382. Fellenius, B.H. and Terceros, M.H., 2017. Information on the single pile, static loading tests at B.E.S.T. Proceedings of the 3rd Bolivian International Conference on Deep Foundations, Santa Cruz de la Sierra, Bolivia, April 27-29, Vol. 3, pp. 1-5.

Information on the single pile, static loading tests at B.E.S.T.

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ABSTRACT. A brief background to the presentation of the results of the static loading tests on the single piles at the B.E.S.T. research site is presented. The test results are available in Excel files placed on the conference web site and reference is made herein to where in the Proceeding Volumes detailed information on the background is available.

1. INTRODUCTION

As a part of the 3rd Bolivian International Conference on Deep Foundations, a comprehensive pile testing programme was undertaken at the Bolivian Experimental Site for Testing Piles, B.E.S.T. The main objective of programme was to compare the results of static loading tests on piles constructed using different methods at a site where the geotechnical conditions would be documented by detailed investigations, using state-of-the-art testing and interpretation methods. The geotechnical conditions and the details on the piles and testing arrangement is presented in Proceedings Volume 2, Chapter 5. All field investigations records of the static loading tests are available for online downloading at http://www.cfpbolivia.com/web/page.aspx?refid=113.

2. TEST PILES AND TEST METHODS

Three main types of piles were included in the testing programme as listed in Table 1. All test piles were installed to 9.5 m depth (bottom of reinforcement cage) below the ground surface. The bidirectional device (BD) consisted of a 200 mm high and 80 mm wide hydraulic jack and was installed centered in the "BD-piles" at 8.3 m depth (lower end of jack) in all TB and EBI (Expander Body with post-grouting) equipped piles, but for Piles F1 and F2, where the BD was installed at 6.5 m depth.

It is important to note that the reversal of shear force direction in the head-down test after a preceding bidirectional test affected the load-movement response of the test pile.

The test piles were strain-gage instrumented and the gages were installed in diametrically opposed pairs at 2.0 m, 5.0 m, and 7.5 m depths. Two parallel and separate systems of gages were used: one system employed electrical resistance gages and the other vibrating wire gages. Due to varying power supply and inability to record the data, but unrelated to the gage system itself, the vibrating wire gages never produced useful records.

The head-down test records of the electrical resistance gages showed that relatively large strains (maximum strains were within about 200 through 400 $\mu\epsilon$). Therefore, where the head-down was applied as the first test (Piles A3, B2, C2), the strain records assisted in determining the load distributions. For the BD tests, however, the records of are not very useful because the strains imposed were too small and the expansion of the Expander Base units imposed residual strains in the pile and that adversely affected the evaluation of the load from the strain values.

The reversal of shear force direction in the head-down test after a preceding BD test affected the load-movement response of the test pile, which made the evaluation of the measured strains during the subsequent head-down test, rather ambiguous.

TABLE 1. Primary information on the test piles**.**

ID	Type	Toe Augment	Test Methods Applied		Remark
Pile A1	620-mm bored pile	EBI	BD	HD	
Pile A2	620-mm bored pile	TB	BD	HD	
Pile A3	620-mm bored pile	- -	HD		Pressure grouted
Pile B1	450 mm CFA pile	EBI	BD	HD	Pressure grouted
Pile B2	450 mm CFA pile	- -	HD		Pressure grouted
Pile C1	450 mm FDP pile	EBI	BD	HD	Pressure grouted
Pile C2	450 mm FDP pile	- -	HD		Pressure grouted
Pile D1	150 mm bored pile	EBI	HD		Pressure grouted
Pile D2	150 mm bored pile	- -	HD		Pressure grouted
Pile E1	300 mm FDP pile	EBI	BD	HD	Pressure grouted
Pile F1	450 mm bored pile	EBI	BD	HD	
Pile F2	600 mm bored pile	EBI	BD	HD	
Pile G1	helical pile	EBI		HD	

EBI = Expander Base with post-grouting at pile toe, TB = Toe Box, BD = bidirectional test, HD = Head-down test.

