Proceedings of International Conference : Problem, Solution and Development of Coastal and Delta Areas
Semarang, Indonesia – September 26th, 2017
Paper No.C-50

Dealing With Issues in Construction in the Coastal Area of Soft Clay: Solution, Strategy & Implementation

Pratikso, Soedarsono
Sultan Agung Islamic University, Department of Civil Engineering
Jl. Raya Kaligawe Km.04, Semarang, Jawa Tengah, Indonesia
pratikso@unissula.ac.id

Abstract - In this condition, cities with coastal area have soft clay soil. The main problem is that the soft clay soil has bee n suffering from great settlement due to consolidation that makes the buildings around become instable, it causes the landfill is done on the soft soil. Suppose the consolidation happens naturally as it is, it will run in a relatively longer time, years or even decades. In order to be stable, it needs longer time, as consequence, the soil is not able to be used for building to which it will give damage in term of time and finance. It is why engineering is needed to fasten the consolidation process in order to make the soft clays soil able to be used efficiently. One of particular methods to fasten the consolidation process is building vertical drain. There are many ways and materials that can be used to set up vertical drain, among which are making small holes through drilling then filling it up with porous materials such as sand and gravel stone or coir. Nowadays, new method has already been available to fasten the consolidation process by geosynthetic. It is *Prevabicated Vertical Drain* made of polymer material. The use of geosynthetic for vertical drain can fasten the consolidation process significantly. The speed process of consolidation depends on the types of soil and model of the vertical drain as well as the distance among holes. Vertical drain can only accelerate the settlement due to consolidation, but it does not minimize it. By applying the drain model, time for the soil settlement can possibly be arranged that makes the soil of reclamation more ready for use.

Keywords: *consolidation, vertical drain, goesynthetic*

1. Introduction

Semarang Coastal has become soft soil that must count the impact to environment. The primary objective of this soft soil area was to make use of the damaged areas, slightly less useful to become new better and productive area. This new area could also be for residence, tourist area, office, business center, etc. In term of city plan, coastal area could be categorized as city expansion. Basic soil which is covered is fine-grain soft soil. Therefore, it will later experience settlement due to relatively massive consolidation happening in a long time. Natural consolidation of the soft soil needs years or even decades that makes it unable for use within short period of time. In term of finance, it is damaging. As a result, engineering is needed to enable faster consolidation.

2. Treatment to Soft Soil Using Vertical Drain

Definition of soft soil

Soft soil is divided into two kinds, they are:

a. Soft Clay
   Soft Clay is soil containing clay minerals and high moisture content
b. Peat Soil
   Peat soil is soil primarily made of plant debris

Problems of soil

Problem of soft soil that frequently happens in the work of civil engineering is massive settlement caused by load on it. This is very dangerous for the building thereon. For instance, settlement to the bridge abutment, this will cause inconvenience and disturb concentration of drivers and this also possibly causes accident. Settlement happens to buildings, in case, there is differential settlement, this will cause damage to the building and will endanger the occupants of the building. Another example may happen to road construction, during process of landfill, supposed that the road will experience settlement, then another landfill is covered for repairmen, next, this pavement is immediately constructed and finally the road is ready for use. Due to the fact that this is soft soil, settlement unavoidably happens what brings damage to the road and brings inconvenience to drivers. Soil settlement happens is due to consolidation. Soil previously consisted of soil grain and water filling the soil pore, however because of receiving load from landfill or building, this pore water will come out and consolidation will happen to the soil and cause soil settlement.

Consolidation and soil settlement

Referring to Das (1998), consolidation is a slow process of downsizing the soft soil with low permeability caused by the excess of pore water. This process will keep progressing till it is overpressure of water pore caused by the increase of total stress that will have already gone. According to Hancock and Skinner (2000), consolidation is a process of pore water excess from the soft soil due to loading. In general, this consolidation will last in one direction, to which it is vertical due to the layers imposed additional load cannot move in horizontal direction as it is held by soil around as shown in the figure 1. In this kind of condition, water will flow, especially to the vertical direction, this is recognized as one dimensional consolidation and the calculation of consolidation is almost always based on the theory of one dimensional consolidation. During the process of consolidation, construction on the soil layers may suffer from settlement.

