

Study on the influence of support structure on vacuum preloading

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Abstract. The vacuum preloading will produce an effect of tension fracture on existing road. We have established the mechanical model of vacuum preloading in vacuum preloading zone by using FLAC3D software and analyze the influence of the supporting structure, which one is the cast-in-place and the high pressure jet grouting pile. In the first supporting structure, the influential area of vacuum preloading on the expressway is 45 meters and the largest settlement is 2.37 centimeters. Obviously, the cast-in-place pile and the high pressure jet grouting pile can weaken the influence of vacuum preloading on the expressway obviously more.

1 Introduction

On the one hand, as urban land becomes less. On the other hand, the construction capability of reclamation is continuously improved, so it must contribute to the development of foundation treatment technology, however the impact of the soft foundation treatment on existing structure (construction) will be an important problem which we must consider in the process of soft foundation reinforcement in the future. This problem will be connected to the people's lives and social stability.

Vacuum preloading is an important solution in treating soft foundation^[1], according to the requirement in 《Building foundation treatment norms》 (JGJ79-2002)^[2] and on the basic of abiding the basic principles of geotechnical^[3], realization of finite element simulation of vacuum preloading process, and to carry out the safety evaluation of supporting structure^[4]. It is a good reference for the similar project in the future and has a certain practical significance.

2 Project overview

There is a vacuum preloading area close to an expressway which has a large traffic flow. The minimum distance between the side boundary of vacuum preloading area and pipeline corridors group of expressway is 7 meters. There is surface backfill soil in vacuum preloading area, containing part of the stone, and burial depth is pretty large, and it is hard to conduct board construction. Before board construction we need to conduct excavation and filling in the vacuum preloading area, some of areas need to fill until 0 meters high. There exists some influence of excavation and filling on pipeline corridors group. So, before excavation and filling we need to use jet grouting pile for supporting treatment, and consider adopting cast-in-place pile and the jet grouting pile for supporting treatment. Adopting pouring pile + jet grouting pile for support treatment in the east side where a big depth of excavation and filling in there. Continuous wall formed from high pressure jet grouting pile may



become the vacuum preloading sealing wall.

Expressway adopts CFG pile to deal with foundation. The red line of the road is treated with a square interval of 2.0m of CFG pile; the pipeline corridors are treated with a regular triangular interval of 2.0m of CFG pile. The CFG pile adopts commercial concrete with diameter of 40 centimeters and strength grade of C15. The design height of the pile is 2.0m. Cushion adopt rubble with thickness of 50 centimeters. All the CFG pile punch silt and punch into the holding layer is not less than 1.0m.

Expressway is existing building. The conduct edge of vacuum preloading area from the pipeline corridors group with the nearest distance of only 7m. It is necessary to verify the reasonableness of isolation protection measures which between the vacuum preloading area and expressway, and guarantee whether the effect of vacuum preloading on the expressway is small enough and will not have too much damage to the expressway.

3 Geological prospecting data and soft foundation reinforcement scheme

Processing width of vacuum preloading area is 25 meters, First of all, we need to level off the site to 2.2m meters high, and then set up the supporting structure.

Considering the most unfavorable situation, select the section with the largest thickness of the soft soil as the calculated section; calculate the soil parameters of the section as shown in Table 1.

Table 1 Calculation of soil parameters table

Name of the soil layer	Depth (m)	Density (g/cm ³)	Modulus of compressibility (MPa)	Internal bunching cohesion (kPa)	Angle of internal friction (°)	Coefficient of permeability (cm/s)	
						Vertical	Level
1-1Plain fill	2.16	1.72	2.06	7	16.8	2.71E-05	2.95E-05
2-1Silt	8	1.62	1.84	6.7	16.2	3.44E-07	4.56E-07
2-2Silt	2	1.6	1.72	6.7	16.2	2.90E-07	4.37E-07
3Silt	7.5	1.62	1.64	7	16	2.56E-07	3.38E-07
6-1 clay	4.3	1.71	2.29	8.8	16.5	7.21E-08	7.15E-08

The preliminary design scheme uses the vacuum preloading to deal with the foundation, the depth of drain board at the computation cross-sections is 17m, plum-shaped arrangement, spacing 1 meter. The support structure between the vacuum preloading area and the expressway is a combination of cast-in-place pile and high pressure jet grouting pile. The following is the numerical analysis.

