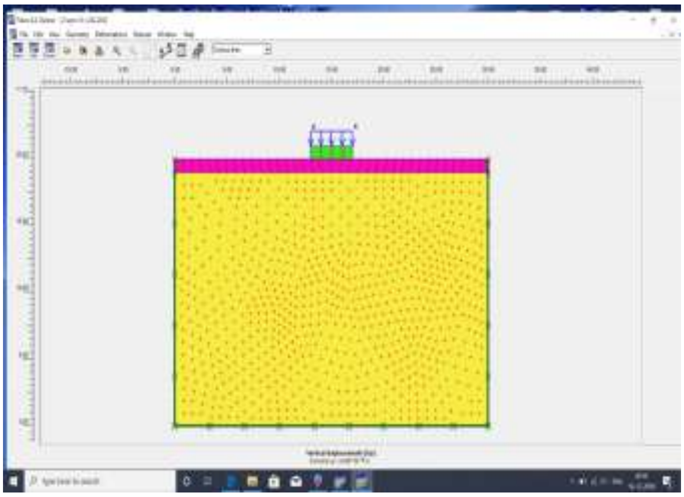


Fig -2.19: Displacement when E1=5E2 (-14.65x10'-3m)

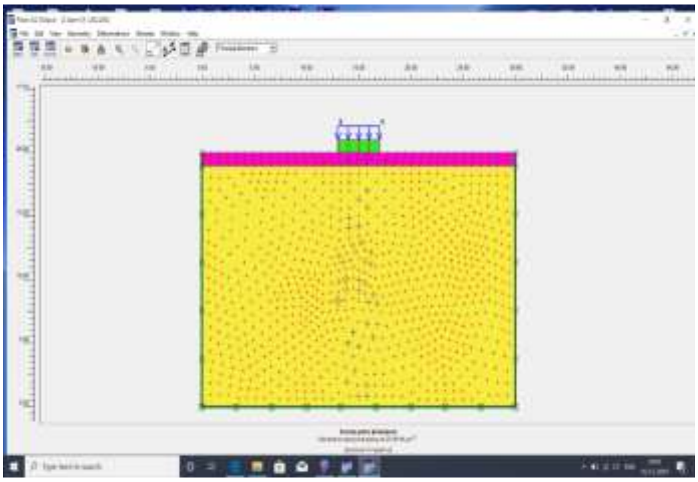


Fig -2.20: Excess pore water pressure when E1=5E2 (27.94 KN/m2)

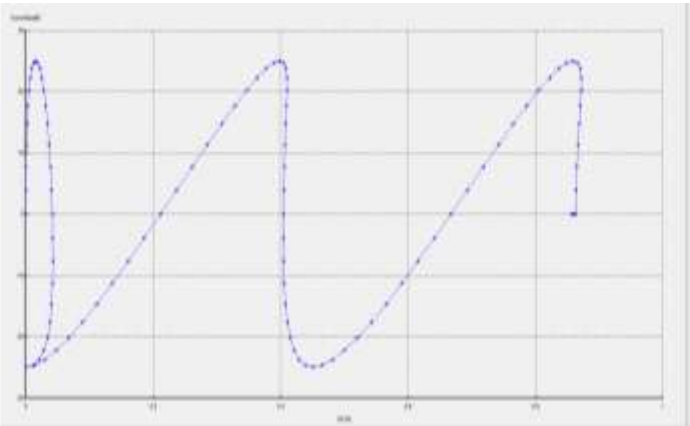
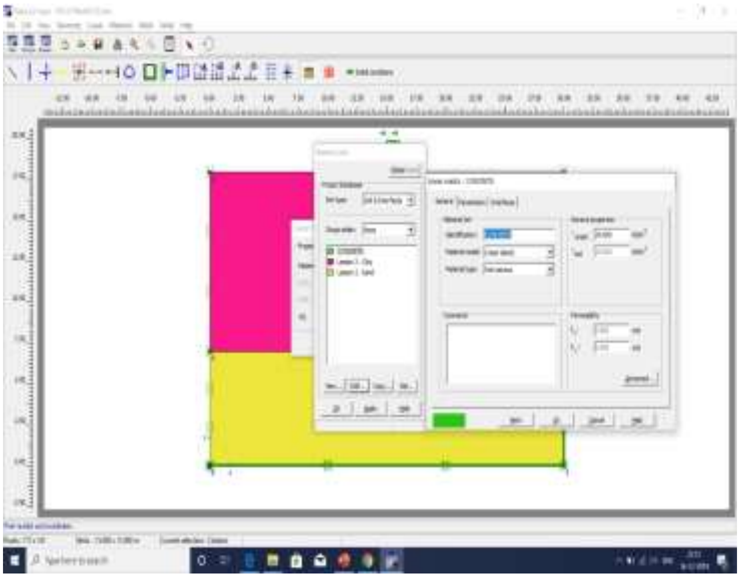


