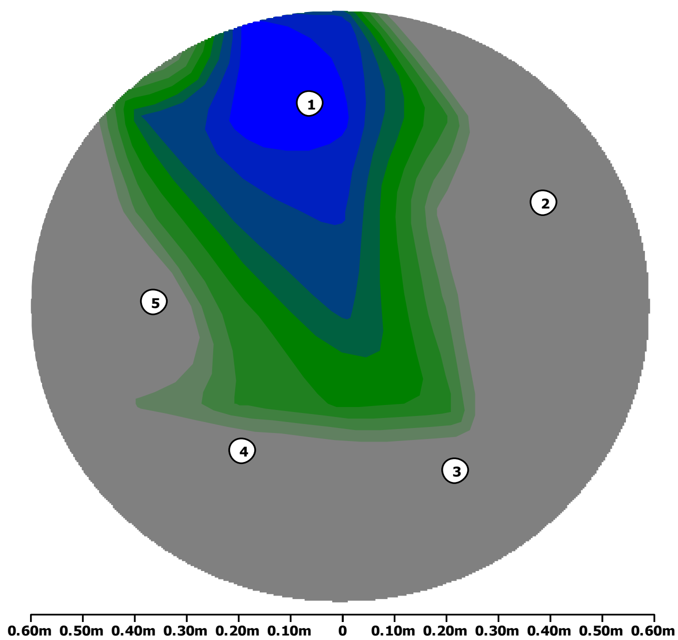

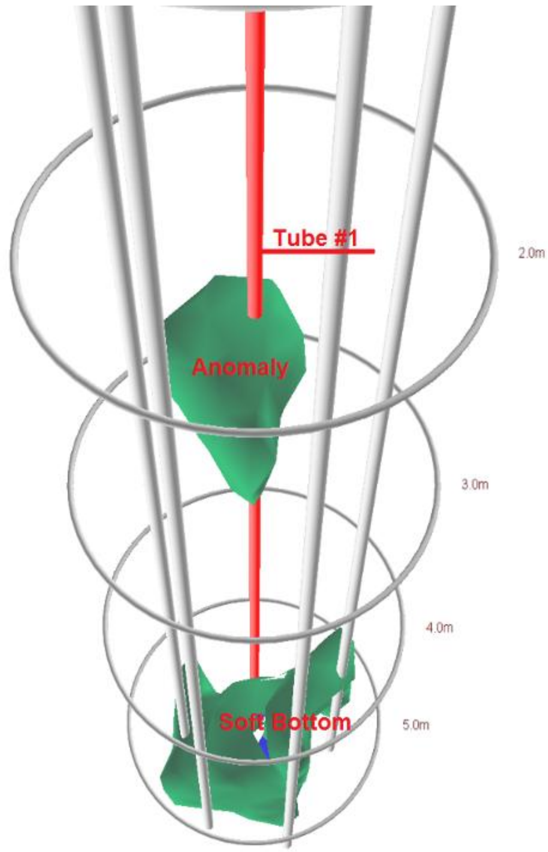

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Comments on the B.E.S.T. intentional defects and anomalies

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ABSTRACT. The B.E.S.T. testing programme included an integrity testing demonstration, wherein the piles subjected to static loading tests and a total of eight additional piles constructed with intentional flaws that were kept unknown to the integrity tester. The value of the testing is very limited because only one company volunteered to participate by performing the integrity tests and, more disappointing, the preparation of the piles for intentional defects was botched due to inadequate communication between the organizers' office and field. The following are brief comments addressing what should have been addressed in the testing programme.

1. INTRODUCTION

In preparation of the 3rd Bolivian International Conference on Deep Foundations, an integrity demonstration was planned and executed with two main objectives in mind:

1. To demonstrate to participants up to date techniques for integrity testing of piles.
2. To invite manufacturers and testing firms to take part in an integrity testing competition on piles constructed with intentional defects.