Piles A3, B2, C2, and E3 were included in a Prediction Event reported separately in Volume 3.

After completion of the 1st test on Pile A1 (Pile A1 BD), it was found that the data acquisition equipment had not stored the records. The test was then repeated.

The file called EB Expansion Records.xlsx reports the grouting volumes and pressures. The expansion of the TB resulted in a 115-mm increase of height and the final grout pressure was 4.2 MPa. The BD unit of Pile A1 had 800 mm nominal diameter expanded to about 650 mm. All other EB-units (Piles B1, C1, D1, and E1) had 600 mm diameter and were expanded to widths of about 500, 500, 400, and 350 mm, respectively.

Test on expanding the EB in-air, i.e., unrestricted by pile tension and soil resistance, has shown to result in an about 200 mm shortening of the EB length. Such shortening of the EB in the soil could potentially result in softening of the soil below the EB and it is counteracted by post-grouting below the EB (EBI).

The BD piles were also instrumented with telltale rods to measure the movement of the upper and lower BD plates. Unfortunately, the expansion of the EB (and TB) invariably broke the connection of the telltale to the pile BD bottom and only the upper telltale gave useful records of movement. The usefulness is only approximate, however, because the telltales were deformed bars inside a pipe and side friction obviously affected the movement measurements.

3. THE TEST RECORDS

Each test record is placed in an Excel file available at the above-mentioned conference website. The file names identify the pile and the letter BD or HD signify when the load was applied by the BD jack and when by a jack placed on the pile head, HD. Each Excel file has a first tab entitled "All Test Records" that contains all measurements of applied load, movements, and strains, usually recorded at 10-second intervals. This tab is the factual test report. To assist the user of the data, we have reduced the records to a second-tab table limited to listing the first and last reading of each load. The second tab table also includes some preliminary compilation of the records. Tentative plots of the records are comprised in a third tab ("Graphs").

A fourth tab includes analysis results of the measured load-movements and effective-stress back-analyses with a few comments. For explanation of the back-calculation approach and the effective stress analysis, see the comments on the prediction provided in Volume 3, Chapter 3 "Prediction Papers".

It is important that the user of the test records understands that the fourth tab comprises a preliminary evaluation and that a more thorough study might well have led us to revise the back-calculation results. Thus, the fourth tab is solely included because including it will make it easier, we believe, for others to estimate what the test records contain and decide whether or not it would be a worthwhile effort to take a closer look at the records.

4. GENERAL INFORMATION

The EBIs used in the experimental site and its general characteristics are:

Pile A1 equipped with EBI 815.
Pile B1 and C1 equipped with EBI 612.
Pile D1 equipped with EBI 612, expanded only to 500 mm.
All Piles E equipped with EBI 612 expanded only to 400 mm.

Table 1 presents the general characteristics of the EBI models used at B.E.S.T.

Table 1. General characteristics of the EBI models.

Model	Length prior to expansion (m)	Length after expansion (m)	Diameter of the expanded body (mm)	Cross section at max. diameter (m)	External area (m^2)	Volume (m^3)
EB 612	1.20	0.96	600	280	1.83	0.27
EB 815	1.50	1.26	800	500	3.17	0.63

5. EBI DIAMETER VERSUS GROUT VOLUME

Figure 1A shows an exhumed EBI (EBI 612) and Figure 1B shows an EBI (EBI 815) expanded in air. The difference in shape is in expanding in soil the soil stress around the base of the body exerts a confining stress not present when expanding in air. Is important to clarify that for the maximum injection volume, the final maximum diameter is larger than the nominal value due to the plastic deformation of the steel, as shown in Figure 2.

Fig. 1. Exhumed EBI (EBI612).

Fig. 2. in-air expanded EBI (EBI815).

Each model of EBI has a calibration curve representing the maximum diameter of the body versus volume of injected grout, cf. Figure 3. These curves are useful in the cases when the maximum volume is not reached, which could happen for reasons, such as like leakage, lack of pump capacity, etc.