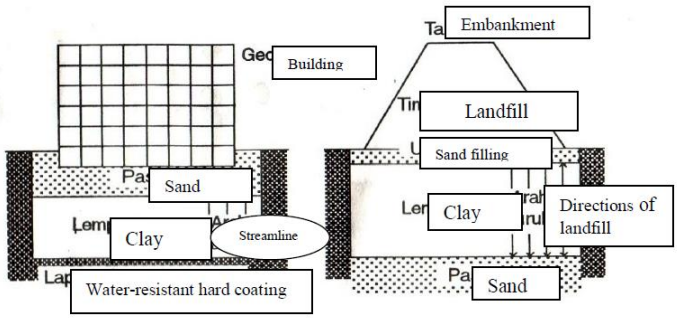

Figure 1: One Dimensional Consolidation (Das, 1998)

Equality commonly for level of settlement/total settlement of soli is:

St = Si + Scp + Scs + Slat

Where:

St = Total Settlement
Si = Immediate Settlement
Scp = Primary Consolidation Settlement
Scs = Secondary Consolidation Settlement
Slat = Settlement due to lateral displacement

Below is settlement mechanism of the soil:

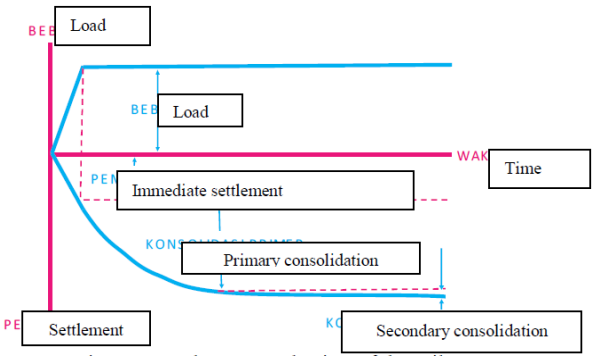

Figure 2: Settlement Mechanism Of The Soil

Based on figure 2, this can be inferred that there is immediate settlement during the construction and landfilling process which is relatively big. The immediate settlement is as a result in elastic deformation of dry, moist and water soft soil without moisture change. Calculation of immediate settlement is based on the settlement derived from theory of elasticity.

After construction process is completed, what causes primary consolidation with relatively massive settlement. This settlement is as a result in the change of water soft soil volume due to water release covering the soil pores as consequence of load addition on it. As the primary consolidation is done, soil settlement is still progressing that is during secondary consolidation, however, settlement on the secondar consolidation is not that big as in the primary consolidation.

In the field of civil engineering, the important soil settlement has to include:

a. How big the settlement is and
b. How long it takes

Within the work of civil engineering, the most important thing is safety after the building has been completely constructed and used by the occupants.

Treatment Method to the Soft Soil

To deal with the issue of soft soil/ improve the soil condition, several ways are possible to do:

a. Installing pile from bamboo under the building foundation to improve the soil condition
b. Accelerating the settlement by using *Prefabricated Vertical Dain* (*PVD*) and *Prefabricated Horizontal Drain* (*PHD*) to prevent settlement exceeds the safety standard that may bring danger after the building is completely constructed.

In this case, treatment to the soft soil will be discussed by using PVD and PHD with the objective of accelerating the settlement.

PVD is kind of design of several geosynthetic models belong to geocomposite functioning to flow water pore vertically from bottom to top using capillary force fom the PVD material. To accelerate more the consolidation process, the use of PVD can be combined by using PHD which is then absorbed by using vacuum, so the water can be released from the soil pores and will make the soil stable.

Model and Function of PVD

a. PVD Model

Elongated flat PVD consists of core and is wrapped with jacket as shown on Figure

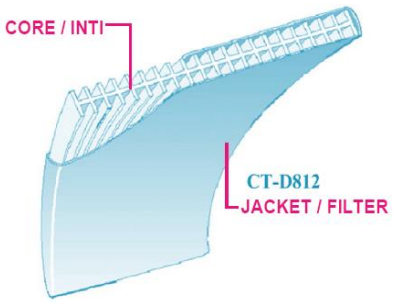

Figure 3: PVD Model

b. Function of PVD

PVD is used to accelerate primary consolidation process. By referring to figure 4 below, try to compare the result in the soil settlement using PVD and without using this.

