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IMPLEMENTATION OF SOIL IMPROVEMENT WORKS AS PART OF RECLAMATION ENGINEERING IN BELAWAN PORT PROJECT.

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Abstract: Soil improvement as steps to be taken in reclamation works where the condition of soil under seabed is very bad based on soil investigaton . It is engineering requirement to do so in order to be able to get the stable soil surface where people can built port facilities on top of it. Pumping or deformation have to be hindered and for this purpose many method can be used in port project. Port facility is a heavy duty construction due to it works for loaded cargoes and heavy equipment as well. It's bearing capacity have to be strong enough to support it. In case of Belawan port development project there are two (2) difference project side by side for the same purpose namely the extention of the existing Belawan International Container Terminal. The Phase I finance by Islamic Development Bank (IDB) and Phase II finance by joint venture parties consist of PT Pelindo I, as majority share holder 70% , PT Hutama Karya and PT Wijaya Karya 15% respectively. Soil improvement works used in both project . In order to make stabilize soil and reduce time settlement both project installed Prefabricated Vertical Drained known as PVD.The original design required that for soil stabilization the project have to install PVD for -40 M depth below seabed and use the triangular pattern. If the phase II project used PVD for 26,5 M depth below seabed and have already installed but the phase I project which don't start the works yet will install the PVD for - 44 M from final surface . Settlement for -40 M in phase I around 4.654 M and in phase II at around 7.039 M. For the same purpose namely construction of container yard but apply different method . Both project have the same soil characterisic under the seabed. The impact of it probably vertical and lateral deformation under seabed will occur from phase II into phase I . In this case the soil improvement works will not obtained the engineering requirement. The research finding that there is no lateral deformation from phase II into phase I but vertical deformation will happen within 99 days.

Keywords: Soil Improvement, Engineering Requirements, Settlement, Deformation, Prefabricated Vertical Drained (PVD)

Introduction

The Belawan Port Development Project Phase I and II is planned for soil improvement works using PVD (prefabricated vertical drain) with triangular pattern and 1.3 meters distance to -40.0 meters depth from seabed level. Meanwhile, in adjacent locations, Belawan Stage Port Development Project is undergoing land improvement using PVD (prefabricated vertical drain) with triangular pattern and 1.3 meters distance to -26.5 meters depth from sea level .

The different depths of PVD installation will potentially cause technical problems, including the lateral deformation of the Phase II area towards the Phase I area which is assured to be a larger decrease, as shown in Figure 1.

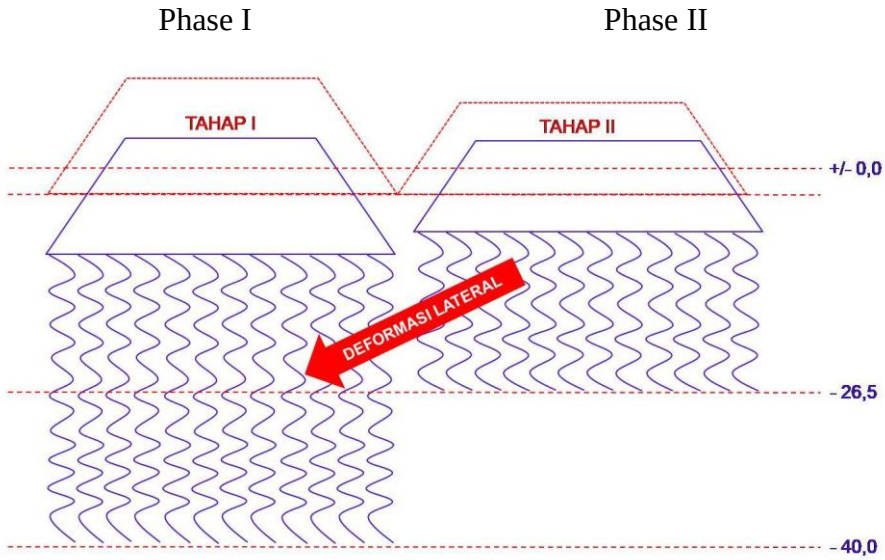

Figure 1: Potential occurrence of lateral deformation

The potential for deformation becomes more likely because of the implementation of reclamation in the Phase I area after reclamation in the Phase II area is completed.

