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Comparison of sand drain and wrapped flexible pipe drain in Khuzestan clay

Comparison des methods du drainage sablier, avec drainage couvert flexible tubulaire, dans les argiles du province Khuzestan

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ABSTRACT: Great and extended efforts have begun to develop petrochemical industry projects in south of Khuzestan region in south west of Iran, by the government. This area which is adjacent to Persian Gulf is flat and formed of quaternary sediments. Subsurface layers are consequently consisting of fine-grained soils with considerable thickness, unable to carry heavy or moderate loads. Preloading with vertical drains is an alternative to improve the ground and reduce large settlements when project time schedule is not very critical. The method was employed with good results and up to 160 Cm settlement was observed. Efficiency, technical specifications and economical costs for sand drain and prefabricated drains (wrapped flexible pipe drain and band drain) are compared in this paper, advantage and disadvantages of each method is overviewed.

RESUME: Actuellement l'Etat d'Iran a commence un vaste investissement au sud de Khuzestan pour developper les industries de petrochimie. Cette zone de plaine (a la proximite du Golf Persique) est formee des alluvions du IV eme epoque geologique. Les petits sediments du sol dans cette zone, sont molles et souples, jusqu'a une profondeur considerable, et ne peuvent subir les lourdes charges, ni celles de moyennes. Dans ce cas, et pour les parties du project, don't le temps n'est pas suffisant, on peut utiliser les methodes de renforcer, accompagnes du drainage vertical, a fin de renforcer le train. Ces methodes ont ete deja utilisees, et les resultats de 160 Cm on ete pris. Dans cet article, on a fait comparaison du rendement et des caracteristiques techniques, economiques des methodes du drainage sablier, et ce de construit par avant (compotant le drainage couvert tubulaire), et les avantages, ainsi que les vices de chacun d'eux, ont ete verifiees.

1- GENERAL

Two similar and adjacent tank foundations chose for installation of sand drain (Tank A) and wrapped flexible pipe drain (Tank B). The tanks are located on tankage area in the Aromatic Plant (Bou Ali Petrochemical Company). Deep and surface settlement probes and piezometers were installed for both area with the same height of filling. Height and diameter of proposed tanks are 12.5 and 14.0 meter respectively.

2-SUBSURFACE CONDITION AND GEOTECHNICAL SPECIFICATIONS

Based on geotechnical investigation, subsoil consists of fine-grained soft silty clayey soils with a thickness of 12 to 15 meters (first layer) over a dense silty sandy layer. Subsurface conditions with the location of the tanks are presented on Figure 1.

3- PRECONSOLIDATION METHOD

More than 10 petrochemical plants are under construction in the area known as "Petrochemical Special Economic Zone" in south of Khuzestan Plain adjacent to Persian Gulf. Prefabricated band drain was employed as vertical drain in one of the plants and wrapped flexible pipe drain employed on tankage area in Aromatic Plant. Wrapped flexible pipe drain consists of a metallic spring covered with two layers of acrylic clothing where distance between the spring steps is about 1 centimeter. Flexible pipes are pushed through the mandrel pushed in to the ground by special hydraulic equipment. Diameter of the completed hole is twice the diameter of flexible pipe.

Technical designed specification of wrapped flexible pipe drains and construction efforts applied by the contractor as responsible to fully preconsolidate the soft layers of the plant for Tank B are as follow:

Pipe drain diameter : 4.0 Cm
Spacing in triangular pattern : 140 Cm
Diameter of preloading area : 14.0 m
Height of fill : 8.5 m
Estimated time : 120 days

Workability and efficiency of the specified flexible pipe drain was not clear for us as a supervising consulting firm, so it was decided to install conventional sand drain for similar condition and compare the results. The specification of installed sand drains are as follow:

Diameter : 15.0 Cm
Spacing in triangular pattern : 140 cm
Diameter of preloading area : 20.0 m
Height of fill : 8.5 m
Estimated time : 120 days

According to our calculation and design, final settlement of the Tanks (A&B) is estimated to be 53 Centimeter where 51 Centimeter of the settlement occurs in effective time period. Radius of the drained area under Tank A was considered to be 3.0 meter more than tank diameter in order to have a uniform settlement in and around the tank foundation plan.

Deep and surface settlement probes were measured every day to record the rate of settlement. The results are shown on Figure 2 (Preconsolidation Settlement Versus Time and Height of Fill).