Unfortunately, the first objective could not be met due to weather conditions on the assigned date. The second objective suffered from the fact that only two firms appeared on site of which only one (Piletest.com Ltd.) submitted a report of the results. Thus, the affair could hardly be defined as a competition. Several aspects of this event are highlighted below for the benefit of similar events organized in the future.

2. PILE TESTING COMPETITIONS — OBJECTIVES AND PRINCIPLES

Pile testing competitions should be held with the following objectives in mind (Amir and Fellenius 2000 - this reference is reproduced for convenience in the Appendix to Volume 3 of the proceedings).

1. Kindling the competitive spirit between developers, manufacturers, and users of equipment in order to advance the state of the art.
2. Verifying capabilities and limitations of the testing methods.
3. Serving as milestones to monitor progress in both instrumentation and analysis tools.
4. Providing an opportunity for potential clients to obtain reliable comparative data regarding the performance of available commercial instruments.

To meet the above objectives, a competition should try to simulate a realistic testing environment within the capabilities of existing instruments. The necessary conditions are, therefore:

1. The design of the competition should be based on firm theoretical grounds, meeting both stress-wave and statistical theories.
2. The tests should involve real piles, conventionally constructed, and constructed in real soil.
3. The piles should have various lengths and diameters.
4. At least some of the piles should include flaws (increased and decreased cross-section).
5. For low-strain impact testing, only one flaw per pile shall be installed.
6. For cross-hole ultrasonic testing, piles may have several flaws with sufficient vertical spacing between them.
7. Down the pile, the flaws should be of growing importance, from hardly discernible to an almost complete discontinuity.
8. The data related to the flaws shall not be disclosed to the participants (type "A" prediction).
9. The participants should get the same kind of data they expect in actual testing: Soil profile, piling method, pile length (both design and as-made), and construction records.
10. The pile heads should be properly prepared, i.e. all poor quality concrete must be trimmed off, all loose concrete chunks removed and the surface made reasonably smooth and clean.
11. Access tubes must of the correct type (steel/plastic) and diameter and be free of obstructions.
12. The results should be reported in full for all piles, including the graphs and raw data.

3. SUGGESTED TESTING SCHEME

Based on the above principles, a testing setup, as summarized in Table 1, was prepared and submitted to the organizers of the B.E.S.T. ahead of time.

Nine piles were prepared with intentional flaws: Piles F3, DC1200-1, DC620-1, DC620-2, DC620-3, CFA450-1, CFA450-2, FDP450-1, and FDP360-1. Unfortunately, instructions to the field staff on how to prepare the flawed piles was let to the field staff's own devices. They elected to produce the intentional flaws by tying multiple sand-filled bags with dimensions of about 200 x 100 mm—about 12 % of the pile cross section—to each reinforcing cage at different depths before inserting it into the hole or casing. This, obviously, is an impossible testing situation. The cross section of the "flaw-bags " is notably smaller than the accepted detection threshold of the integrity testing equipment (notwithstanding that the uppermost bag was clearly detected as a flaw by the single-hole ultrasonic method—the rest were invisible). For a series of flaws down a pile, the deeper-located flaws can only be assuredly detected if they are larger than those above—all bags were about equal size, however—and limited in number. The intentional flaws, as prepared, had neither relevance to the testing methods nor to being representative for flaws in actual piles.

Figure 1 shows the location of the "flaw-bags" as placed in Pile CFA450-1, a 450-mm diameter CFA pile.

TABLE 1. Suggested test setup.