Purpose And Objectives

This paper is made with the intent to provide an idea to eliminate of the potential occurrence of technical problems, especially the potential for lateral deformation of the Phase II area to the Phase I area and provide an alternative solution in order to eliminate the potential for such lateral deformation so that technical problems that may arise can be avoided .

Available Data

At least there are 4 (four) data to provide an idea of the potential for lateral deformation of

a. location of Works

b. Soft soil thickness

c. Depth data of PVD

d. Reclamation Schedule

Location of Works

The reclamation work location of Belawan Port Development Project Phase I is adjacent to Belawan Port Development Project Phase II as shown in Figure 2.

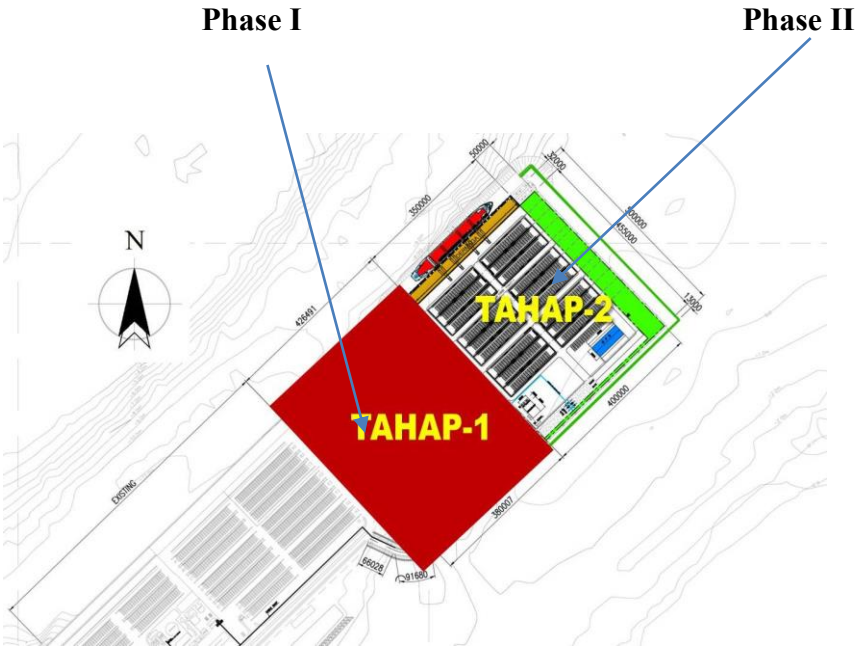

Figure 2: Phase I and Phase II reclamation area

Red is Phase I , Black and Green Phase II

Characteristic of Soil

Soil layer conditions of Belawan Stage I Port Development Project and Belawan Stage II Development Project are relatively the same thickness up to 41 - meter (Stage I) and - 42 meter (Phase II) elevation from sea level as shown in Figure 3 .