5. EXPANDER BODIES USED IN THE B.E.S.T.

In the B.E.S.T. the actual EBIs had the following injected volumes and maximum diameters:

Pile A1 EBI 815 was injected with 266 liters, corresponding to 700-mm maximum diameter.
Pile B1 EBI 612 was injected with 237 liters, corresponding to 675 mm maximum diameter.
Pile C1 EBI 612 was injected with 210 liters, corresponding to 668 mm maximum diameter.
Pile D1 EBI 612 was injected with 130 liters, corresponding to 489 mm maximum diameter.
Pile E1 EBI 612 was injected with 110 liters, corresponding to 407 maximum diameter.

Acknowledgment

The detailed planning of the pile tests, instrumenting and constructing the piles, and performing the static loading tests were handled by Mario Terceros Arce and Bernado Vidal of Incotec S.A., Santa Cruz de la Sierra, Bolivia.

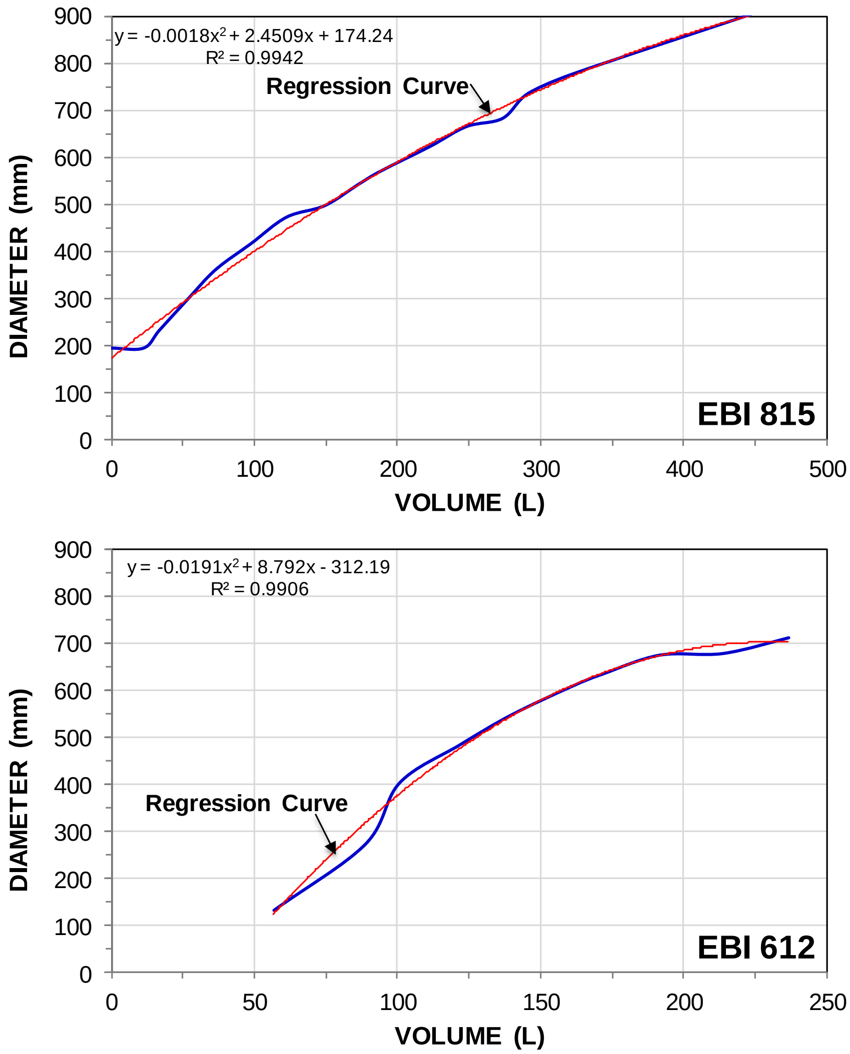

Fig. 3. EBI calibration curves – expansion in air.