SOME OBSERVATIONS AND EXPERIENCE WITH PILE INTEGRITY TESTING AT VARIOUS PROJECTS FOR ESSAR.

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ABSTRACT: Essar Steel Hazira Ltd has proposed new integrated steel plant near Hazira- Gujarat under SEZ developments and new pellet plant at Paradeep, Orrisa. A construction of other new structure like Jetty at Hazira is also under progress. Almost all the structures founded on driven cast-in-situ pile foundation at Hazira and bored cast in situ pile at Paradeep, Orrisa. Quality monitoring of these thousands of pile at various locations has been carried out by pile integrity testing equipment along with static pile load tests. This paper describes some deficiency found due to construction operations which was remarkably highlighted by the pile integrity testing. As pile integrity testing has been carried out using two different instruments, this paper also describes the experience with both of the instruments.

Keywords: pile integrity testing, pile foundation**.**

1 INTRODUCTION

Essar Group has established its 4.6 MTPA integrated steel plant at Hazira near Surat, Gujarat. As a part of its expansion plan Essar has proposed various facilities near the existing steel plan including extension of new Jetty and SEZ developments. Essar Group has also planed to establish its new pellet plant near Paradeep. Due to poor subsoil condition, almost every structure are founded on the pile foundations for both the sites.

1.1 Pile foundations for Hazira facilities

The generalized subsoil profile at Hazira site is presented in the Table 1. Total pile foundations proposed for these new facilities of steel plant are of around 40000.

Table 1: Soil Profile for Hazira site

Layer no	Thickness (m)	Description
1	0 – 3	Filling of Silty Fine Sand
2	3 – 7.5	Soft Plastic clay with silt
3	7.5 – 16.5	Dense Medium to Fine silty Sand
4	16.5 – 18.5	Stiff Clay with Sand & Gravels
5	18.5 – 35	Very Dense Med. Sand with Gravels

For various structures it was decided to install 0.45m to 0.5m diameter driven cast in situ concrete pile of 16 to 18 m length from ground level. As the job was huge, Essar Construction (India) Ltd has employed 7 MAIT machine for driving of piles up to the desired depth. Essar Group is also expanding its Bulk Terminal facilities by extending old Jetty with newer one. For this 1m and 1.2 m diameter bored piles of 35m length are installed with casing for the top 15m length.

1.2 Pile Foundation for Paradeep Pallet Plant

Generalized subsoil profile at Paradeep site is presented in Table 2. Total pile foundations proposed for this pellet plant are around 11000.

Table 2: Soil profile for Paradeep Site

Layer no	Thickness (m)	Description
1	0 - 3	Fine Silty Sand (upper filling)
2	3 – 7.5	Soft Plastic clay with silt
3	7.5 – 16.5	Dense Medium to Fine silty Sand
4	16.5 – 24	Clay with Sand and Gravels
5	24 – 25	Very Dense Med. Sand with Gravels

For various structures it was decided to install 0.5m to 0.6m Bored cast in situ concrete piles of 23m to 25m length using drilling mud technique.

2 QA/QC FOR INSTALLED PILE

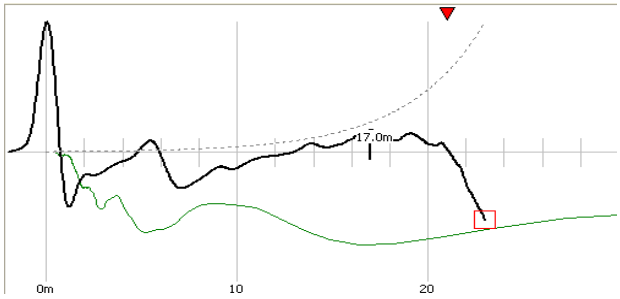
QA/QC for pile foundation is carried out by performing Pile Load Tests along with Pile Integrity Testing. For Pile Integrity Testing, Essar Construction had purchased PET (Pile Echo Tester) from Piletest.com Ltd., UK for Hazira site and PIT-W (Pile Integrity Tester) from Pile Dynamics Inc., for Paradeep site. The Integrity testing has been carried out on larger number of piles in order to maintain highest standard of quality along with faster construction progress. The instruments used are shown in Fig 1 and 2.

Fig. 1 PET Instrument for Hazira Site

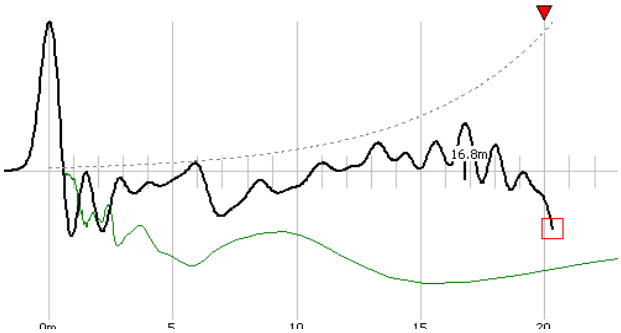
Fig. 2 PIT Instrument for Paradeep Site

3 OBSERVATIONS AT HAZIRA SITE

The observations of pile integrity testing were recorded regularly. It has been found that in some of areas of the site, the collected reflectograms shows defects at various locations. Few representative recordings are presented in Figure 3a and 3b.



