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Bad Foundation and its Treatment of HeBei Coastal Highway

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Abstract

In recent years, with the accelerating urbanization process, the national road network continues to expand, a lot of highway construction projects are in the countryside. The geological properties of high level, long distance highway foundation are complicated. In order to guarantee the stability of highway embankment, we need to deal with bad foundation. And the same project may use several different forms of foundation treatment methods, each method has its own characteristics and the optimal conditions shall apply. After the start of construction, as the stratum situations of the construction slot are further revealed that designers often have to dynamically adjust foundation treatment scheme according to actual conditions. In this paper, based on the Hebei Qinhuangdao, Tangshan coastal highway road construction as an example, we briefly expounded the engineering geology, the characteristics of soft soil foundation, geological properties and engineering treatment methods.

***Key words**: bad foundation, soft soil foundation, method of shallow treatment*

Introduction

In this paper, basing on the project of the northern section of hebei coastal highway, to make this paper more understanding, first, a brief introduction of basic situation of the project.

According to coastal highway geological survey datas the underground layers are simple. From section Q, the geological time of layer is between Archeozoic and Proterozoic. Rocks are black homogeneous mixed plagioclases. They are full, strong or weak weathered. The rest of the sections are basically the quaternary Holocene stratums, belong to shock, diluvia layer, the exposed layers are fabulous clay, clay, silt and fine sand, medium sand, clay, gravel, pebbles, etc. Common bad foundation soil types: soft soil, expansive soil and collapsible loess, saline soil, as well as the permafrost, karts rock, etc.

Sand Liquefaction

North of the Bohai area, belongs to the north China plain seismic structural zone, coastal highway is adjacent to the coast, laying on the wide plains routing through changli fault zone, seismic activity is frequent in this area. On July 26, 1976 Tangshan earthquake happened here. The peak ground motion acceleration is 0.1(g)~ 0.2(g).the characteristic cycle of ground motion is 0.35(s)~ 0.4(s).Because of high level underground water, plenty of saturated fabulous clay and clay, sand liquefaction happens easily. The seismic data show that sand liquefaction phenomena were very common. Luanhe area which is past by highway belongs to seriously sandy area.

When sudden earthquake happened, sand soil in the layer suffers a huge earthquake force; its pore stress becomes so high that pore water can't discharge instantly. Sand soil becomes liquid immediately. The foundation bearing capacity fell sharply, buildings on the ground damaged and sank into the quicksand (Chian, 2011). This phenomenon is known as sand liquefaction.

Table 1: Seriously liquefied section of Hebei coastal road

Serial number	Segment	length (m)	Bottom depth (m)	layer thickness (m)
1	K83+045.50~K83+283.50	138.00	14.20	6.00
2	K102+149.50~K102+207.50	58.00	11.35	6.00
3	K106+786.00~K107+084.00	298.00	6.20	2.00
4	K119+221.00~K119+568.50	347.50	4.30~8.70	4.30~6.20
5	K122+265.00~K122+637.00	372.00	2.70	2.70

The Engineering Properties of Soft Soil Foundation

In the process of project construction, soft soil has some special engineering properties. According to research, such as silt soils on the masonry structure, the settlement of civil building with three floors ranges from 15(cm) ~30(cm), four floors ranges from 25(cm) ~60(cm). When the building is more than five floors, the settlement is above 60 (cm). Reasons of large amount of settlement, one is large void ratio, high compressibility. Second, the sludge layer is thick. So in silt soil area, the upper structure exists altitude intercept. There are so many buildings cracked because of differential settlement.

Soft soil was made of clay, silt and clay content is high, and contains organic matter. The permeability is low, the permeability coefficient is usually ranges from $10^{-8} \sim 10^{-6}$ cm/s, is makes soil consolidate for a long time. Buildings spend several years getting stable for subsidence. Under normal construction speed, the settlement of buildings more than three floors during the period of construction accounts for of the total, the rest of the settlement can cost more than 20 years. For many newly-built highways, differential settlement in embankments phenomena can be found

Fast loading can cause a lot of settlement, tilt and fall. The bearing capacity of saturated silt is deeply influenced by the drainage condition of the load. If loading speed is too fast, the water in the soil cannot be ruled out, will cause the higher pore water stress in soil, when the load exceeds 50% of the allowable load force, the deformation of foundation is plastic and elastic. A large number of soil in the plastic flow state, to squeeze out, cause foundation sinking, serious instability of foundation.

