ASSESSING DEPTH OF WELL FOUNDATION – CASE STUDY

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ABSTRACT

Parallel seismic test and sonic pulse echo response test are effective non-destructive methods to determine the depth of an existing foundation. The paper presents a case where depth of well foundation installed for a bridge across a drain was questioned by the owner. While the contractor insisted that the well depth was 12.2 m below the well cap as per the drawings, the owner doubted it. The results conclusively proved that the well depth was about 11 m below the well cap. The tests provided a scientific basis for confirming the as-constructed depth of the foundation.

Keywords: foundation depth assessment, NDT Testing, Parallel seismic test, sonic echo response test, well foundations

INTRODUCTION

Well foundations had been provided for a bridge under construction across a drain in Faridabad (Haryana), Due to a debate with the contractor, the owner wanted a confirmation on the depth of the wells. As per the drawings, the well depth was 12.2 m below the well cap but the customer doubted whether the well had actually been extended to the required depth.

To resolve the issue and preferably avoid litigation, it was decided to go in for non-destructive testing. The non-destructive determination of depth of unknown foundation (Olson et al. 1996) used for this study is as follows:

- Sonic Echo / Impulse Response test.
- Borehole Parallel Seismic method, and

The authors have used a combination of these techniques to assess unknown depth of piles (Sanjay Gupta et al, 2015). The paper presents a case study demonstrating application of NDT methods to assess the depth of well foundations installed for the bridge and confirms reliability of the technique for such application .

While the tests are usually carried out to assess unknown depth of piles, this case study presents application for well foundation. The analysis for well foundation presents a challenge because the concrete well has filled with sand and water.

PROJECT DETAILS

A four lane dual carriageway bridge was under construction across a drain in Faridabad (Haryana). Six well foundations, four wells for the abutment (two at each abutment) and two wells for the piers had been provided.

As per the project specifications, the well foundation dimensions are as follows:

Outer Diameter of well	:	6.0 m
Thickness of well lining	:	650 mm
Depth of well below bed of drain	:	9.5 m
Depth of well below well cap	:	12.2 m

A view of the partly completed bridge is presented on Fig. 1. The further construction had been stopped by the owner to resolve the issue regarding well depth.

Fig. 1. View of the well cap and deck of bridge under construction

Fig. 2 presents a schematic section of the bridge at the well location showing the well details at the abutment location.

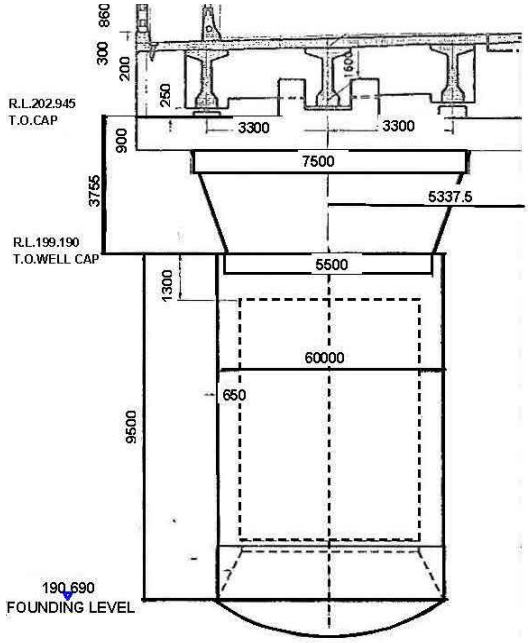

Fig. 2. Section of bridge at abutment well location

PULSE ECHO RESPONSE TEST

Low-strain pulse echo response test was carried out at the project site using a hand held hammer (Rausche et al, 1988). A photograph of the test equipment is presented on Fig. 3. The equipment, primarily used for low strain pile integrity testing, has been used to evaluate the well depth.

Fig. 3. Pulse Echo Response Equipment

A small portion of the well cap was leveled and the accelerometer was placed on it. The hammer was impacted on the edge of the well cap. The response obtained is presented on Fig, 3.