Fig -2.21: Displacement when E1=2E2 (-14.93x10'-3m)

4. PROBLEM STATEMENT 2

- Single concrete pile with 0.4m diameter and 11.5m length is located in soft clay underlay by sand subjected to machine load
- The pile parameters are taken as follow; Young's modulus of concrete (E) = 3x107 kN/m2, Poisson's ratios of concrete (μ) = 0.1, Unit weight of concrete (γc) = 25 kN/m3 for dynamic analysis.
- The properties of soft clay are taken as γunsat=16kN/m3, γsat=18kN/m3, Eref =15000kN/m2, Rinter=0.5, C=2kN/m2 , ϕ=24°, μ=0.3 and
- the properties of sand were taken as γunsat=17kN/m3, γsat=20kN/m3 ,Eref=50000kN/m2, Eoed=50000kN/m2 Eur=150000kN/m2, Rinter =0.67, C=1kN/m2, ϕ=31°, μ=0.2.
- Dynamic analysis with amplitude 5000kpa and frequency 5Htz
- Water level coincide with soil surface.



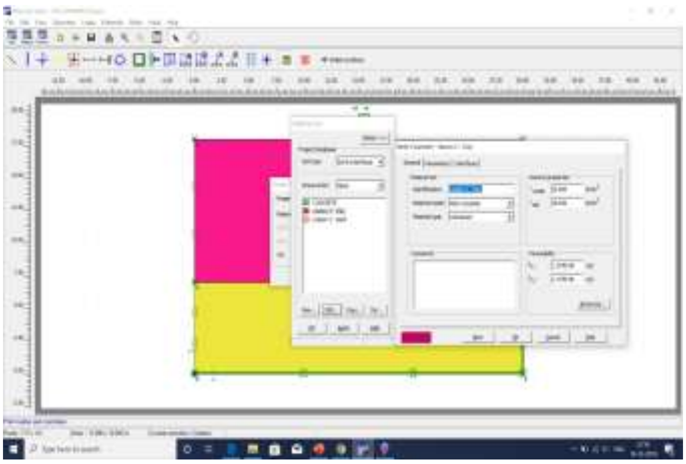


Fig -3.1: Assign material properties

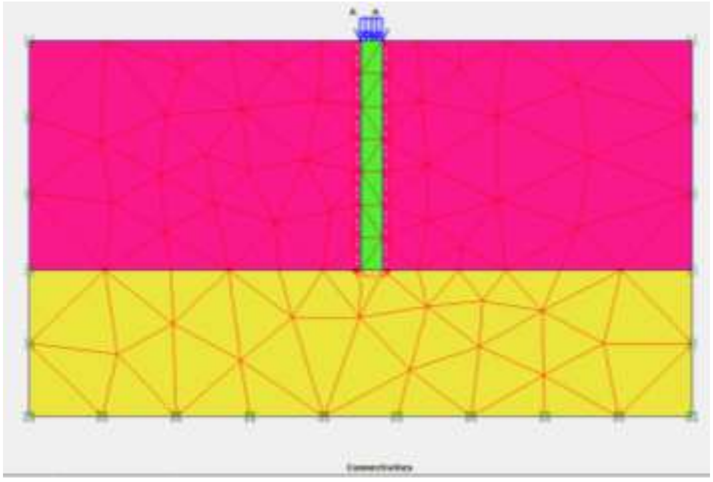


Fig -3.2: Mesh is generated

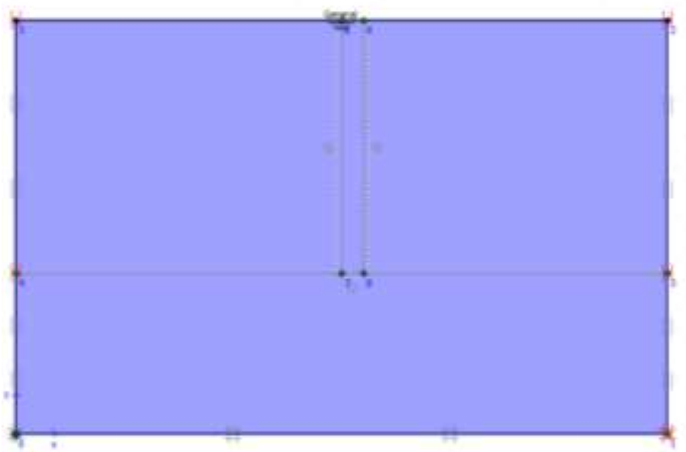


Fig -3.3 : Ground water table coinciding with ground surface

Fig -3.4: Calculations tab

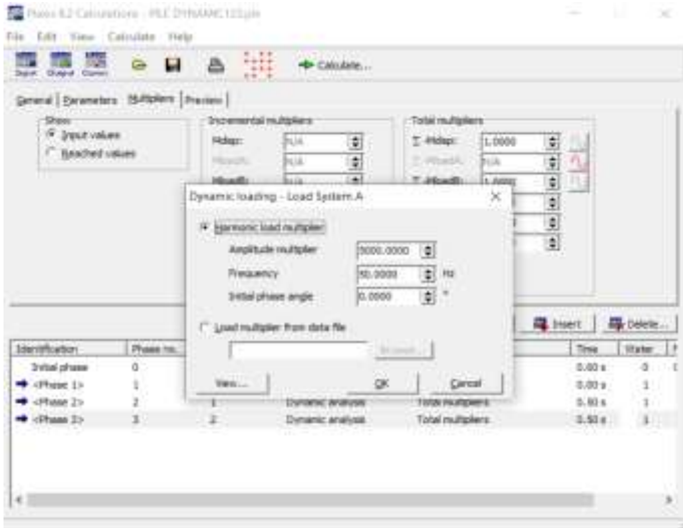


Fig -3.5: Input the values

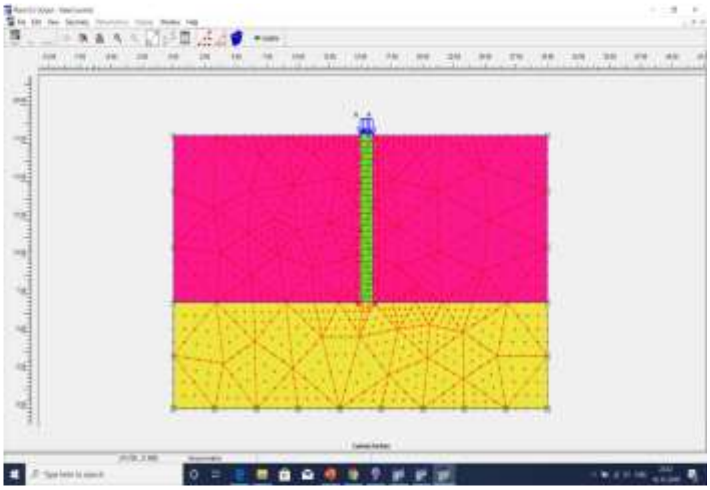


Fig -3.6: Selection of nodal point

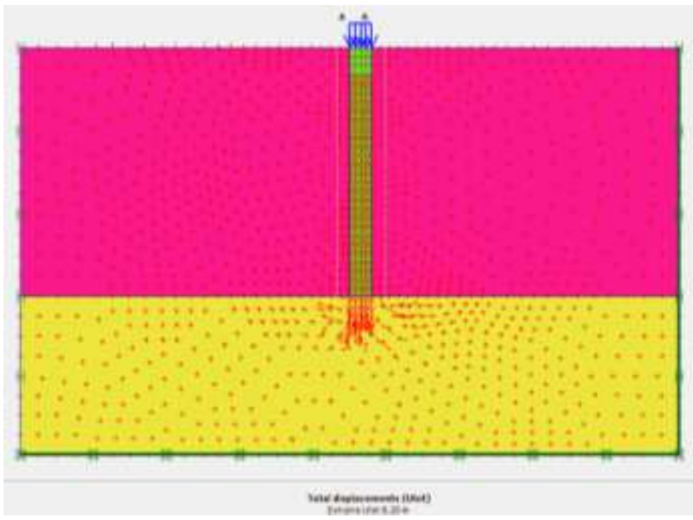


Fig -3.7: Total displacement (8.2mm)

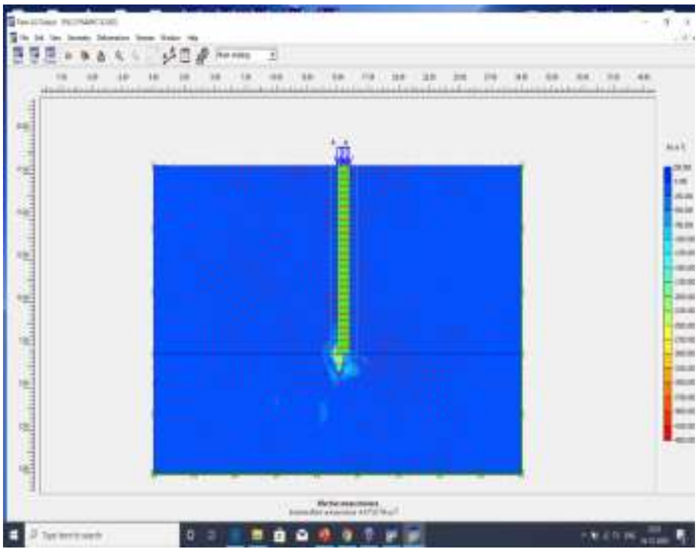


Fig -3.8: Effective mean stress(4.4x10'3 KN/m2)

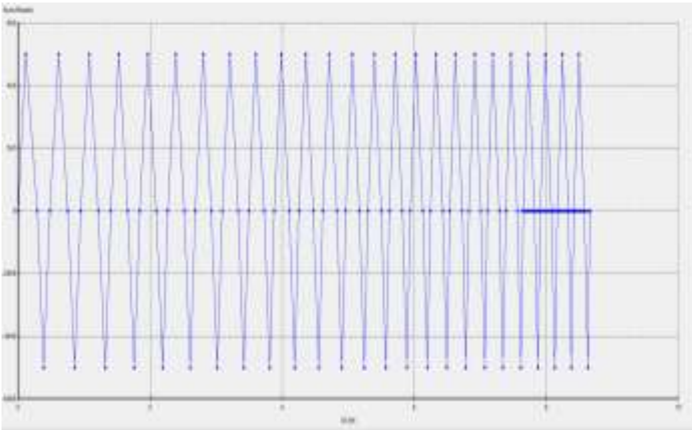


Fig -3.9: Displacement vs time graph

5. DISCUSSION

1. The displacement decreases remarkably when E1 is duplicated 2-4 times E2, then the effect decreases.

2. The pore water pressure increases remarkably when E1 is increased to about 5 times E2.

3. The maximum vertical settlement of pile due to machine loading is about 8.36mm.

4. Most of the settlement occurs in phase 3 after the machine is stopped.

5. This is due to the fact that compression wave is still propagating downwards in the pile causing additional settlement.

6. RESULT

- The dynamic behaviour of machine foundation by varying soil foundation by two-layer system is analysed.

- The dynamic response of singe pile located in soft clay underlie by sand is analysed.

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