

# THE METHOD TO REDUCE THE POST-CONSTRUCTION SETTLEMENT OF SOFT SOIL SUBGRADE

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**Abstract:** The post-construction settlement of soft soil subgrade is one of the main problems of railways and highways that troubling builders and designers. Reducing the post-construction settlement has a great significance. This article presents the treatment and precautions of design. Finally, it gives a brief introduce of the new development technology of foundation treatment.

The bearing capacity of soft soil foundation is often 50kPa~80kPa, without any treatment, it will not suitable for big loads, otherwise it will have a risk of local shear or whole sliding; Also likely to have larger ground or differential settlement. The subgrade post-construction is a potential of the accidents of rail and road, cause waste for railway and highway maintenance and driving operation. it is not only damage the car body easily but also may cause traffic disruption, and accidents. In junction of road and bridge, easy to form the steps .The train attached vertical acceleration, the coupling vibration of the axle, and reduce life of bridge when it go into Bridges. For road, subgrade is the main supporting body of pavement, subgrade of post-construction settlement will damage the normal use of the pavement. Flexible pavement will present the damage forms such as rutting, collapse and so on. Rigid pavement may break, in the joint of different road or the combining site of bridges and roads are easy to form dislocation. These are not only affect the comfort of driving, but also reduce roads, Bridges and vehicles life, and case accident.

In order to ensure the vehicle work in a safety, high speed, smooth and comfortable mode. Subgrade must have sufficient strength, stiffness and stabile, it is needs to strictly controlled the deformation and the sedimentation of roadbed in allowed range [1].

## The Methods to Reduce Soft Subgrade Settlement after Construction

Construct embankment on it has two characteristics. One is easily form bulge on both sides of the foundation bottom or outside embankment slope toe and case collapse, it is proved the collapse surface is circular; the other is larger settlement. We should do treatments on it to avoid post-construction settlement and collapse [2].

The construction methods to reduce the post-construction settlement as follow. One is subgrade treatment method, such as controlling the type of the filler and the depth of each layer, etc. Another is foundation treatment method. This method is commonly used on the treatment of foundation. There are so many methods for soil improvement and each method has its own principle and effects, it is important for us to clear the purpose of the foundation treatment and adjust measures to local condition.

## The method of Soil Improvement

The method of soil improvement is the usage of external mechanical force or electrical, chemical means to enhance the density of the soil, or to accelerate soil consolidation.

**Increasing the Density by the Method of Drainage** The disappearance of the excess pore water pressure before ground consolidation occurs when clay foundation under loading, at the same time, the pore water is slowly discharge and the shear strength is improved. Experience has shown that, a prior greater load than a predetermined pressure to a pre-consolidation of the soil, when the load acting later, which will reduce the amount of compression, shear strength were much larger than the time of overpressure. By using the method of drainage to increase the density of soil is the use of the properties of clay to improve the mechanical properties of the foundation. Including:

**The method of reducing underground water level:** It is reduce underground water level to decrease water pressure to deal with the problems caused by groundwater. It also can make effective stress increase, promote the foundation consolidation.

**Vertical drainage method:** Good permeable material is placed vertically in a thick clay layer, then with the stagger drainage distance to accelerate consolidation.

**Electro osmosis method:** It is the method of using electro osmosis ruled out the moisture from the soil. The electro osmosis is settled direct current in the soil. The water in the soil generally moves from anode to cathode. To accelerate consolidate.

**Atmospheric pressure method:** Gas-impermeable film is covered on the ground, using the vacuum pump to drainage, reduce ground water pore pressure to increase the effective stress and apply the load for the consolidation.

**Hammer compaction method:** with a considerable weight of the hammer falling from a considerable height, a large impact force generates by the foundation's approach.

**The method of semi-permeable membrane:** The fiber waste liquid is poured into a solution of a polyvinyl alcohol of the semi-permeable membrane interposed paper tube, then buried it in the earth. The water discharged into the paper tube method for the semi-permeable membrane osmotic pressure generated by soil.

**Increasing the Density by the Compaction Method** Vibration and shock force is applied in loose sandy soil. Sand particles arrangement will be dense, so that the soil was sandy compaction. Sandy soil after effects such as squeezed real load, it will reduce the amount of compression. With the compression load increases, the pore becomes smaller. In addition, the soil dense, the sandy shear strength improved. It is not easy to produce liquefaction with relative density increases. Increasing the density by compaction method make use of these properties of sand to improve the foundation. Including:

**Direct Impact Compaction method:** using the motion produced by the H-rod with a pressure plate shaking force up and down to compact the foundation.

**Sand compaction pile method:** With hammer impact or vibration generated by the vibration hammer casing pressure buries in the sand to make the sand compaction pile.

**Vibration flush method:** Insert horizontal vibration in the foundation shaking body and shoot water, filling the pores to form aggregates in the vicinity of the shock body, making foundations increased density.

Above methods are the two basic methods to process the sand foundation.

**Consolidation Method** This method is to cure agent into soil pore, or to mix in the soil, or to cool or heat the soil. The soil consolidation improves the soil shear properties, compression property and water permeability. The consolidation is as follows:

Mix method: a mixture of cement, lime and soil for the ground treatment.