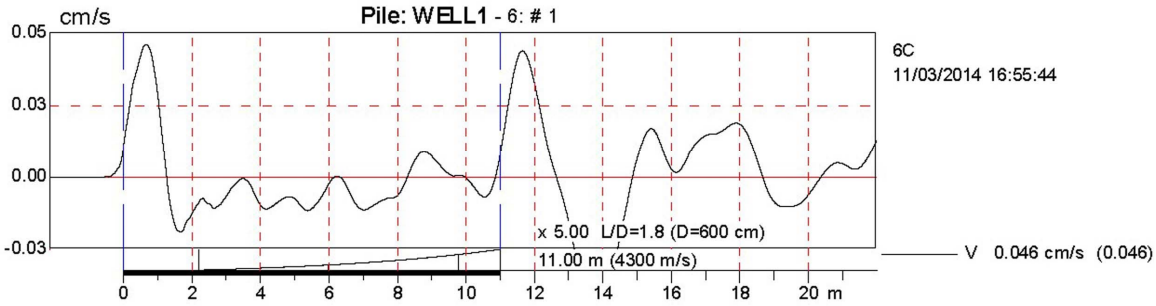

Fig. 4. Sonic echo response data (time domain)

For the purpose of analysis, the velocity of the wave was taken as 4300 m/s. A strong reflection at 11 m depth suggested that the well depth below the well cap is about 11 m.

For a better assessment, a profile analysis was done (Rausche and Likins, 2000). The results of the analysis are presented in Fig. 5. Reviewing the well profile interpreted from the test, the interpreted well depth is 11 m.

