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Discussion on the Methods for Mass Excavation and Embankment in Silt

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Abstract— **When road construction crosses low lying swamp land or pond, it must dig or fill in silt. Because the slit is running and its bearing capacity is very small, constructing road in silt is very difficult. Against the characteristic of digging and filling in silt, this paper proposes many principles. When digging in silt, take best efforts to reduce the perturbance and destruction of adjacent soil body, and persist in digging silt near the excavating machine and unloading silt far from excavating machine. When filling in silt, take best efforts to extrude silt entirety. At last, the paper introduces several useful methods of digging and filling in silt on a large scale. They are the method of placement in layers, the method of road bank extruding silt, the method of rib slab filling and the method enclosed filling, directly digging, enclosed digging and semienclosed digging. Analyzing and comparing these methods from their technics, useness bound and notice proceeding, providing evidence for construction.**

Keywords-mass excavation; embankment; silt;

Where road construction encounters swamps or ponds, excavation and embankment in silt is often required, during which slides caused by the instability of silt usually occur if water content is greater than liquid limit and void ratio greater than 1.5 and embankment under such circumstances tends to be accompanied by silt squeeze and consolidation settlement. The problem can be resolved by special excavation, embankment and proper construction procedures and methods. Based on years of construction practice, in-depth investigation is made in regard to roadbed construction.

I.PECULIARETIES OF EXCAVATION AND BACKFILL IN SILT

Direct excavation is more difficult than direct embankment due to the liquidity of silt. For this very reason, filling should be substituted for excavation wherever possible. Procedures of excavation and embankment in silt are opposite to that of general earthwork: backfill should precede excavation. Filling construction should be conducted at both sides of the existing embankment in a symmetrical way. Silt on either side should not be too high in order to prevent displacement. Because the bearing capacity of silt is relatively low, proper consideration should be give to construction roads and platform prior to the major work. To ensure lower cost and safer construction, structural and working measures should be considered as an entirety constituting construction roads, platform and supporting facilities that can be used during the project and also preserved as part of a permanent structure [1].

A. Peculiarities of excavation in silt

The area affected by excavation carried out to form soil slopes is half of the depth designed for the entire excavation work. For silt in the shape of flow plastic, the affected area well exceeds the depth of excavation and measures must be put in place to avoid excessive excavation caused by the collapse of silt. In case of thixotropic silt of high sensitivity, in order to maintain stability that is intrinsic of the silt, adjoining silt should be left as undisturbed and intact as possible and hard crust laying in the silt should be preserved wherever possible. Excavation near silt fillings should be proceeds according to the principle of "digging in proximity and unloading at a far distance", so as to reduce the loss of fillings as silt drifts. During construction, fillings of permanent structures should be used first to build construction roads and platforms for the excavation of silt.

B. Peculiarities of embankment in silt

Permeable soil is generally used in silt embankment, where it is filled to 0.5m above silt surface or a bedding course of permeable soil is laid first. If water exists on the silt surface, fill it with rock ballast until it rises to 1.0m above water. When the embankment exceeds the maximum height of fill in the silt, displacement or even collapse may occur. In order to stabilize the embankment, the protruding part of the silt should be removed to prevent potential slides caused by rain that leads to major collapse of the embankment. During embanking by toe-shooting method, non-stopping operation should apply, consolidating the stir of the surrounding silt, destroying its structural strength and ultimately enhancing the sinking effect of the embankment targeted by the toe-shooting method. Conversely, where bearing capacity of the silt is utilized for embanking, intermittent operation should be implemented to avoid any stir of silt and the embanking speed should not exceed the strengthening speed of the silt. In case scattering of stones is used in the embanking suitable for flow-plastic shaped silt with a certain degree of bearing capacity, holistic toe-shooting method should be applied due to the fact that filling will be low in strength and the sinking effect not good enough with rocks filled with silt in between.

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II. ANALYSIS OF METHODS FOR SILT EMBANKMENT

For direct embankment in silt, the four methods can be adopted: placement in layers, toe-shooting method, stiffened plate embankment and closed silt blocking [2].

Placement in layers involves the formation of soil and rock embankment by roller compaction and layer-by-layer fillings. Embankment in layers, without damaging the silt foundation, can reduce the quantity of filling submerged in the silt, resulting in lower costs. It takes longer for the project to complete, as construction should be interrupted each time when filled soil exceeds the critical height allowed for the silt. The method is applicable to project where silt surface is protected by a hard crust, the required height of embankment is moderate, the work schedule is not tight and no anti-scour requirement is placed on the embankment. For parts with water logging instead of hard crust on the surface layer, water should be drained clear and the silt surface kept dry. Fillings should be obtained or dumped 20 meters beyond the tail of slop of the embankment. For embankment with a smaller critical height, layers should be filled by a regular, uniform building-up method. Where final height exceeds the critical height of silt in its natural status, intermittent embanking should be adopted. Where the height of embankment is no greater than 1.3 times the critical height, more gentle side slopes can be made in order to shorten the time limit for the project. Where embankment is 1.5~2.0 times as much as the critical height, loading berm can be adopted. Appropriate height and width of the loading berm should be 1/3～1/2 and 1/4～1/2 of that of the embankment. The loading berm should be built simultaneously with the embankment to avoid collapse of the latter. Where silt is used as filling, interbedded embanking should be adopted. First, water logging on the silt should be drained, followed by a hard crust that forms itself over time, which is leveled and compacted with a layer of mountain soil 0.7～1.0m thick then covered by backstep method with silt transferred from the digging area. When silt laid on the soil reaches 0.8m and interconnected cracks take shape after dehydrated, mountain soil is laid to 0.2～0.3m in thickness upon which silt 0.8m thick is then built by backstep method. After cracks appear again, 0.2～0.3m of mountain soil is filled in. The process of interbedding should be repeated until reaches designed height.