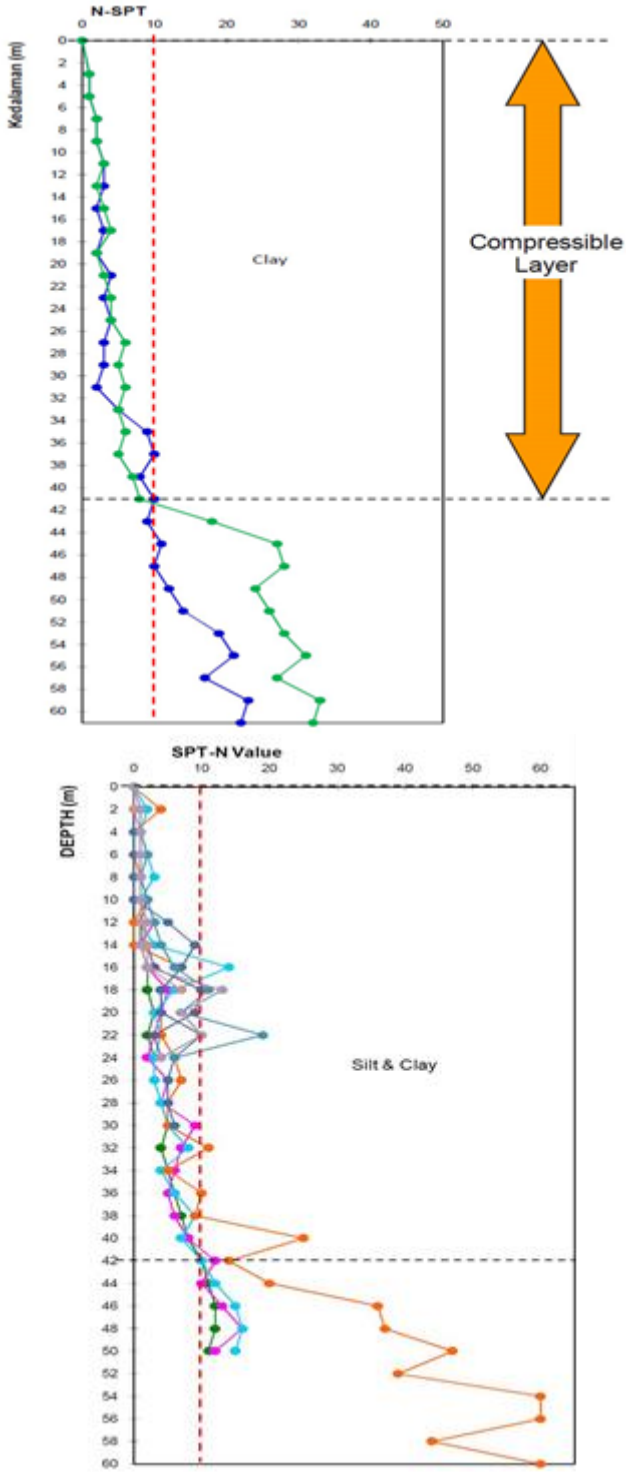

Figure 3 : Soft soil layer thickness

Literature Review

According to Terzaghi (1943) a decrease of water content of a saturated soil without replacement of the water by air is called a process of consolidation.

Depth of PVD Installation

The depth of PVD installation at Belawan Port Development Project Phase I is up to - 40 meters as shown in Figure 4 and at Belawan Port Development Project Phase II is up to 26.5 meters depth as shown in Figure 5.

Thus the question arises if the depth of PVD installation plan between the two Projects is different.