4 Numerical analysis model

According to geological data in Table 1, using large-scale commercial software FLAC3D established mechanical model as shown in Figure 1.

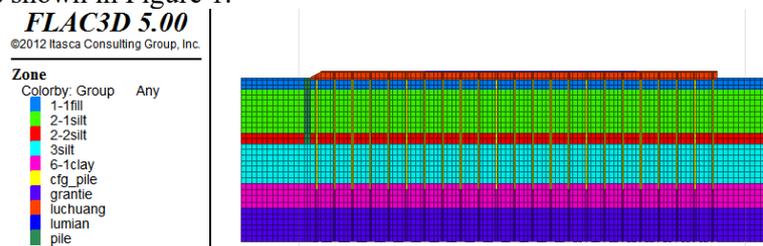


Figure 1 Mechanics model of Vacuum preloading area

Considering the symmetry, this model select only half of the vacuum preloading area and the expressway side. Due to the pipeline corridors group with CFG piles is arranged by regular triangle interval of 2m, thus the thickness of the model is 1m; the total model size is 100m×40m×1m. The CFG pile is staggered on the front and back of the model, CFG go deep into 6-1 silty clay layer 1m, according to the design requirements. In the figure, Pile is the support structure between the vacuum

preloading area and the expressway, which is divided into high pressure jet grouting pile and pouring pile plus high pressure jet grouting pile two. The model of the two supporting structures will be analyzed separately below. In the figure, cfg_file is the CFG pile in the foundation of expressway, and the pile is 40cm in diameter. The pile enters the silty clay 1m and is simulated by the solid element.

Figure 2 shows the retaining wall, the west side of the retaining wall is composed of the double-row high pressure jet grouting pile, high pressure jet grouting pile is 700mm in diameter, lap 200mm, retaining wall is 12m in depth. The east side of the retaining wall is used to support the cast-in-place pile and high pressure jet grouting pile wall, the diameter of cast-in-place pile is 800mm, interval of 1200mm, the pile is filled with high pressure jet grouting pile, and the diameter of high pressure jet grouting pile is 600mm. cast-in-place pile is 13m~23m in depth, high pressure jet grouting pile is 6m~8m in depth.

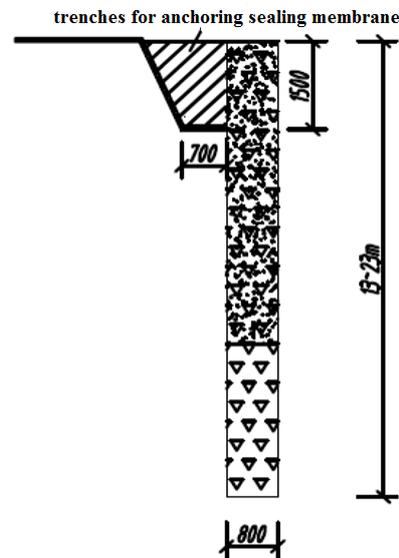


Figure 2 Schematic diagram of the retaining wall

Figure 3 is the loading plan of the vacuum preloading, after applying the vacuum preload, the vacuum under the film reaches 80kpa in few days, Then calculating the vacuum preloading loading time, planned to load 120 days, vacuum preloading depends the measured settlement value in the later period to calculate the consolidation degree, residual settlement, forecast settlement trend, and the design institutions to determine the specific preload unloading time.