Toe-shooting method can be adopted where water logging exists on the silt surface. Under such circumstances, mechanized high-speed construction should be used. According to different ways fillings sink to the bottom, the method can be further divided into three sub-categories. Suspension toe-shooting involves mass loading of fillings to squeeze silt, where gutters are dug out in both sides to channel out the silt so that the embankment suspends above the silt in stability. The second is bottom-connecting toe-shooting, in which the embankment sinks in spite of the silt until it reaches the hard layer that supports. The last one is sideway constraint, which is adopted after bottom-connecting near the tail of slop to form a cutoff wall on one or both sides that connect to the bottom, followed by embankment works.

Stiffened plate embankment is especially suitable for station yard project with no strict requirement on settlement difference. In general, mass embankment carried out in silt unaffected by tides should be preceded by earth banks built in parallel and lengthways, followed by earth banks running in lateral directions, so that a square mesh is formed for massive cutting of silt. Finally, full-scale embankment is constructed into a shape of stiffened plate.

Closed silt blocking involves the formation of a closed foundation ditch isolated from surrounding silt by making the height of embankment greater than the depth of silt, where silt-blocking rocks sink through silt to the supporting layer. In the process, silt is squeezed by rock ballast, out-loading, water jetting displacement and dynamic compaction. The method integrates working and structural measure, where silt is both squeezed and consolidated by dynamic compaction. The bank thus built is of high quality and serves not only as a silt blockage but also a construction road and platform where mechanized operation can be conducted.

III. ANALYSIS OF METHODS FOR SILT EXCAVATION

In silt excavation, three methods can be adopted: direct excavation, semi-closed excavation and closed excavation [3].

Direct excavation can only be applied to silt no deeper than 4 meter and can be further divided into three sub-categories. First is stratified excavation applicable to silt areas surrounded by higher terrain or protected by banks or dams in a way that logging water can be drained. 0.2～0.3m of hard crust is removed by bulldozer, scraper or pull shovel adaptable to swamps, revealing the layer beneath which is dried until a new crust appears. The crust is then removed again and the process repeats itself until the work is done. The second is natural collapse, in which one-time excavation is made to a substantial depth and the bottom of silt is supported by a hard stratum. When the hard stratum turns out to be slope, excavation should proceeds from the shallow to the deep. Each excavated section is backfilled again to form platforms and road for construction purposes. Where no significant difference exists between silt depths, rocks should be first filled in to make short embankment that will support backward digging made by the dredger, which, after the platform connecting to the supporting hard stratum forms, can move onto the construction platform where further excavation can proceed.

Semi-close excavation can be subcategorized into three types. The first one is platform excavation. When platform is built, silt is gradually removed through digging followed by filling. The method can reduce the degree of over-excavation. The second is toe-shooting excavation, where fillings are thrown in to make ballast that squeezes silt. Where the bottom of the embankment fails to reach the

designed depth, protruding silt is removed by digging machines on the embankment to form escape passages and the embankment continues to sink. When the designed depth is reached, fillings are thrown in again to form ballast that squeezes the silt until the embankment reaches the designed height. The third is fixed-point deep excavation, especially applicable to where silt surface needs to sink to a substantial depth and the surface is relatively smooth. During construction, digging machines are stationed on the embankment that has already sunk to the bottom. Surrounding silt is excavated by pull shovel while silt from a distance away flows continuously to the digging point. As a result, mass excavation of silt can be achieved without redeployment of machines.

Closed excavation includes closed excavation on pressing platform and closed excavation on blocking embankment. The former can overcome difficulties encountered in the digging and transporting of flow plastic shaped silt by changing the excavation of silt into that of earth and rock fillings. Side slopes thus formed in the gutters have greater bearing capacity and some degree of anti-scour capacity. The latter involves blocking the foundation ditch by silt-block embankment, followed by the removal of the silt within by dredgers stationed on the embankment. The method is featured by easy construction, great reliability, complete excavation and low cost.

IV.CONCLUSION

There are many methods for mass excavation and embankment in silt. Each method has different characteristic. The constructor must use rational method, so the engineering cost can be reduced. In this paper, the author proposes all methods and compares each characteristic and supplies reference for construction.

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