Finite element analysis of gravel pile composite foundation under flexible foundation of Airport Engineering

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Abstract. On the basis of consulting data, the bearing mechanism of gravel pile composite foundation is analyzed in this paper. The use of ANSYS software under flexible foundation according to the plum blossoms gravel pile additional stress between pile and soil additional stress distribution, load on pile top stress and pile bearing rate of modulus ratio between pile and soil on the pile top stress and rate of pile bearing capacity, pile-soil effect the stress ratio was calculated and analyzed, providing reasonable design reference for the design of gravel pile composite foundation.

1. Introduction
Wide application of composite foundation in civil engineering and promote the development of the theory of composite foundation, especially from the rigid foundation composite foundation of industrial and civil construction department developed, has formed a relatively complete theory system and design methods, and effectively guide the engineering practice of composite foundation. With the development of airport construction, composite foundation has also been widely used in dealing with airport soft foundation. The stiffness of the filled embankment is small and is regarded as the flexible foundation.

2. Finite element analysis of flexible foundation (embankment) calculation model
The finite element calculation model adopted in this paper has simplified the field conditions of the actual project, specific as follows:
(1) The distribution of foundation soil layer is: 0 ~ 8m is soft clay layer C1, below 8m is medium sand layer C2, soft clay is the main reinforcement area.
(2) The gravel pile in the foundation soil under the flexible roadbed is arranged by plum pattern, each row of lateral layout of 25 piles, two rows fender pile of each side of the roadbed, in order to facilitate the modeling, according to the principles of equal area will be simplified for the rubble wall, according to plane strain problem. The width of the rubble wall is 0.5m and the distance is 1.0m. Figure 1 is the schematic diagram of the plane layout of the calculation model.
(3) The calculation range of foundation soil: the length of semi structure is 25m, and the depth is 20m. According to the characteristics of plane strain problems, a row of piles is selected to calculate, and the number of piles in Figure 1 is 6.
Considering the symmetry of half structure calculation, is divided into 4 units, respectively, the subgrade fill, pile, subsoil C1 and subsoil C2, unit selection into forty-second categories: unit ANSYS program provides two-dimensional isoparametric solid element, pile-soil interface element, defined by contact Target169 and Contact171 unit. The soil drainage consolidation is not considered in the calculation.

Fig. 2 is a finite element mesh diagram of the ANSYS model. The physical and mechanical parameters of the material are shown in table 1.

Table 1 physical and mechanical parameters of materials in calculation model

| type            | Elastic modulus /MPa | Poisson ratio | internal friction angle /° | Cohesive force /kPa | severe /kN.m⁻³ |
|-----------------|----------------------|---------------|-----------------------------|----------------------|----------------|
| Subgrade fill   | 60                   | 0.26          | 32                          | 50                   | 19.6           |
| subsoil C1      | 4                    | 0.35          | 8                           | 12                   | /              |
| subsoil C2      | 10                   | 0.30          | 20                          | 16                   | /              |
| gravel pile     | 30                   | 0.18          | 42                          | /                    | /              |

3. Analysis of finite element calculation results
(1) additional stress of pile and distribution of additional stress of soil between piles
Figures 3 and 4 are the distribution curves of the additional stress of pile body and the additional stress of soil along the depth under the action of embankment load.
Due to the different positions of the pile in the embankment, the difference is large, and the center line along the embankment attenuates to the slope. The stress at the top of the pile close to the middle line of the embankment has little difference, and the stress at the top of the pile under the slope is much smaller. Additional stress between pile than the corresponding depth of pile stress is much smaller, because the compressive modulus of pile is much larger than that of the soil between piles, when the two to bear load, load distribution according to the foundation material compression modulus, performance of stress concentration to the pile on the substrate, thereby the composite foundation of stress redistribution. But the attenuation rule is basically consistent between the additional stress of pile and the additional stress of the soil between piles. And the stress ratio of the two is close to about 2.5.

(2) the influence of load level on the stress of pile top and the bearing ratio of pile

Pile bearing ratio refers to the ratio of the upper load to the total load of the pile in the composite foundation. In the finite element calculation, the change of the load of the superstructure is continuously changed to simulate the change of the load on the composite foundation, and the curves of the load level and the stress at the top of the pile and the bearing capacity of the pile are shown in figures 5 and 6.

Because the flexible embankment of the bearing capacity of the pile body play are not synchronized, the load is increased from 60kPa to 150kPa, the composite foundation of pile top
vertical stress increase with the weight of the embankment increases, the pile top stress changes are basically linear change. The bearing capacity of the pile increases nonlinearly with the increase of the upper load, and then decreases gradually, which coincides with the stress variation at the top of the pile. Flexible embankment due to the low stiffness of the load on the pile in the composite foundation and soil share strong regulation, initial loading, with the load increasing, the bearing capacity of the pile body gradually play its share of the load increases, when the load increases to a certain value, the bearing capacity of the pile body have to play to the limit, with the increasing load, the pile top stress increases with the increase of load amplitude is very small, in part by the pile gradually to the soil transfer between piles, pile bearing capacity ratio becomes smaller.

4. Summary
(1) for the flexible foundation gravel pile composite foundation, the additional stress of gravel pile is weakened along the center line of embankment to the slope. The compression modulus of the pile is much larger than that of the soil between the piles, which determines that the additional stress of the soil between the piles is much smaller than that at the corresponding depth. the attenuation rule is basically consistent between the additional stress of pile and the additional stress of the soil between piles.  
(2) the vertical stress of the pile foundation in the flexible foundation gravel pile composite increases with the increase of the load, and the stress changes at the top of the pile are basically linear. The bearing capacity of the pile increases nonlinearly with the increase of the upper load, and then decreases gradually.

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