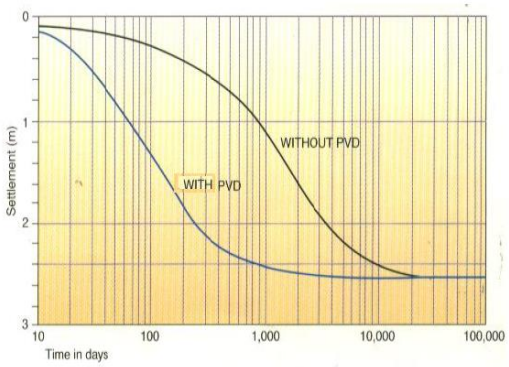

Figure 4: Comparative figure of soil settlement with and wothout usning PVD

After seeing the comparative figure of soil settlement on the figure 4 above, this can be inferred that soil using PVD experiences faster settlement, this is because the water pores inside the soil will be sucked out by PVD and by addition of temporary load before the building is operated. Therefore the settlement is faster compared to the settlement that does not use PVD and just relies on the preloading. Besides, through faster soil settlement by using PVD and preloading, it is expected that when the building will have been operated, settlement will not happen anymore. Supposed that this happens, it is supposed to be little and still within the reasonable limits. What can be inferred, the use of PVD will not minimize the settlement, but it just accelerates it. Size of it depends on kinds of soil and load on it.

The use of PVD

PVD is used for project of soil improvement by using preloading and Vacum Consolidation method.

a. Method of Preloading On the preloading method, pore water in the soil is sucked out through preloading using landfill.
b. Method of Vacuum consolidation in this method, pore water in the soil is sucked out by vacumming and by using waterproof coating.

c. Method of Ceteau Vacuum System In this method, pore water in the soil is sucked out by vacumming without using waterproof coating.

Distance of PVD Installation

Below is the distance figure of PVD installation:

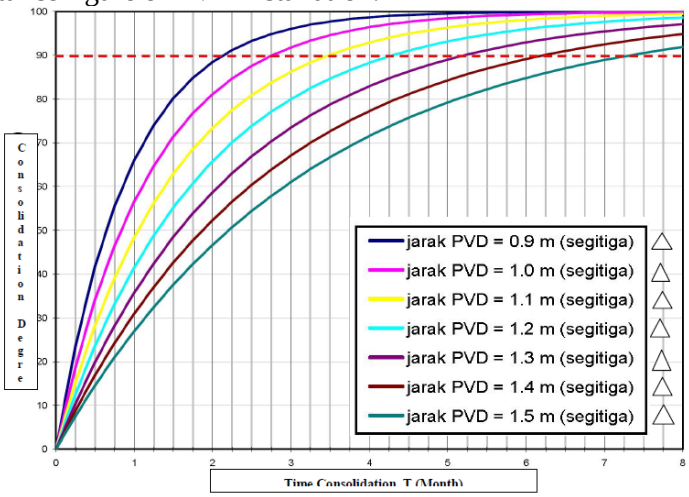

Figure 5: Time of consolidation settlement using PVD pattern; triangle PVD size 4 mm x 100 m

The above figure can be read by, for example, supposed that consolidation degree is 90%, then it depends on how long we want the consolidation process to run, say, we take one month, meaning that we just need to draw a vertical line to the X axis on the figure 1 and draw horizontal line to the Y axis then it is later marked and sorted on the curved line. This will show the distance of PVD we need to install at the time of implementation by referring to the existing information.

At the above example, if the meeting point is on the yellow line, meaning that by referring to the existing information on the figure, PVD should be installed each with distance around 1.10 m.

PVD Installation

There are several designs of installing PVD, they are:

a. Triangle and,
b. Rectangular

For detail, see the following figure 6:

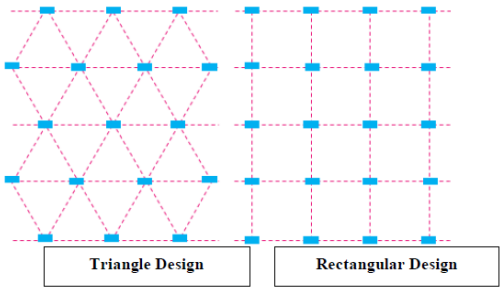

Figure 6: PVD installation design

Working Principle of PVD

In the process of natural consolidation, due to being pressed from the above, water from the soil pores will flow to soil surface in the capillaries. Consolidation process to the soft soil will run slowly that this needs longer time, years or even decades as shown in the Figure 7. Whilst, in the figure 8, this shows the consolidation process using PVD. Water from the right and left will run quickly to PVD, because of the poreus PVD material, then it is vacuumed out what makes consolidation will run quickly.