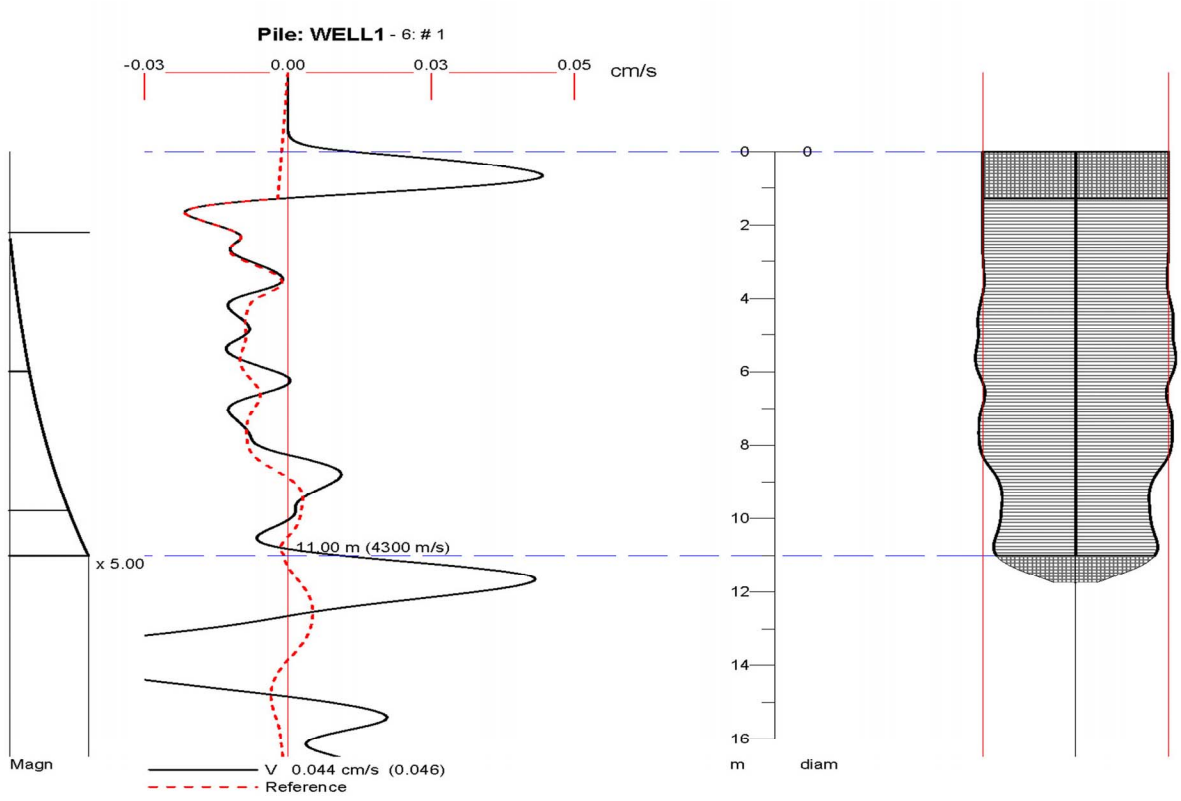

Fig. 5. Sonic echo response Well Profile Analysis

The well profile analysis from the pulse-echo test suggested that the bottom of the well was probably at about 11 m depth. It also indicated possible reduction in diameter of the well below 9 m depth.

PARALLEL SEISMIC TEST

To assess the depth of the well foundation, parallel seismic test was performed on one abutment. The test can give reasonable assessment of depth of unknown foundation (Stain, 1982). The basic concept is that if there is a change in the trend of wave-arrival time and the velocity when reflection is obtained from the concrete foundation and that obtained from soil medium. For good results, a borehole is drilled as close to the existing foundation as possible and geophone is placed in the hole to obtain the response as a hammer impacts the top of the foundation.

For conducting the test, a borehole was drilled about 0.9 m distance from the RCC false steining of the well foundation at an abutment location. The borehole diameter was 150 mm. A 75 mm diameter PVC pipe was placed in the hole and the annular space between the pipe and the hole was grouted using cement-bentonite slurry. The grout was allowed to set for about a week before performing the test.

A 5 kg hand-held hammer with a teflon tip was used to impact the bridge structure. The point for hammer impact was selected carefully on the edge of the well cap so as to ensure that the wave travels through concrete.

Two down-hole triaxial geophones at 1.0 m spacing were used to receive the compression and shear waves traveling down the foundation. Measurements were taken for every 1.0 m depth interval up to the final borehole depth of 18.5 m. A schematic of the test setup is presented on Fig. 6.

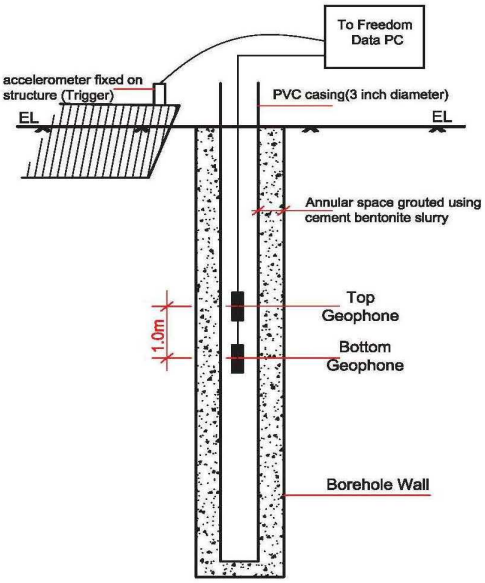

Fig. 6. Schematic of Test Arrangement

The data acquired is the time of arrival of the P-wave. The arrival times from both geophones (spaced 1 m apart) are recorded and plotted versus depth. A clear change in the slope of the time of arrival of P-wave versus depth (See Fig. 7) helped identify the well depth.