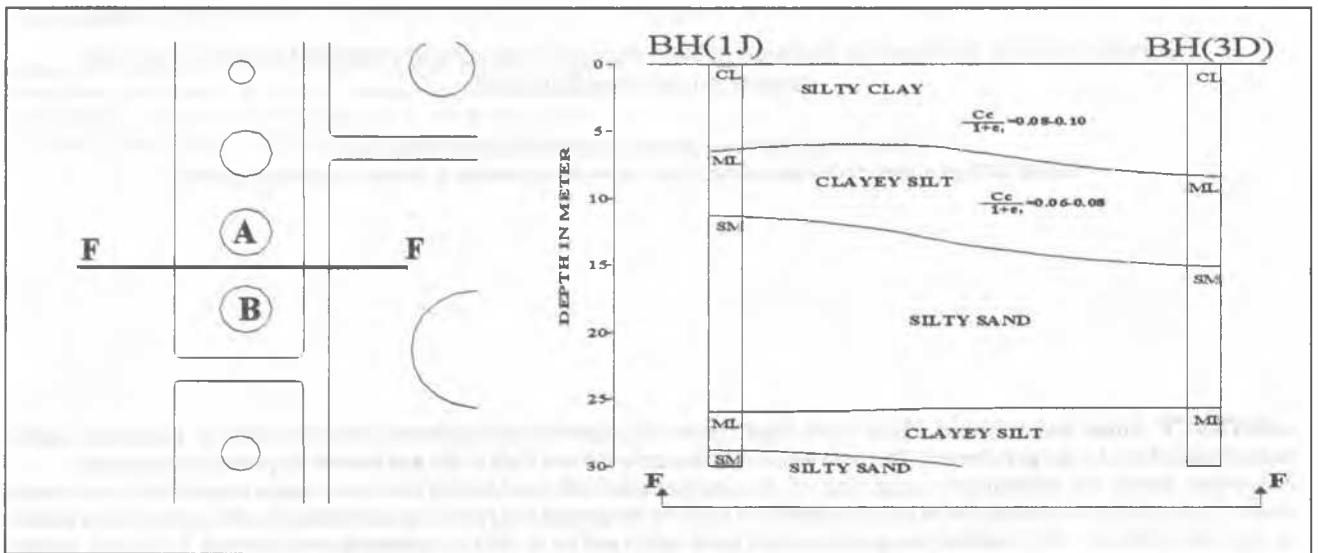


Figure 1. Tank Foundations Plan and subsurface Condition

4- GENERAL RESULTS

The results obtained in tank foundations show that :

- Maximum observed settlement after 140 days (118 days net) in both tank foundations, was slightly shorter than expected time.
- Maximum measured settlement in sand drain is 45 centimeter, 6 cm less than the predicted settlement.
- Maximum recorded settlement in wrapped flexible pipe drain is 38 centimeter, 7 centimeter (15%) less than sand drain in defined time period.
- The recorded settlement in the lower parts of the layer is 14 centimeter in a settlement probe established at depth of 1.0 meter under Tank A and 23 centimeter (4 centimeter less than predicted) in a settlement probe established at depth of 2.5 meter under Tank B.
- Maximum rate of settlement occurred when fill height increases from 3.0 meter to 7.0 meter (1.3 Kg/cm^2 load). Mean natural soil pressure at center of the layer (6 meter depth) is in the order of 1.2 Kg/cm^2 . Khuzestan clay recognized as normally consolidated clay.

5- COMPARISON OF THE METHODS

Each of the compared methods, sand drains and wrapped flexible pipes have some advantages and disadvantages. Wrapped flexible pipes have some priorities such as:

I-construction rate is very high; 250-500 meter of drains could be installed per day. This is in the range of 60-120 meter for sand drains.

Installation cost is relatively low because pushing equipment is needed for penetration and installation of drains. These are predicted to be 2-3 times more in sand drain method.

In the other hands, sand drain method has some advantages and priorities as follows:

I-Material price (sand) is relatively negligible in the area, so the need for purchasing expensive materials is limited.

II-Number of drains is significantly less than that of the first method. Thin size and small diameter of wrapped flexible pipe drain results in increasing the number of drains (generally 2-3 times more than sand drain) and decreasing the distance