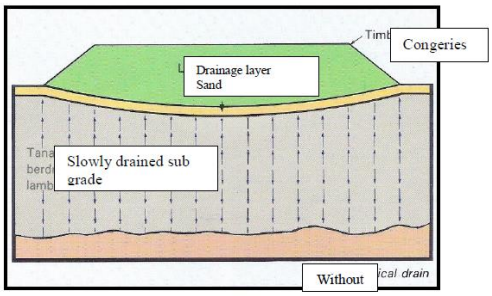

Figure 7: Without PVD

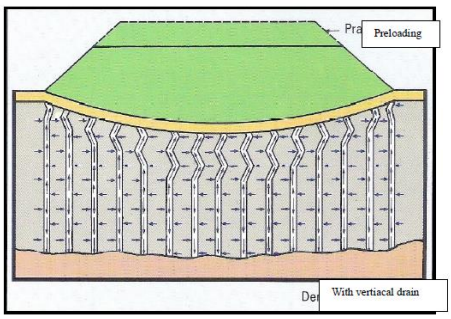

Figure 8: Using PVD

3. Conclusion

a. Soft soil in coastal area will suffer from relatively massive settlement as a result of soil consolidation what makes the building above become instable. This can be the cause of landfill conducted on the soft soil.
b. This consolidation process will naturally take longer time, years or even decades, that is why, acceleration process is needed in order the soil to be utilized soon.
c. To accelerate the consolidation process, vertical drain method using PVD can be applied. As the settlement was completed, the soil becomes stable that this can possibly be utilized for buildings, for example; road, bridge, building, tourist area etc to which economically it is beneficial.

References

Bapeda Kota Semarang, 2008, *Kondisi Fisik Bagian Wilayah III (BWG III) Semarang*, Bapeda Semarang, Semarang.

BPS Kota Semarang, 2008, *Profil Kependudukan Kota Semarang Tahun 2008*, BPS Kota Semarang, Semarang.

Braja M Das, Mekanika Tanah Jilid I, dan II, Terjemahan, Erlangga, jakarta.

Burrough, P. (1986) Principles of GIS. M.N. Demers, Fundamentals of GIS,Eddy Prahasta."Sistem Informasi Geografis, P.A. *Longley Geographical Inforamtion Systems*, volume 1&2.

Dinas Pertambangan Jawa Tengah dan Direktorat Geologi Tata Lingkungan, Bandung, 1995, *Pengamatan Resapan Air Bawah Tanah Daerah Semarang dan Sekitarnya*, DGTL Bandung.

Joseph E Bowles, Johan K Hainim ; 1991, Sifat-Sifat Fisis dan Geoteknik Tanah, terjemahan, Erlangga, jakarta.

Laboratorium Mekanika Tanah, 2010, Sifat Fisis dan Mekanis Tanah, Fakultas Teknik Jurusan Sipil UNISSULA, Semarang.

Poland J.F dan Davis, G. H., 1969, *Land Subsidence due to with drawal of fluids*, A.R. Eng.Geol, USGS, Sacra and Wash, DC Vol 2, P 187-269.

Pratikso, 2015, Pengaruh amblesan tanah (*Land Subsidence*) terhadap perubahan luas genangan air (studi kasus dataran alluvial Kota Semarang Penelitian Hibah Tim Pascasarjana DRPM. (Tahun ke 1)

Pratikso, 2016, Pengaruh amblesan tanah (*Land Subsidence*) terhadap perubahan luas genangan air (studi kasus dataran alluvial Kota Semarang Penelitian Hibah Tim Pascasarjana DRPM. (Tahun ke 2)

Pratikso, 2015. The Effect of Land Consolidation to Changes in The Most Extensive Puddle in Semarang-Indonesia International Journal of Applied Engineering Research (IJAER).

Soedarsono, 2010, Pengaruh Banjir Genangan Terhadap Lingkungan Permukiman di Muara Kali Semarang, Disertasi.