CONSTRUCTION OF UNDERGROUND SCALE PIT AT ESSAR STEEL – HAZIRA :- DEWATERING AND CONSEQUENCES

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ABSTRACT: Essar Steel Hazira Ltd has proposed new integrated steel plant near Hazira under SEZ developments. During the construction of 25m deep underground scale pit, there are various geotechnical problems occurred due to dewatering operations. Dewatering followed by soil movements cause settlements of nearby structures including piled raft, chimney etc. This paper describes the entire study from origination to the solution of the settlement problems. Due to these consequences commissioning of entire area had been stopped as settlements have been observed on almost all the adjacent structures. Settlement was continuously monitored on important piled raft and some adjacent structures during entire operation. Paper also describes the methodology adopted for arresting the settlements and some design changes has been made for bottom plug for scale pit.

1 INTRODUCTION

As a part of huge investment of Essar group and diversified product development, Essar Steel Limited has started construction of its Essar Plate Mill Project in 2007. Scale pit is important part of EPML as it collects the scales generated during manufacturing of Steel Plates.. The structure is located very close to Plate Mill where water table is very close to ground level and strata are essentially cohesionless with very high permeability. Figure 1 describes the Scale Pit along with location of dewatering wells.

1.1 Problem Statement

After construction of required well and lowered upto specified depth, ECIL has planned to carry underwater concreting to plug its bottom. ECIL had pumped 500 m^3 concrete in the well using tremie and tried for plugging the scale pit without dewatering. After putting underwater concrete, the water level in side the scale pit was lowered using direct pumping from the pit assuming that bottom has been plugged. Direct removal of water within the Scale Pit created gradient between the outside ground water level and water level within the Scale Pit. This resulted in large water pressure at the base followed by seepage at various locations inside the scale pit. Along with seepage, large quantity of silt and fine sand seems to have entered inside the scale pit. Due to Excessive seepage into the pit from bottom following consequences were noticed: 1) Settlement of structures in the vicinity. 2) Sand-silts are entering into the pit bottom under excessive water pressure. Due to settlements in the surrounding structures the commissioning of the other structure was temporarily stopped and there was urgent need to arrest the settlement for safeguard of other structure. The construction of the scale pit was delayed as without plugging the bottom other operations cannot be started. All these consequences severely affect the progress of entire Plate Mill Project.

2 SCALE PIT CONSTRUCTIONS

The size of scale pit planned was 46.05m X 19.6m with bottom of base raft located at -24 m from ground level. The construction of pit was done initially by sinking and grabbing method just like construction of well foundation

2.1 Sub Soil Strata

The site area is fairly levelled having average elevation of + 5m above mean sea level. The strata comprises essentially of silty fine to medium sand with an average permeability of 10^{-4} m/sec up to explored depth of -25m. No bed rock or impervious layers has been encountered. The ground water table is about 1 to 1.5m below ground level. Soil profile comprises of the following layers:

Layer 1) From +5.0m to 0.5m is clayey silt / silty clay having SPT(N- Value) in the range of 15 to 25.

Layer 2) From +0.5 to -13.0m is blackish dense medium to fine sand. The SPT(N- Value) in this layer varies from 25 to 60.

Layer 3) From -13.0 to -17.5m is Reddish non plastic silty medium to course sand with gravels with some clay binders having SPT in the range of 35 to 50.

Layer 4) From -17.5 to -25 m is Yellow dense gravely sand with clay binders and kankars. The SPT value in this layer varies from 50 to 100.

It has been observed that the permeability of the sandy layers are too high and close proximity to the sea shore has added extra problems during deciding dewatering scheme.

2.3 Dewatering Scheme

As the direct dewatering from the pit itself has induced considerable settlements to adjacent structures, it is required to dewater in very controlled manner. For the purpose of lowering the ground water table in scale pit area, 30 to 35m deep wells were provided at locations shown in Figure 1. The peak discharge of all the pump together is about 150 m^3/hour.