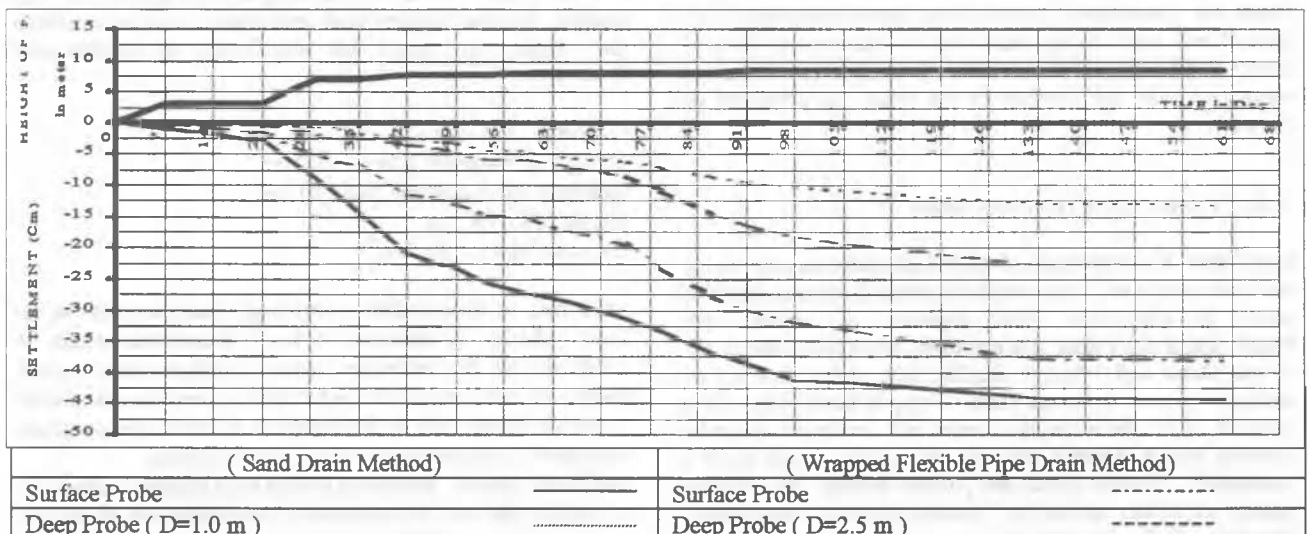


Figure 2. Preconsolidation Settlements Versus Time and Height of Fill for Two Compared Methods

between them (may be less than 1.0 meter) which result in interference of construction efforts and lowering the efficiency. This is more critical when the depth of the soft layer increases (more than 10 meter).

III-Smear effect in prefabricated drain is an important and well-known disadvantage, which strongly limits its application.

IV-Wrapped flexible drain is plugged due to soft soil horizontal pressure.

V-Existence of dense sandy layer in any thickness prevents the mandrel to pass through it and results in defective and unfinished preconsolidation process and incomplete necessary settlement. That was the case in some local areas when intended to install wrapped flexible pipes.

VI-Our experience and measurements in the site confirms that the predicted settlements did not complete on estimated time schedule on any tank foundations and in some cases, assigned time period was increased by 50%. The problem was more critical in case of large tanks on thick soft layers (like the case for a 52 meter tank diameter on 20 meter soft layer and resulted settlement of about 160 centimeter).

6-ALLOWABLE CAPACITY AFTER PRECONSOLIDATION

Dynamic sounding test results at the center of Tank A before and after preconsolidation are shown on Figure 3. The results indicate that there is a factor of safety of 2.3 against shear failure in Tank A after preconsolidation process.

7- DISCUSSION AND CONCLUSION

Based on the overall results, we come to the conclusion that with a slight increase in cost, the sand drain gives more reliable results. The measured settlement in sand drain method is in

more agreement with the predicted settlement, and settlement takes place in shorter time after application of surcharge.

In case of flexible pipes we believe that pipe spacing should be reduced to at least 1.1 meter and the preloading area should be increased by 60% to get the similar results, which of course will increase the installation cost.

Therefor we recommend using sand drain method especially where the settlement is very limited due to the sensitivity of the structures.

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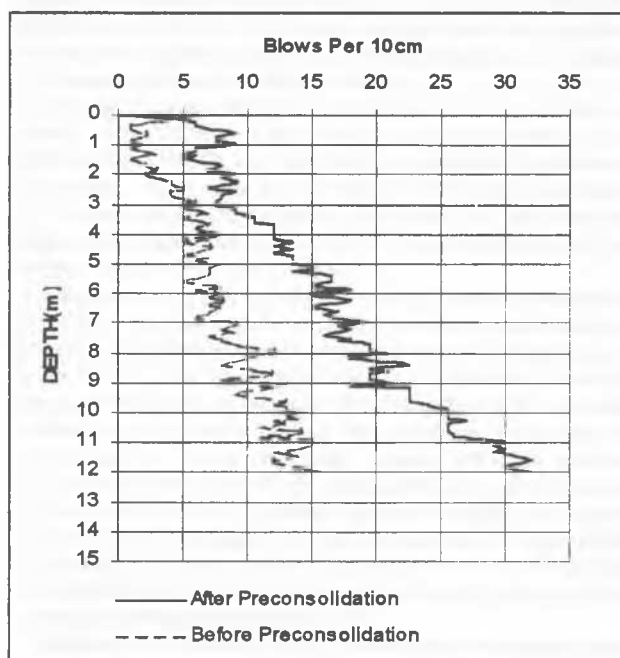


Figure 3. Dynamic Sounding Test Results, Before and After Preconsolidation.