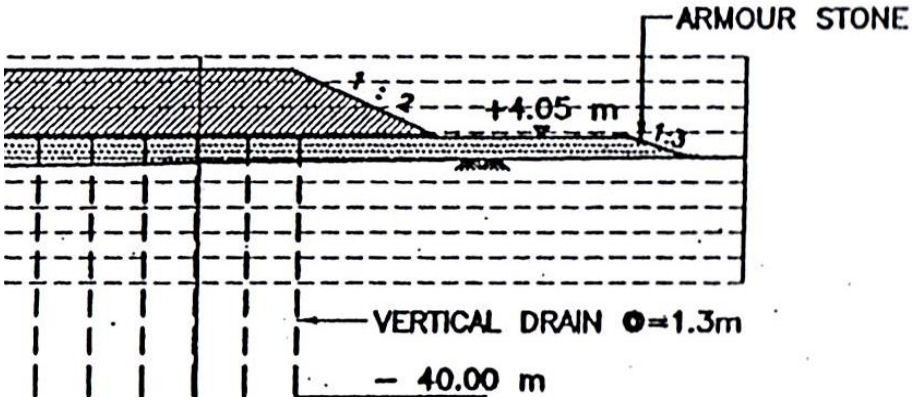

Figure 4: Depth of PVD mounting in Phase I area

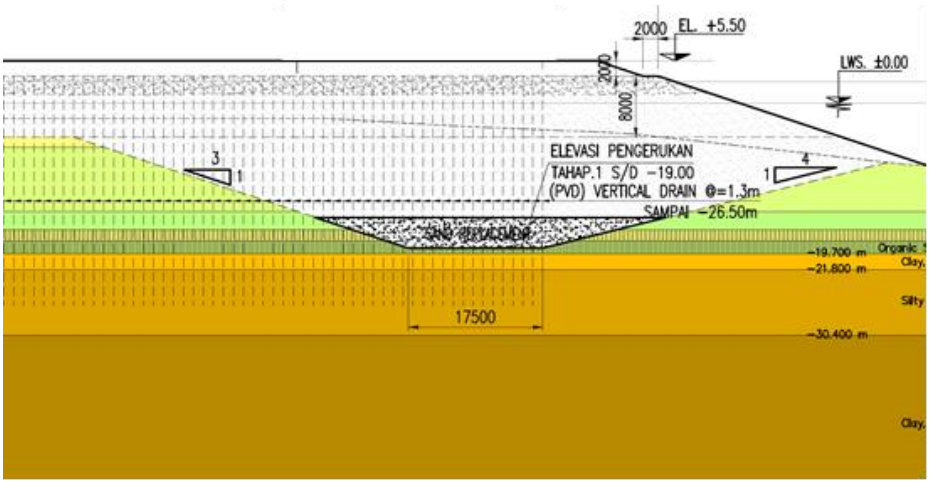

Figure 5 : Depth of PVD installation in Phase II

Implementation Stage

Up to the present time the reclamation work on the Belawan Port Development Project Phase I has not yet started its implementation. Meanwhile, reclamation work on Belawan Port Development Project Phase II has been implemented. Even the installation work of PVD has also been implemented as shown in Figure 6.

Figure 6: PVD Installation in Phase II

Result and Discussion

At least there are 4 (four) data to provide an idea of the potential for lateral deformation of the area from phase II to Phase I area, namely:

a. Location of project

b. The thickness of soft soil layer is relatively the same

c. Different depth of PVD

d. Time of work execution

Alternative solutions to avoid potential lateral deformation of the Phase II area towards the Phase I area, namely a). PVD is installed with the same depth following the depth of PVD mounting that was first implemented b). The timing of the consolidation process is planned relatively simultaneously with the consolidation process which has already taken place.

If it is assumed that the PVD work plan on the Belawan Port Development Project is:

Installation pattern = triangle

Installation distance = 1.3 meters

Depth of installation = 44 meters

Job volume = 3.884.643 meters

Number of installation points = 88287 points

Installation area = 129,249 square meters

If the PVD work on the Belawan Stage Port Development Project is changed with a rectangular pattern and installation distance of 1.0 meters then:

Installation pattern = rectangle

Installation distance = 1.0 meter

Installation area = 129,249 square meters

Number of installation points = 129,249 dots

Job volume = 3.884.643 meters

Depth of installation = 30 meters

Figure 7 shows the graph of the relationship between PVD installation spacing, degree of consolidation and timing of consolidation achievement at Belawan Stage Port Development Project Phase I for pattern of rectangular installation. Figure 8 shows the graph of the relationship between the installation distance of PVD, the degree of consolidation and the time of consolidation achievement in the Belawan Stage Port Development Project for the pattern of the triangle mounting.

From both graphs it can be seen that the installation of PVD at the Belawan Port Development Project Phase I is:

a.Pattern = triangle; distance = 1.3 meters; 90% consolidation time = 7.75 months

b.Pattern = rectangle; distance = 1.0 meter; 90% consolidation time = 5.00 months

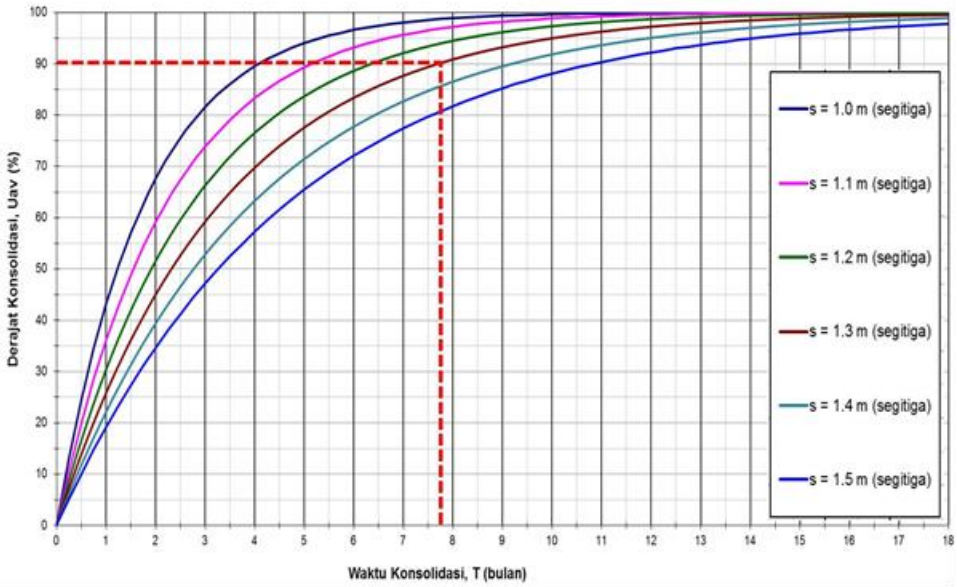

Figure 7 : Graph Correlation between Consolidation and PVD instalation distance Triangular model