The shearing strength of the soft soil is very low, easy to slide. The strength of the soft soil is close to zero. Saturated silt soil structural strength depends on the cohesion value ranges10kpa - 20kpa. So the highest allowable bearing capacity of foundation is 100kpa, lowest is 30-40kpa. The stability value of soft soil slope is very low, only 1:5 (the ratio of the height and horizontal distance), for earthquake it is 1:10, but after preloading, foundation bearing capacity can be doubled.

Shallow Soft Foundation Treatment Method

Shallow soft foundation means the thickness of soft soil layer is less than 3(m).the treatment methods for shallow soft foundation are varied, be summarized as follows: cushion method, back stress method, surcharge preloading method, geosynthetics method (Barbosa-Cruz, 2007). However, in practical engineering, these methods are often synthetically used. This article selects cushion method to introduce in detail.

Generally we use artificial, mechanical and other methods, and eliminate weak soil layer, the replace with high strength materials such as: sand, gravel, pure soil, dry slag, coal ash. And then, we use mechanical stress actually meet the design requirements of compaction. This is most commonly used method of shallow soft soil (Rasion, 2004).

After the discharge water on the surface, use machinery to eliminate the silt. For example: the layer of soft soil is thin, such as fish pond, salt pond, lake, swamp, machinery method can be used, and then fill in materials which meet the technical requirements (Mitchell, 2002). In the rivers or water depressions, silt stratum lies under water and hard soil layer lies under silt. On this condition, ripped-rock method can be used, throw weather-resistant rocks from roadbed center to both sides, make flagstone sink to the bottom layer.

Requirements for Replacement Materials

Sand-gravel material: it is supposed to choose well granular composition material, do not contain complex material and organic material. When using the powder sand should be mixed with 25% ~ 30% of gravel and pebbles, maximum particle size should be <50(mm), Sand should be chosen medium sand and more coarse sand, silt content should be < 3%.

The earth-rock chip packing: partical size should be < 2(mm), total amount should be < 40%, and the amount of packing whose particle size is less than 0.074(mm) should be < 9% .The amount of silt content should be less than 3%.

Pure soil packing: the organic content should be < 5%, not containing expansive soil; when containing gravel diameter, the particle size should be < 50(mm).

Dust packing: volume mixing ratio appropriate for 2:8 or 3:7. Appropriate use of clay soil is silt or floury silt whose plasticity index is more than 4.

Industrial residue packing: industrial waste residue, including dry blast furnace slag and flyash, not containing living garbage and plants.

Packing should be pressed properly and meet the design requirement for degree of compaction.

For swamp, coastal beaches, soft soil layer is flat, soft soil becomes flow state, it will be difficult to succeed when using general filling material (Rawlings, 2000). To achieve the desired purpose, should use big rocks as filling material. The rocks must be weather-resistant, and the thickness or diameter should be no less than 300(mm). the amount of diameter whose particle size is less than 30 (mm) should less than 20%.

Thickness of Filling Layer

For general filling layer using sand-gravel materials, the thickness z of filling layer can be estimated with the following equation:

$$Pz + Pcz \leq fz \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where:

- Pz is the additional stress in the cushion bottom corresponds to the standard combination of action effects (Kpa);
- P_{CZ} is unit weight of soil in the cushion bottom (Kpa);
- fz is cushion foundation bearing capacity after processing (Kpa);

The additional stress in the cushion bottom can be calculated by the following two equations:

The additional stress in the cushion bottom is shown as figure 1:

