Influence of Surcharge Preloading Improvement on Surrounding Environment Based on Plaxis 3D

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Abstract: In order to evaluate the influence of surcharge preloading on the surrounding environment, the surcharge preloading are numerically simulated in the paper. The results show that: 1) With the increase of surcharge load the maximum horizontal displacement gradually increases. 2) The horizontal displacement is symmetric respect to the center of the distributive load. 3) Due to the existence of drainage surface, the excess pore pressure mainly concentrates between the surfaces and then soon dissipates.

1. Background
Due to the economic and feasibility, the drainage consolidation is widely used in the improvement of soft ground. The surcharge preloading method has been widely used in the improvement of soft ground to increase its bearing capacity [1-5]. Compared to the vacuum preloading method, the surcharge preloading is free to the special equipment. Usually it is used accompany with the plastic vertical drains so that the excess pore pressure caused by embankment load can dissipate in time. During the improvement stage, the influence on the surrounding environment is always the highlight and the inclinometers are usually installed near the boundary of the improvement area. In this paper, the horizontal displacement during the surcharge preloading is numerically simulated to consider the environmental influence.

2. Calculation conditions

2.1. Mesh Division
Figure 1 demonstrats the mesh information for the calculation. The equivlent load with magnitude of 80kPa is used to represent the embankment. The normal constraints are applied on the four side surfaces and the fixed constraints are applied on the bottom surface.

2.2. Soil Parameters
The ground is composed of 6 layers and the corresponding parameters are listed in Table 1. In the calculation, Mohr-column model is used.
Figure 1 Mesh information

Table 1 Soil Parameters

| NO. | Soil          | Bulk density (kN/m³) | Young’s Modulus (kPa) | Poisson’s ratio | Friction angle (°) | Cohesive strength (kPa) | Permeability (m/d) |
|-----|---------------|----------------------|-----------------------|----------------|--------------------|------------------------|-------------------|
| 1   | Mud           | 16.4                 | 1241                  | 0.3            | 12.3               | 6.8                    | 1.1e-4            |
| 2   | Silty clay    | 19.8                 | 3982                  | 0.3            | 14.4               | 25.4                   | 5.2e-4            |
| 3   | Mucky silty clay | 18.7              | 3098                  | 0.3            | 18.0               | 14.5                   | 1.2e-4            |
| 4   | Silt          | 20.0                 | 5690                  | 0.3            | 30.2               | 12.0                   | 5.7e-3            |
| 5   | Silty clay    | 19.6                 | 3216                  | 0.3            | 9.6                | 27.0                   | 3.6e-5            |
| 6   | Clay          | 20.2                 | 5478                  | 0.3            | 28.5               | 24.3                   | 3.6e-5            |

2.3. Drainage Passage

The drainage surface/line can be used to simulate the plastic vertical drain, where the excess pore pressure is set to be always zero so that the surrounding pore water can flow into the drainage surface. Therefore, in this simulation, the drainage surface is used to represent the plastic vertical drains and the interval space is 2m.

3. Variation of Horizontal Displacement

3.1. Displacement at the Border

In the practical engineering, the inclinometer near the boundary of improvement area is installed to evaluate the influence on the environment. In this numerical calculation, a line is drawn near the border of improvement area along the depth and the horizontal displacement on this line is shown in Figure 2. As can be seen, with the increase of surcharge load the maximum horizontal displacement gradually increases. The maximum horizontal displacements at each stage are 5.5cm, 11.1cm and 27.5cm and the direction is towards the outside of the ground.
3.2. Distribution of Horizontal Displacement

Figure 3 gives the distribution of horizontal displacement inside the ground. As can be seen, the horizontal displacement is symmetric respect to the centre of the distributive load. The maximum value appears at the boundary of the load, near the ground surface.
3.3. Variation of Pore Pressure

The distribution of excess pore pressure is shown in Figure 4 and the distribution of excess pore pressure after 30d consolidation is shown in Figure 5. As can be seen, due to the existence of drainage surface, the excess pore pressure mainly concentrates between the surfaces and then soon dissipates. Also because of the drainage passage, the excess pore pressure is always smaller than the overburden effective stress so that the embankment is stable. After 30d consolidation, the excess pore water pressure dissipates rapidly.
Figure 4 Distribution of excess pore pressure inside the ground at different stages
4. Conclusion

The characteristics of horizontal displacement during the surcharge preloading are numerically simulated in the paper. The drainage surface is used to represent the plastic vertical drain where the excess pore pressure is always zero. The conclusions are as follows:

1) With the increase of surcharge load the maximum horizontal displacement gradually increases. The maximum horizontal displacements at each stage are 5.5cm, 11.1cm and 27.5cm and the direction is towards the outside of the ground.

2) The horizontal displacement is symmetric respect to the center of the distributive load. The maximum value appears at the boundary of the load, near the ground surface.

3) Due to the existence of drainage surface, the excess pore pressure mainly concentrates between the surfaces and then soon dissipates.

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