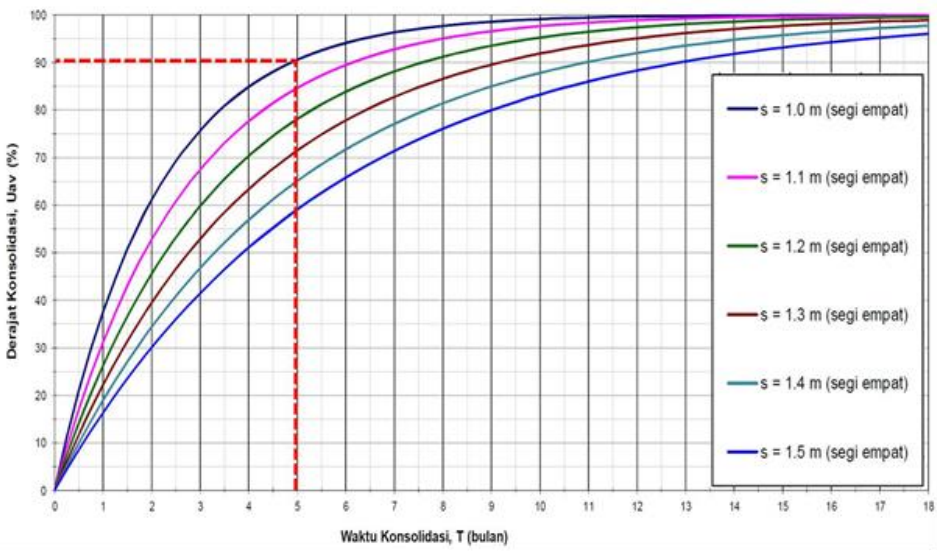

Figure 8: Graph Correlation between Consolidation and PVD instalation distance Rectangular model