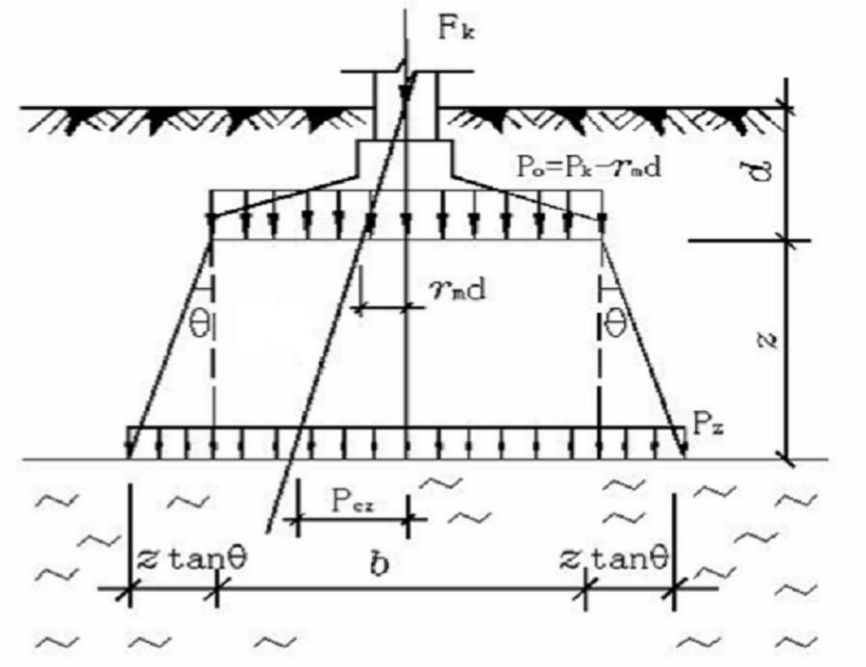

Figure 1.Additonal Stress Calculation Diagram

Strip foundation:

$$p_z = \frac{b(\mathrm{p}-\mathrm{p_c})}{b+2z\tan\theta} \qquad (2)$$

The rectangular foundation:

$$p_z = \frac{bl(\mathrm{p}-\mathrm{p_c})}{(\mathrm{b}+2z\tan\theta)(1+2z\tan\theta)} \qquad (3)$$

where:

B is the width of the rectangular foundation or strip foundation (m);

L is the length of the rectangular foundation (m)

P is the average stress in the bottom of foundation corresponds to the standard load effect combination (Kpa)

P_C is the unit weight of soil base (Kpa)

Z is the thickness of filling layer (m)

θ is stress spread Angle of cushion layer, should be determined by experiment, when there is no test data, can choose the data in table 2

Table 2: Different filling material cushion stress diffusion Angle

z/b	gravel	clayey soil	dust	Grit including: medium sand and coarse sand, gravel, pebbles, breccias, round gravel, crushed stone.
0.25	20	6	28	
＞0.50	30	23		

Note: (1) z/b < 0.25, in addition to the dust take = 28 °, the rest of the material are taken = 0, should be tested to determine if necessary.

(2) when the 0.25< z/b < 0.25, the values can be interpolated.

Summary and Conclusions

The following summary and conclusions are based on the data, analyses, and interpretation presented in this paper:

1. Cushion method can be used for silt, silt soil, pure soil and other soft soil shallow treatment.
2. The thickness and width of filling layer should meet deformation requirements.
3. Before we start, we should check the geological survey data and design data, make a reasonable construction plan according to engineering characteristics of the foundation, hydrological geology, construction environment to ensure project quality.

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Acknowledgements

Based on the "governance" bad foundation this complex topic as the research background, combining with engineering examples to discuss the basis, stand in the perspective of theoretical research and practical pay equal attention to, with the learner's attitude to explore bad governance foundation. In this paper, the data are from the real data collected in the engineering example, the proposed method is also from the generalizations of the actual production, the study of the subject has a certain depth and insight. Limited to the level and time, the author of this article is insufficient even inaccurate, hope readers understanding and opinions are put forward.