Sintering method: It needs to dig holes in the foundation, heat the hole wall soil to make consolidation and dehydration.

Lime pile method: The lime pile is set into in the foundation, for lime owning a variety of effects to process cohesive foundation.

Injection method: A cement suspension, water glass and polymer-based liquid curing agent pressure into foundation, to increase it strength and make it impermeable.

Jet mixing method: Use high pressure jet the curing agent used in the injection method, move or rotate mix each soil foundation treatment agent, form a cut-off wall and a columnar cured body. To make the water permeability and strength increase. And this method has no limited by the condition of the foundation, also apply to the cohesive soil.

Electrical consolidation method: Using the electro-osmotic dehydration for the soil, the anode is easy electrolysis anode aluminum and other metal ions to flow, leaving salt formation in the soil to

accelerate the soil consolidation.

**Soil Replacement Method** This method is change the soft soil into good quality. It is the best method to treatment the soft sticky soil. The soft soil thicker, the project cost higher. So use sandy soil is commonly, it have effect on improve shear properties and compression, No effect on impervious foundation. In addition, the replacement of sand not fully Compaction is possible liquefaction. Soil replacement methods as follow:

Excavation replacement method: Some or all of the soft soil will be digged, and replaced with good quality soil.

Forced displacement method: It is the use of weight-for-filling, shot water or blasting, use sand column pressed out the soft soil, then Replaced with good quality soil.

**Soil Reinforcement Method** Use film, rope, sheet piling constraints of foundation soil, or placed high tensile reinforcement material in the soil to form a composite foundation to strengthen and improve the shear properties of soil. However, this method does not prevent the foundation deformate, the cohesive compression deformations may last a long time.

Laying thin film and rope method: Soil surface are constrained by the foundation to prevent damage the soft foundation slip and flow. The former uses the chemical fiber membrane. The latter uses a combination of film and rope to enhance the overall tension.

Sheet pile Containment method: On both sides of the sheet pile with a rod to pull, rely on the side constraint to strengthen the foundations.

Composite reinforcement method: Put steel, steel mesh, steel lattice, synthetic resin into the soil, rely on the friction between soil and the reinforcing material.

**Use of Geotextile Reinforcement Method** Between embankment and the surface of the earth laid a layer or multilayer earth polymer chemistry of materials. It has great shearing strength and permeability. So it has no effect on drainage. Chemical polymer use as geotechnical materials, include geotextile, geogrid. Geotextiles can divided into two categories, woven and non-woven, non-woven used as filtration materials, have a good effect on subgrade; woven use as reinforcing material and filter mat.

## **The Design of Foundation Treatment**

The subgrade post-construction settlement control standard is a technical and economic problem, the standard higher, the cost more. And there are merits and demerits of various measures, so as the application condition. When select the treatment of soft foundation, we should think about the foundation condition, the target and range of treatment, project cost, the progress of works, the source of materials condition and local environment.

Usually, there are three stages of natural soft roadbed, including filling, prepressing and pavement construction. Every period of it will consolidation in different degrees. In the meantime, the strength of the subgrade soil is improved accordingly. When load on soft soil foundation, the foundation will produce additional stress. With the dissipation of pore water pressure in soil, the soft soil of degree of consolidation will continue to increase.

The strength of the soft soil foundation is increasing with the growth of the subgrade soil consolidation degree apparently. And the degree of consolidation has been affected by external load, nature, soil condition and drainage. Therefore, according to the nature of subsoil, only taking sound measures will it improve the degree of consolidation effectively, which will help to control the subgrade post-construction settlement.

Confirmed above conditions, first, not treatment the foundation, calculate the bearing capacity, settlement, sliding damage, deformation, permeability and liquefaction, etc. then carries on the preliminary budget of project schedule, cost when the foundation treatment's necessity is clear, only the purpose of treatment clear can choose the right measure.

## **The latest development of ground treatment technology**

The recent development of foundation treatment has been reflected in machines, materials, design theories, as well as the continuous development of new ground treatment measure and a variety of integrated application of foundation treatment measure.

Foundation treatment machinery development quickly in recent years, such as, the compaction machinery, deep mixing machine, etc., the development of the treatment machine increases the ability of foundation treatment obviously.

Foundation treatment technology development is also reflected in the comprehensive application of the method to improve a variety of ground level. Such as vacuum preloading method and preloading and comprehensive application method can overcome the vacuum preloading method preload load drawback less than 80kPa, expanding its scope of application, the vacuum preloading method combined with high pressure jet grouting method can make the vacuum preloading method applied to larger horizontal permeability soil layer. And High pressure jet grouting method combined with grouting method can improve the reinforcement effect of grouting. Geotextile sub crust combined with sand can effectively improve the stability of the foundation. Anchor rod static pressure method combined with drawing soil method, anchor static pressure method combined with liter method make the remedy reinforcement technique to a new level. Pay attention to the various ground treatment methods of comprehensive application can obtain good effects.

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