PLAXIS MODELLING

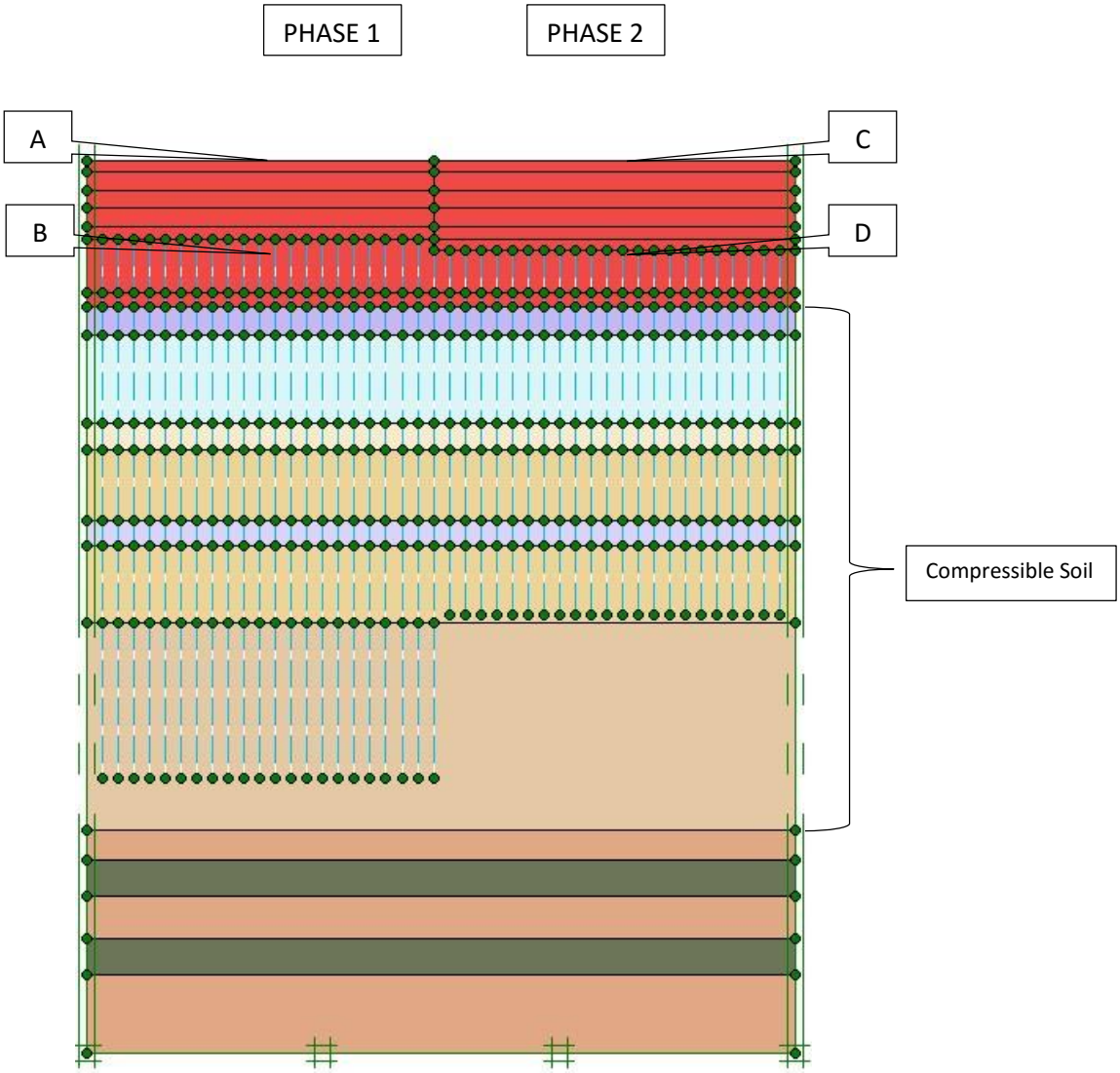

Figure 9 : Plaxis Modelling for Compressible Soil.

Table 1
Total Displacement
IMPLEMENTATION STAGE

No	CONSTRUCTION STAGES	Days	Total Days	Total Displacement (m)	Excess PP KN/m2
1	Reclamation Phase 2 up to elv 0.0 m	4	4	0.047	-12.96
2	Reclamation Phase 2 up to elv. +3.5 m and Reclamation Phase 1 up to elv. 0.0 m	12	16	0.538	-56.8
3	Install PVD Phase 2	15	31	0.521	-57.45
4	Preloading phase 2 up to elv. +4.4 m	5	36	0.643	-68.17

Table 1, Cont. Total Displacement
IMPLEMENTATION STAGE

No	CONSTRUCTION STAGES	Days	Total Days	Total Displacement (m)	Excess PP KN/m2
5	Waiting time for phase 2	10	46	3.97	-28.06
6	Preloading phase 2up to elv. + 5.5 m	5	51	4.1	-36.12
7	Preloading phase 2 up to elv. + 7.0 m	5	56	4.29	-48.29
8	Waiting time for Phase 2	10	66	5.5	-28.96
9	Reclamation phase 1 up to elv. +4.4 m and preloading phase 2 up to elv. +8.5 m	14	80	5.48	-66.54
10	Install PVD Phase 1	15	95	5.48	-66.54
11	Preloading phase 1 up to elv. + 5.5 m	4	99	5.44	-75.65
12	Preloading phase 1 up to elv. + 7.0 m and preloading phase 2 up to elv.	5	104	5.52	-95.51
13	Waiting time for Phase 1	10	114	6.69	-56.51
14	Preloading phase 1 up to elv. +8.5 m and preloading phase 2 up to elv.	5	119	6.72	-71.48
15	Preloading phase 1 up to elv. +10.0 m	5	124	6.68	-80.35
16	Preloading phase 1 up to elv. +10.9 m	3	127	6.66	-85.79
17	Waiting time for consolidation	99	226	7.08	-0.872