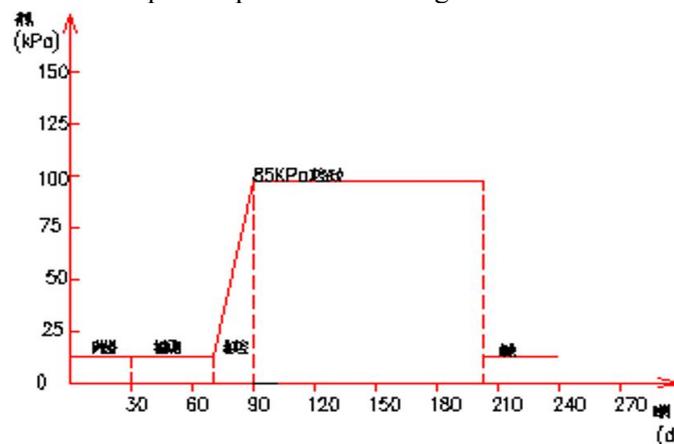


Figure 3 Vacuum pressure loading plan

5 The calculation results and analysis of the model under the supporting structure of cast-in-place pile and high pressure jet grouting pile

Figure 4 is the calculated sedimentation cloud, the maximum settlement of the model is 2.37m.

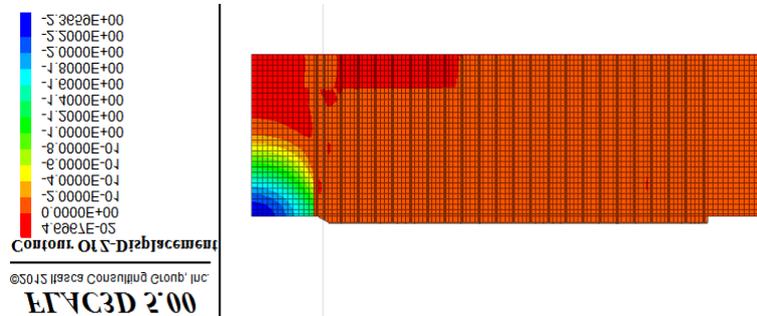


Figure 4 Settlement cloud map

According to the simulation results, it can be seen that the CFG pile of the expressway has a tendency to bend to the vacuum preloading area.

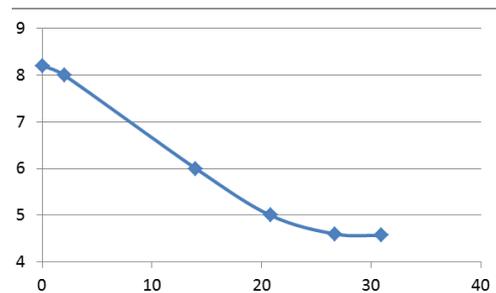


Figure 5 The relationship between the lateral displacement of the surface layer and the distance from the retaining wall

Figure 5 is the relationship line between the lateral displacement and the distance from outer edge of the cast-in-place pile and high pressure jet grouting pile supporting wall. The figure shows the lateral displacement of the foundation surface on one side of the expressway adopt the orientation of supporting wall is positive.

According to the simulation results, it can be seen that the surface subsidence is smaller where the farther away from the cast-in-place pile and high pressure jet grouting pile supporting wall. the foundation settlement of the supporting wall is less than 3cm, more closer to the expressway the settlement is more smaller; the results indicates that the vacuum preloading has little influence on the foundation settlement of CFG pile. When vacuum preloading supporting structure with the high pressure jet grouting pile, the effect distance of foundation treatment on the expressway is 45m, the maximum lateral displacement of the CFG pile near the vacuum area is 12.6cm. when the vacuum area away from the expressway 15m , the maximum lateral displacement of the CFG pile is 10.1cm.

6 Conclusion

In this paper, the mechanical model of vacuum preloading in vacuum preloading treatment is established by using FLAC3D software. The influence of the vacuum preloading on the expressway is analyzed, which supporting structure is the cast-in-place pile combined with the high pressure jet grouting pile.

When the supporting structure is the high pressure jet grouting pile, the influence region of the vacuum preloading area is away from expressway 45m, the maximum lateral displacement of the CFG pile adjacent to vacuum area is 12.6cm.

When the vacuum preloading area is away from the expressway 15m, the maximum lateral displacement of the CFG pile is 10.1cm.

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