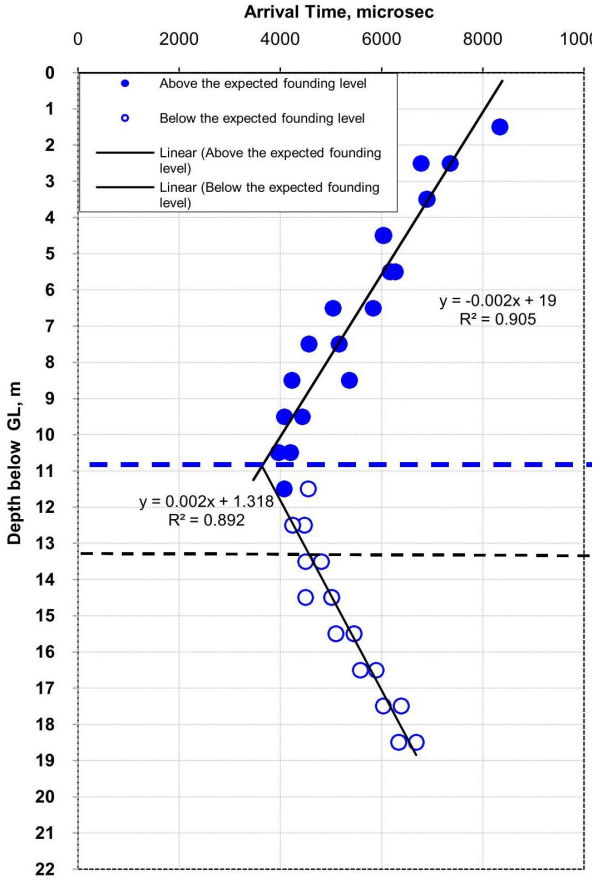

Fig. 7 Parallel seismic test results – Arrival time versus depth

To estimate the trend of wave velocity, it was plotted against the hypotenuse distance between the geophone and the top of the well. A clear break is seen and the change is observed at 11.2 m depth.

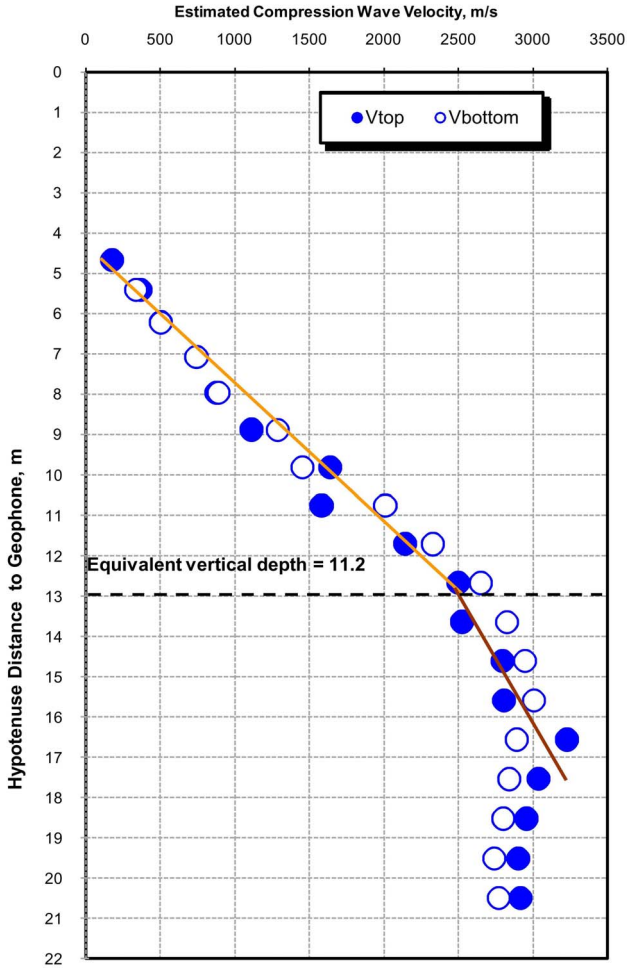

Fig. 8 Parallel seismic test results – P-wave velocity versus hypotenuse depth

The results of the parallel seismic test indicated well depth of 11.2 m whereas the pulse-echo test indicated well depth of 11 m.

INTERPRETED WELL DEPTH

The interpretation is based on the analysis of the wave arrival time. The tests confirmed that the well extended to 11.2 m depth below the well cap, falling marginally short of the required depth of 12.2 m. The test provided a basis for taking a decision on the issue to conclude the debate in a scientific manner. It helped the owner and the contractor resolve the issue.

CONCLUDING REMARKS

Parallel seismic test is a proven method of assessing unknown depth of an existing foundation. It is commonly used to assess pile depth. Coupled with pulse-echo response test, usually used to assess integrity of piles, a very good and reliable assessment of foundation depth can be made.

The present case study demonstrates successful assessment of well foundation depth using these two tests. The tests provide a reliable option for forensic evaluation to resolve disputes on the depth of deep foundations.

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