Graph 1.
Settlement vs Time Curve

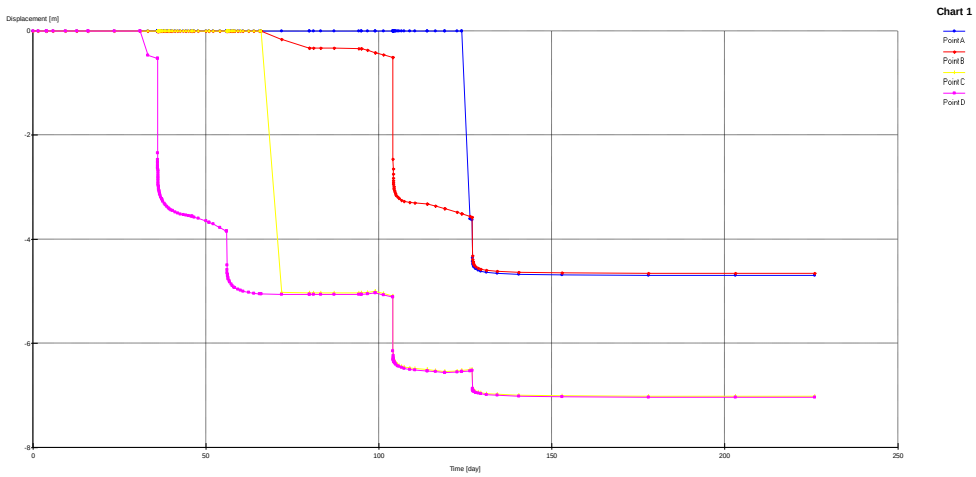

Table 2
Settlement For location A,B,C,D

SETTLEMENT A, B, C, D

No	CONSTRUCTION STAGES	Days	Total Days	Phase 1		Phase 1	
				Settlement A (m)	Settlement B (m)	Settlement C (m)	Settlement D (m)
1	Reclamation Phase 2 up to elv 0.0 m	4	4	0	0	0	0
2	Reclamation Phase 2 up to elv. +3.5 m and reclamation Phase 1 up to elv. 0.0 m	12	16	0	0	0	0
3	Install PVD Phase 2	15	31	0	0	0	0
4	Preloading phase 2 up to elv. +4.4 m	5	36	0	0	0	-0.53
5	Waiting time for phase 2	10	46	0	0	0	-3.564
6	Preloading phase 2 up to elv. + 5.5 m	5	51	0	0	0	-3.676
7	Preloading phase 2 up to elv. + 7.0 m	5	56	0	0	0	-3.85
8	Waiting time Phase 2	10	66	0	0	0	-5.051
9	Reclamation phase 1 up to elv. +4.4 m and preloading phase 2 up to elv. +8.5 m	14	80	0	-0.336	-5.031	-5.063
10	Install PVD Phase 1	15	95	0	-0.336	-5.031	-5.062
11	Preloading phase 1 up to elv. + 5.5 m	4	99	0	-0.422	-5.004	-5.036
12	Preloading phase 1 up to elv. + 7.0 m and preloading phase 2 up to elv. +10.0 m	5	104	0	-0.505	-5.089	-5.115
13	Waiting Time for Phase 1	10	114	0	-3.32	-6.504	-6.529
14	Preloading phase 1 up to elv. +8.5 m dan preloading phase 2 up to elv. +10.9 m	5	119	0	-3.408	-6.546	-6.568
15	Preloading phase 1 up to elv. +10.0 m	5	124	0	-3.513	-6.521	-6.542
16	Preloading phase 1 up to elv. +10.9 m	3	127	0	-3.579	-6.504	-6.524
17	Waiting Time for Consolidation	99	226	-4.692	-4.654	-7.017	-7.039

Conslusion

Base on proposal during implementation stage to change the design to avoid the potential for lateral deformation of the Phase II area towards the Phase I area, the Belawan Stage I Port Development Project proposed the installation of PVD as follows:

a. Installation pattern = rectangle

b. Installation distance = 1.0 meter

c. Depth of installation = 30 meters (from elevation + 4.0 meters)

With the proposed installation then:

a. The depth of PVD installation is relatively same with the Phase II area.

b. The consolidation achievement time is 90% faster, with the hope of not being closely

linked to the consolidation time in the area of Phase II that has already taken place first.

c. The volume of PVD work is relatively fixed.

d. Phase II works have to add PVD closer in order to be able to make consolidation faster.

The other way around that the result of statical calculation that settlement in phase I that install PVD until elevation -40 M is 4.68 M and settlement in phase II that install PVD untill elevation -26,5 M will 6.215 M Thus this paper finding that may be useful for smooth the implementation of soft soil improvement work at the Belawan Port Development Project Phase I refer to the enough safety factor based on original design . And Phase II have to be careful with the risk possible occur if implementation different with the original design.

Settlement for PVD elv -40 m on phase 1 amounted 4.692 m

Settlement for PVD elv -26.5 m on phase 2 amounted 7.039 m

Time for Consolidation phase 1 and phase 2 namely 99 days, although the phase 2 had already started earlier than phase 1

There is no lateral deformation but vertical deformation will occur in the container yard.

Different for settlement (7.039-4.692) = 2.347 m too high for vertical settlement and will give bad impact for Container Yard facility.

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