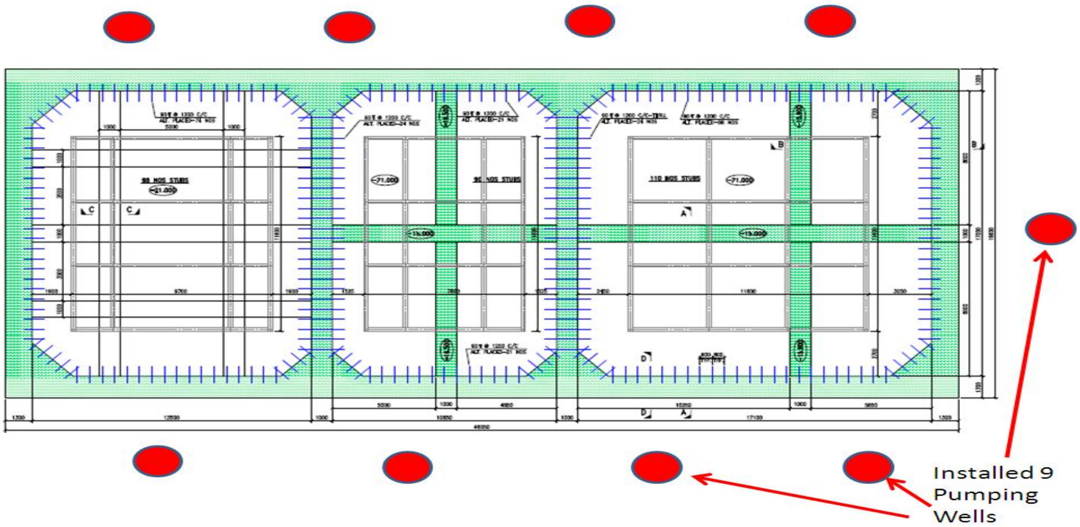

Figure 1 Scale pit for Hazira Plate Mill

Based on the sub-soil investigation carried out, the permeability of the silty sand strata is estimated as 10^{-4} m/sec. As per known theories of dewatering, the total discharge required for lowering the ground water table below – 20 m is estimated using following well known formulae:

$$q = \frac{\pi k(H^2 - h^2)}{\ln(\frac{R}{A})} \quad (2.1)$$

$$A = \sqrt{\frac{F}{\pi}} \quad (2.2)$$

Where,
q= Total rate of discharge required in m^3/hour
k= Permeability constant in m/sec ($1x\ 10^{-4}$)
H=Hydrostatic Head of Ground water level above the impervious layer (30m)
h= Hydrostatic head in the bore well after dewatering (22m)
R= radius of influence for the given drawdown.
A= Equivalent radius of the excavation (16.95)
F= Area of Excavation in m^2 (902. 58)

Substituting values the total discharge required for a drawdown upto – 20m and calculating further, it was decided to install 9 bore wells of 20BHP around the Scale Pit area (4 well on each 46.05 m face and one on right hand side of 19.6m face refer Figure 1). Even after that the water level out side the scale pit could not be lowered -18m below Ground level. During the construction of the bottom raft the vacuumed dewatering pump has been employed along with the three other pumps in order to compensate two failed deep wells.

As mentioned above out of total 9 installed deep wells, 1 has been blocked due to the seepage of fines and misalignment and another was working but not running at full capacity due to blockage. Even though the pumping capacity for lowering the water table is found to be adequate initially the disposal of these huge quantities of water was also a big problem. As the Plate Mill site is located in the central portion of the project site, there has been water logging observed in the initial phase of dewatering. Later a special pipeline along with water drain was assigned to safely dispose these huge amounts of water from the site to sea.

Continuous monitoring of the quality of water from the wells revealed that there was not much soil particles coming out with water and water from the wells are generally clean.

Figure 2 Scale pit view with fine sand at bottom.

When water table is lowered and scale pit bottom becomes visible, it was found that huge qty of fine sand has entered inside left hand side pit compartment (Figure 2). This may be attributed to the earlier attempt of dewatering from inside scale pit after underwater concreting. Strong sand boiling was observed at that location along with some other areas in the scale pit when pumping system suddenly stopped due to sudden power failure. The settlement may be the consequence due to theses large soil movement and huge dewatering under tremendous pore pressure generated by differential hydraulic head.

Dewatering from inside the well using extra two pumps and through installed wells were continued till the completion of construction of base raft along with the bottom beams. Pumping was stopped stage wise as it was need to construct the Flume Tunnel on the left hand side of the Scale Pit. As the Flume tunnel has to connect the scale pit at -14m from the ground level, the retaining of the soil around flume tunnel cases big problem. The soil movement around Flume tunnel due to deep excavation may affect the pumping wells, Sheet pile walls are installed to retain the sides of the excavation near left hand side of scale pit (Figure 3).

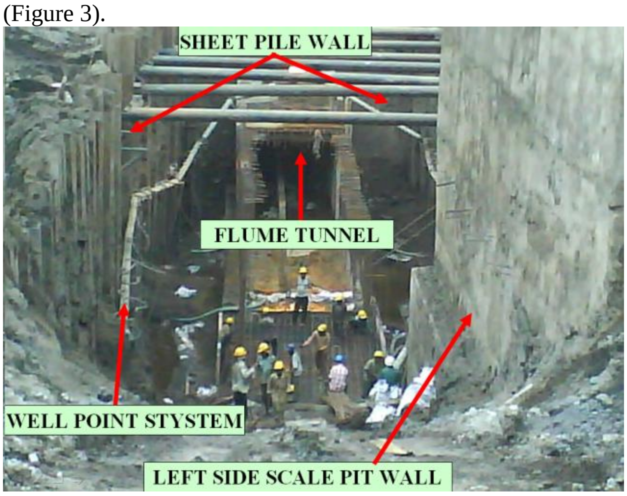

Figure 3. Flume Tunnel with Sheet pile support.

