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Analysis of influence of different pressure and different depth of pvd on soft foundation treatment

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Abstract: According to the depth of plastic vertical drainage (pvd), the arrangement mode and the loading mode to analyze the influence of Vacuum preloading near the existing road. An arrangement mode of vacuum preloading to reduce the impact was put forward. The combination of different depth of pvd and loading modes are used to analyze the effect of vacuum preloading treatment and its influence range. The calculations show that the deformation and the influence distance are smaller by using the 40kPa vacuum loading and 41kPa surcharge load preloading. Reducing the depth of the pvd and vacuum combined surcharge preloading can weaken the influence to the existing highway.

1. Introduction
Vacuum preloading method is an effective method for soft ground treatment. In recent years, this method has been used in airport, dock, yard, expressway and dredger fill foundation treatment [1-3]. Under the vacuum load, the soft soil foundation will produce the lateral shrinkage deformation towards the reinforcement zone, and the adjacent buildings or structures may be affected, even engineering accidents will happen [4-6]. Therefore, in the design of vacuum preloading, on hand, the buildings or structures within the area must take security measures accordingly; on the other hand, also need to optimization the vacuum preloading and the depth of pvd. Based on an engineering example to simulate and analyze the influence of different depth of drainage plate and different loading mode.

2. Project overview
A soft ground treatment site is adjacent to the existing provincial highway. The provincial highway is the main trunk road of the city, with two-way 6 lanes, and the highway is treated with CFG piles of 40cm diameter for the soft foundation. It is difficult to insert drainage plate or carry out mixing wall construction. Replacement work on the site are inserted before construction, and 3m deep excavation within the scope of engineering site, retaining structure is high pressure jet grouting pile.

Are the isolation protection measures between the soft ground treatment site and the existing provincial highway reasonable and are the influence of vacuum preloading on the road is small? It is necessary to verify.
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.

| Name of the soil layer | Depth (m) | Density (g/cm³) | Modulus of compressibility (MPa) | Internal bunching cohesion (kPa) | Angle of internal friction (°) | Coefficient of permeability (cm/s) |
|------------------------|-----------|-----------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|
| 1-1Plain fill          | 2.16      | 1.72            | 2.06                          | 7                               | 16.8                          | 2.71E-05                        |
| 2-1Silt                | 8         | 1.62            | 1.84                          | 6.7                             | 16.6                          | 3.44E-07                        |
| 2-2Silt                | 2         | 1.6             | 1.72                          | 6.7                             | 16.2                          | 2.90E-07                        |
| 3Silt                  | 7.5       | 1.62            | 1.64                          | 7                               | 16                            | 2.56E-07                        |
| 6-1 clay               | 4.3       | 1.71            | 2.29                          | 8.8                             | 16.5                          | 7.21E-08                        |

This paper will choose different ways of ground treatment, comparative analysis the effect of different ways of ground treatment on existing roads, these treatments including condition 1: vacuum preloading, near both side of the road with short drainage plate, length is 10m, other length of drainage plate is 17m; condition 2: Vacuum combined surcharge preloading. Vacuum preloading pressure is 60kPa, Preload load is 24kPa, length of drainage plate is 17m; condition 3: Vacuum combined surcharge preloading, vacuum preloading pressure is 50kPa, Preload load is 33kPa, drainage plate length is 17m; condition 4: Vacuum combined surcharge preloading, vacuum preloading pressure 60kPa, Preload load is 24kPa, close to the both side of the road with a short length of drainage plate for 10m, the other local drainage plate length is 17m; condition 5: Vacuum combined surcharge preloading, vacuum preloading pressure 50kPa, Preload load is 33kPa, close to the both side of the road with short drainage plate, length is 10m, the other drainage plate length is 17m; condition 6: Vacuum combined surcharge preloading, vacuum pressure 40kPa, Preload load is 41kPa, drainage plate length is 17m.

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.

4.1 FLAC3D 5.00

Figure 1 Mechanics model of Vacuum preloading area

Considering the symmetry, select only half of the vacuum preloading area and the expressway side in this model. 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. The pile enters the silty clay 1m which is simulated by the solid element.

Figure 2 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.

The different depth of the drainage plate and the mode of loading are compared. The results are shown in table 2. According to calculation, it is effective to weaken the influence of Vacuum combined surcharge preloading on the lateral displacement of existing highway by using the combination of long and short pvd, and the range of influence and the degree of influence are reduced obviously.

In the Vacuum combined surcharge preloading with the different length of the pvd has CFG distortions which is disadvantage on CFG pile stability, thus not recommended the different length of the pvd.

Compared the different modes of pressure loading on the highway, the Vacuum combined surcharge preloading effects on highway is generally less than the effect of vacuum preloading, Vacuum load and surcharge load is closer, the effects on existing pile foundation and existing buildings is less.

| Condition                              | (1) | (2) | (3) | (4) | (5) | (6) |
|----------------------------------------|-----|-----|-----|-----|-----|-----|
| Vacuum combined surcharge preloading   | 80+0| 60+24| 50+33| 60+24| 50+33| 40+41|
| Combination of long and short plates /m | 17+10 | 17+0 | 17+0 | 17+10 | 17+10 | 17+0 |
|---------------------------------------|-------|------|------|-------|-------|------|
| Influence range /m | 24    | 20   | 15   | 1.9   | 8     | —    |
| Large lateral displacement near vacuum preloading zone /cm | 12.2  | 8.3  | 5.4  | 5.8   | -7.7  | 4.3  |
| large lateral displacement near the vacuum preloading zone 15m /cm | 6.6   | 5.3  | 3.3  | 2.0   | -3.1  | 2.5  |

5. Conclusion

In this paper, the setting different depth of pvd and different layout mode of load are analyzed, and the following conclusions are drawn:

1) The combination of long and short plates is effective to weaken the influence of vacuum preloading on the road when soft foundation is treated, and the range of influence and the degree of influence are obviously reduced;

2) The method of is reducing the vacuum load and increasing preloading load can effectively reduce the influence of pile foundation of highway soft foundation treatment, the influence of protective are more obvious;

3) There is CFG distortions with Vacuum combined surcharge preloading which is disadvantage on CFG pile stability, so the different length of the pvd is not recommended.

4) The deformation and distance are relative minimum when adopt 40kPa vacuum load and 41kPa surcharge loading method.

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