(a)



(b)

Fig. 3 PET records for Pile at Hazira.

It was observed that in the particular area especially near water tank, the number of piles have the reflectogram like Figure 3. It was also seen from the record that piles show tendency to have necking at a depth varying from 3 to 7 m below ground level. It was than decided to test almost all piles in that area for its integrity. In some area piles have been exposed by excavation to check pile shape physically (Figure 4). It was observed that PET record has correctly expressed the pile shapes. Various piles have been found in bad shapes showing necking and other defects, which later build up as the defects are at relatively shallow depth.

Load tests have been recommended on some piles in doubt and extra piles have been installed in order to cater the structural requirements.

Fig. 4 Excavated area for checking pile profile

4 INTROSPECTION FOR DEFECTS OBSERVED

In order to investigate the cause of problem, the pile driving process was modelled using well known finite element software using 15 node axi-symmetric mesh. The behaviour of sand was modelled by means of the undrained hardening soil model and for clay Mohr-Coulomb undrained behaviour was assumed. The pile was modelled by means of the linear elastic model considering non-porous behaviour. Standard absorbent boundaries were used at the bottom and at the side boundary to avoid spurious reflection of the waves generated during driving.

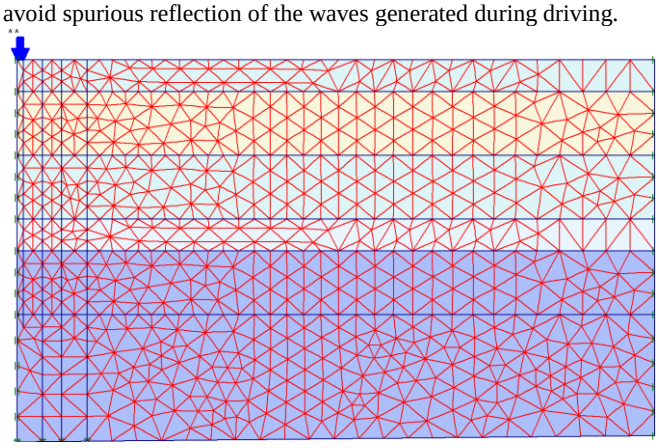


Fig. 5 Geometry of the Pile driving problem modelled

From the study it was found that the generation of the excess pore water pressure cause problems for the freshly placed piles in the vicinity (Figure 5). As the driven piles installed are of displacement piles, the radial pressures exerted due to soil displacement along with the excess pore pressure generated as the water table is at 2m from GL. This has caused serious defects on the freshly placed concrete piles. The excess pore pressure was estimated from the finite element model and found in the range of 137 KN/m^2 (Figure 6). This range of pore pressure has resulted in serious defects of necking at various locations in the freshly installed concrete piles (i.e. 2 to 6m from GL).