3. SETTLEMENT OF ADJACENT STRUCTURES

After the sufficient time from the trial of underwater concreting, one trial has been carried out to empty the well for placing the bottom raft (on 26th Sept 2008). As the well was not properly sealed by underwater concreting the sand boiling and leakage has observed at the bottom of the well under the hydraulic gradient created by the dewatering.

Table 1. Settlement observations for Mill area

Time/Month	1-RCOG In mm	2-MSOG In mm	3-RCIC In mm	4-MSIC In mm
25-Sep-08	-0.43	-0.65	-0.39	-0.79
26-Sep-08	-3.11	-3.42	-2.88	-3.24
1-Oct-08	-3.41	-3.55	-3.28	-3.64
8-Oct-08	-3.26	-3.50	-3.13	-3.64
15-Oct-08	-3.41	-3.62	-3.31	-3.59
22-Oct-08	-3.56	-3.75	-3.68	-3.99
3-Nov-08	-3.91	-4.25	-3.93	-4.24
10-Nov-08	-3.96	-4.25	-3.98	-4.34
17-Nov-08	-4.16	-4.30	-4.23	-4.44
24-Nov-08	-4.01	-4.25	-4.13	-4.34
1-Dec-08	-4.31	-4.55	-4.43	-4.64
08-Dec-08	-3.81	-4.15	-3.98	-4.24

Note: RC-Roll Change Track Side, OG- Out Going, MS- Mill Motor Side, IC- In Coming

This has initialized the soil movement and some settlement was observed in the nearby structures. Due to non uniform settlement of nearby structures, the dewatering and commissioning of the equipments was stopped immediately. Settlement of the structures were monitored inside plate and surrounding mill area by installing 10 points on the entire piled raft by survey instruments to counter any alarming situations. Table 1 represents the settlements of the corner points on the piled raft observed time to time. The dewatering was later carried out with dewatering system explained in section 2, during Nov-Dec 08 and stable system was successfully achieved even during the dewatering.

4. MODIFICATION OF BASE RAFT

Due to abrupt grabbing and sinking of well at the end of well-sinking operation, entire well has sunk 1m more than the specified level. Therefore it was required to fix new reinforcing bars at specified level to correctly anchor the base raft with scale pit side walls. It was decided to grout 90mm dia rods at 1.2m c/c by drilling in the sidewalls of the scale pit (Figure 4).

Figure 4. Drilling for Extra reinforcement along with anchor rods

The raft bottom slab was redesigned and constructed as per new situations. 3m thick raft was constructed in the Scale Pit in three stage as per the Figure 1. The total 1800 m^3 of M-30 concrete was carried out without interruption with installed batching plant. It was very difficult to place reinforcement and bind at -22m hence the reinforcement template was built on ground and lowered using cranes (Figure 5).

Figure 5. Reinforcements lowered for compartment 1

5. Completion of the Scale pit

Dewatering through all the wells were continued till the completion of the construction of the bottom raft along with some other beams to take the uplift pressure. Later backfilling of the wells were carried out using gravels and sand. As the water table is located at -2m from ground level the grouting was also suggested for the concrete joints.

Figure 6 shows the at the condition of the bottom ground after dewatering operations. Even with 9 pumps and some extra pumping from inside, the ground water table cannot lowered more than -20m from the GL. After completion of raft, beams are cast on as per the revised design drawings (Figure 7).

Figure 6. view after dewatering operation.

Figure 7. Finished bottom raft with beams.

4. CONCLUSIONS

Ideally, the structure should have been built only after completion of the Scale Pit. However, due to the tight construction schedule, it was decided to take up the plate mill construction. Though it was not earlier thought regarding the seriousness of the project, the challenges faced had taught some valuable lesions to EC(I)L. Unless adequate precautions are taken, uncontrolled seepage into the excavation can create lot of problems in excavation, construction and can also create large subsidence in the surrounding area. The settlement of Piled raft was observed even though it was rested on 270 nos of pile due to uncontrolled seepage. The pumping test to decide radius of influence, suggested that it was less than 18 to 20m and still settlement was observed in the mill area which is 60 m away from pit. Some uplift was also observed during the settlement monitoring as and when dewatering stopped or interrupted. The stoppage of commissioning for the plate mill caused delay in the project execution but EC(I)L is now ready for these type of job as there are another four Scale Pits are to be constructed in the Hazira area. It was not easy to design the base raft for the huge water pressure and for tremendous shear, as well was sunk 1m extra dislocating the rebar's placed for bottom raft. With help of grouting and anchor bars it was constructed and grouted successfully. Presently the plate mill commissioning is almost over and Essar group is planning to start the manufacturing from the plant in near future.

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