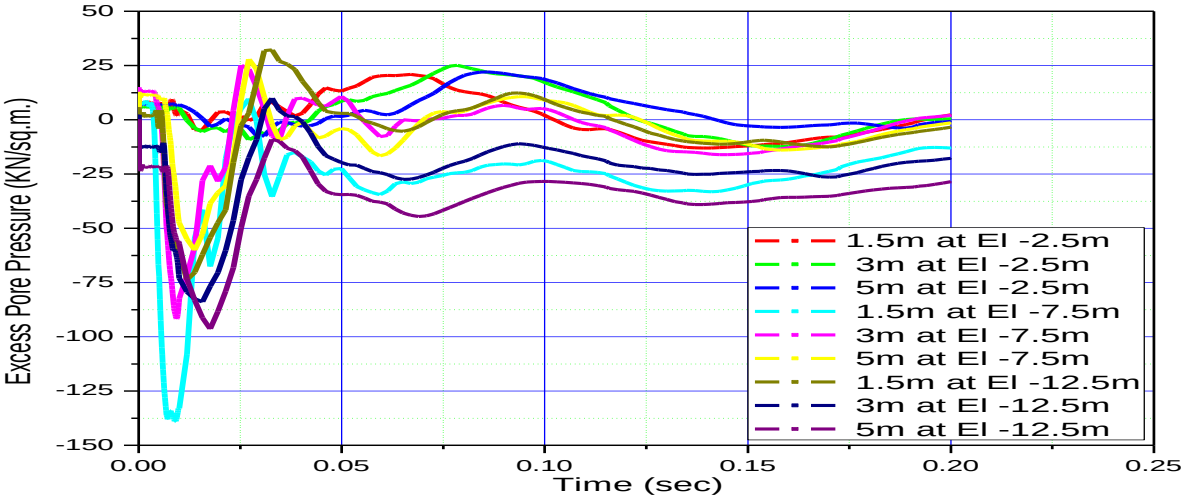


Fig. 6 Excess pore pressure generated due to Pile driving

To overcome the problem, pile driving schedule had been modified and spacing between two consecutive pile installations was increased with slower installation rate. Thereafter the pile shows no construction defect and the same were verified by Pile Integrity Test. Problems have been solved successfully by changing the construction sequence of piles.

5 OBSERVATIONS FOR JETTY PILES

In Jetty area, piles are of 1 to 1.2m diameter with length around 35m. Pile Integrity record had shown some defect in the jetty pile (Figure 7). It was decided to take another opinion for same to countermeasure the problem. The output from the other consultant was also showing same sign of necking at 21mdepth (Figure 8). From both the record it was concluded that there is a necking at 21m from the ground level. As there is a major defect in the pile, Essar Construction had decided to reject the pile and install new pile in the vicinity. Once again Pile Integrity testing has been proved much useful for QA/QC of pile constructions.

6 OBSERVATIONS AT PARADEEP SITE

Initially Essar Construction did not have any instrument at Paradeep and hence, QA/QC have been monitored by Pile load test (Vertical and Lateral). Neckings were reported in many piles and surprisingly consultant gave remark that "can be ignored in case of Group of piles". Reports have been collected from Paradeep and defective piles are marked on the pile layout plan. More than two to three piles are observed defective in the group of four to six piles as per the consultant reports. Ignoring three defective piles in the group of four piles can result serious problem for the stability of structures. It was noticed that interpretation from the record was not upto the mark (Figure 9a and 9b). The recorded reflectograms needs to be corrected for local noise and correct interpretation of the readings requires great skills. Immediate after this, pile load test frequency had been increased and decided to test "*piles in doubt*" for its load capacity. Almost all the load tests were found satisfactory as per the codal provisions.

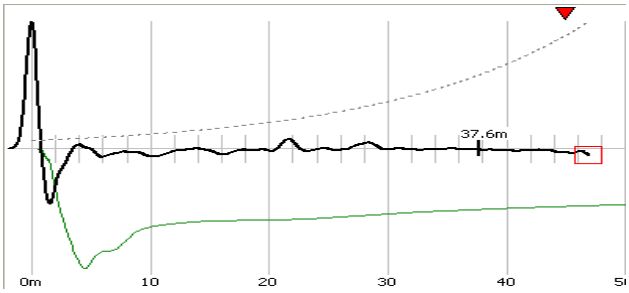


Fig. 7 PET record for Jetty pile at Hazira

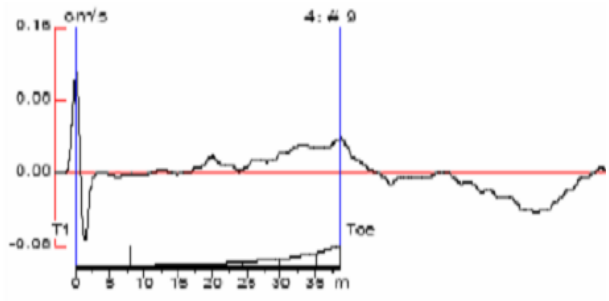


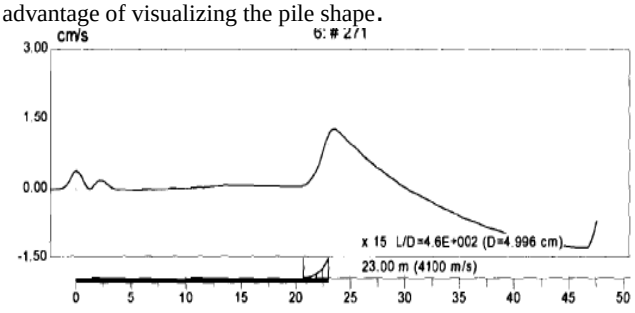
Fig. 8 PIT Record from the consultant for Jetty pile at Hazira

Unnecessary magnification of the record may give misleading information and judgement requires great experience for correct interpretations. Later Essar Construction has purchased PIT-W for pile integrity testing at Paradeep. Testing had been carried out on the various locations and most of the piles found in good shape. PIT-W instrument with profile plotter have added great confidence in use of pile integrity testing at site (Figure 10). The profile can be approximated using inbuilt software and one can use some advanced features for the correct interpretation of the record.

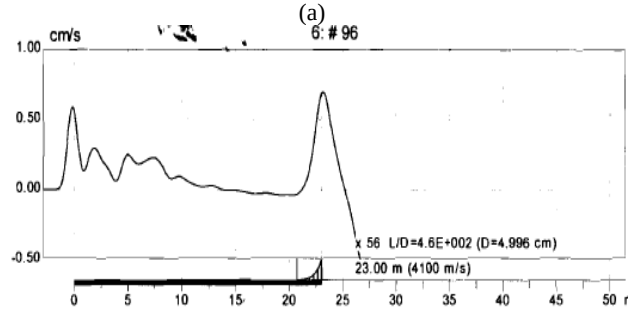
7 EXPERIENCES WITH INSTRUMENTS

Simply to verify the output from both the instruments, testing was carried out on the same piles using both the instruments at

Paradeep (Figure 11 & 12a, 12b). It is found that the reflectogram are more or less same for both the instrument. As PIT-W is having the profile plotter option the user has extra advantage of visualizing the pile shape.



(a)



(b)

Fig. 9 Record received from Consultant at Paradeep

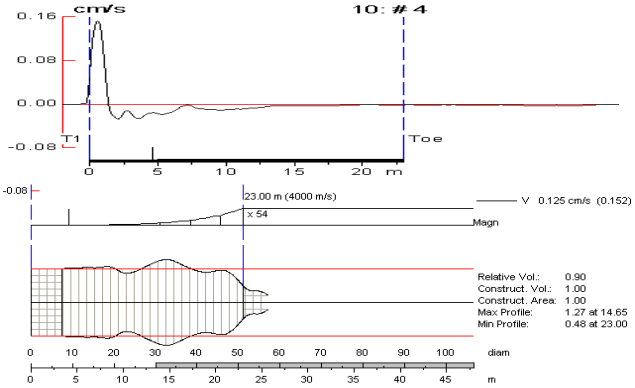


Fig. 10 PITW with profile for pile at Paradeep

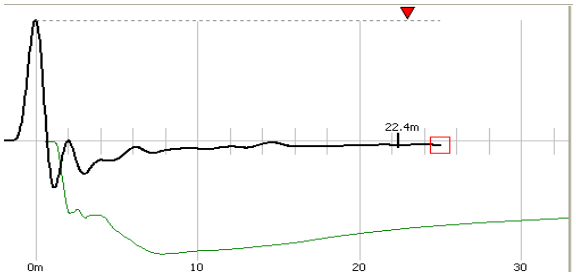


Fig. 11 PET output for Paradeep Pile No FB-A7

PET has smart trigger option which has algorithm to choose best suited number of blows which gives flexibility to user during the recordings. It has also option to sense and prefix the noise/local vibration so that during the recordings it will be eliminated from the main record. Both the instruments are very handy and useful and correctly record the reflectograms. Interpretation is easy in PIT-W as it comes with the option of profile plotting. Even with the profile plotting option, judgement needs experience and great skills.

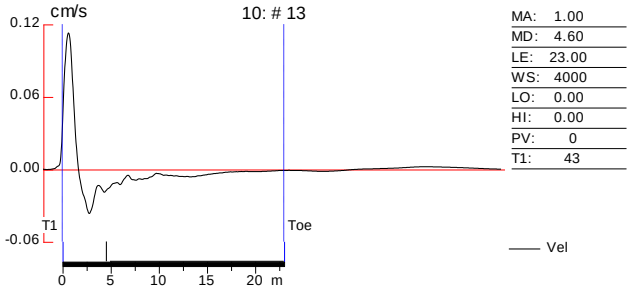


Fig. 12 (a) PIT-W record for Paradeep pile No. FB-C6

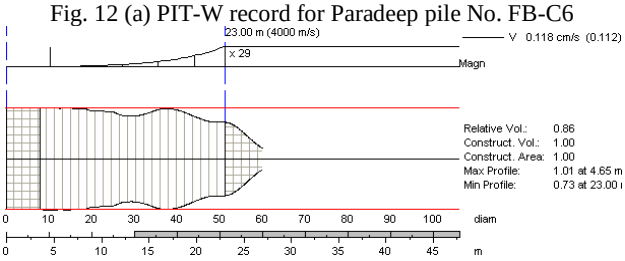


Fig. 12 (b) Pile profile estimated for Pile No. FB-C6 at Paradeep

8. CONCLUSIONS

From observations it is quite clear that Pile integrity testing is simple, reliable and can be quickly performed to locate piles with major or serious defects. The piling method and sequence shall be adjusted looking to the ground condition and water table. The PIT interpretations are very important and poor quality record can be replaced by re-testing on the same pile with accelerometer attached at different locations As per observations for doubtful pile it will be always advisable to use different hammer with different accelerometer location. With advanced features in various instruments it is possible to predict correct shape of pile with no defect.

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