Pile	Construction Method	Diameter (m)	Length (m)	Access Duct	Flaw Type	Note
AI	Cased pile	0.62	12	None	None	1
AII	Cased pile	0.62	2	None	None	2
AIII	Cased pile	0.62	12	3 x steel	30% @ 3 m	
AIV	Cased pile	0.62	12	3 x PVC	50% @ 8 m	
BI	Drilled w. slurry	0.45	12	1 x PVC	Outside ring @ 4 m	
BII	Drilled w. slurry	0.60	12	3 X PVC	Outside ring @ 4 m and soft bottom	
CI	Cased pile	1.20	6	5 x steel	0.12 m^2 around 2 tubes at 2 m 400x400x400 box in the center @ 4 m	
DI1	Drilled w. slurry	1.20	6		5 x PVC Sand bag @ 4m outside cage next to two tubes, 0.4 m high, soft bottom	
EI	CFA	0.45	12	None	None	
EII	CFA	0.45	2	None	None 2	
EIII	CFA	0.45	8	1 X PVC	Interrupted concrete flow at 4 m	3
HIV	Helical			None		
II	FDP	0.36	12	None	Interrupted concrete flow at 4 m	3
III	FDP	0.45	12	None	Interrupted concrete flow at 8 m	3

Note 1: Important to have a no-flaw reference.
Note 2: Constructing a 2 m long pile adds very little to total costs, but increases variety and test options.
Note 4: At the designated level, concrete flow should be stopped while raising the auger 0.3 to 0.5 m, then continued. Computerized records should be kept, when available.

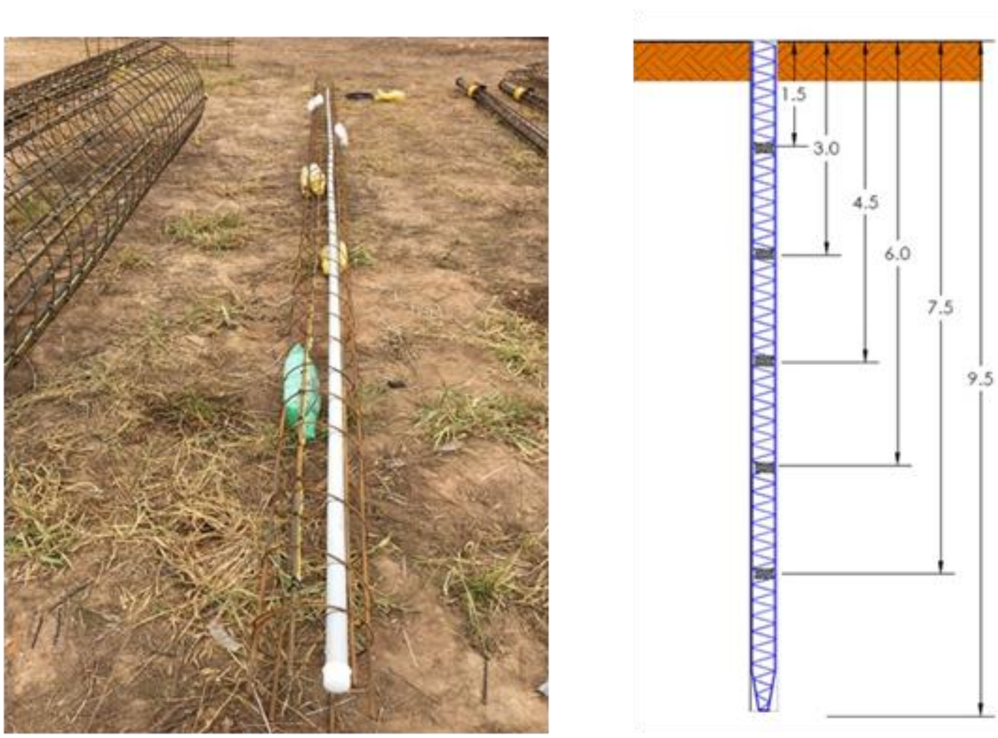

Fig. 1. Installed defects in Pile CFA450-1.

Pile F-3, a 1,200-mm diameter pile drilled with slurry, was equipped with five access ducts. The upper flaw was installed at a depth of 0.5 m (Figure 2) while two more flaws where crowded together at depths of 5.0 and 5.5, respectively. Due to the close spacing and proximity to the toe they could not be separated in the test. Interestingly, the ultrasonic test managed to discover an unplanned flaw at a depth of 3.0 m, proving the importance of closely-controlled construction on such test sites.

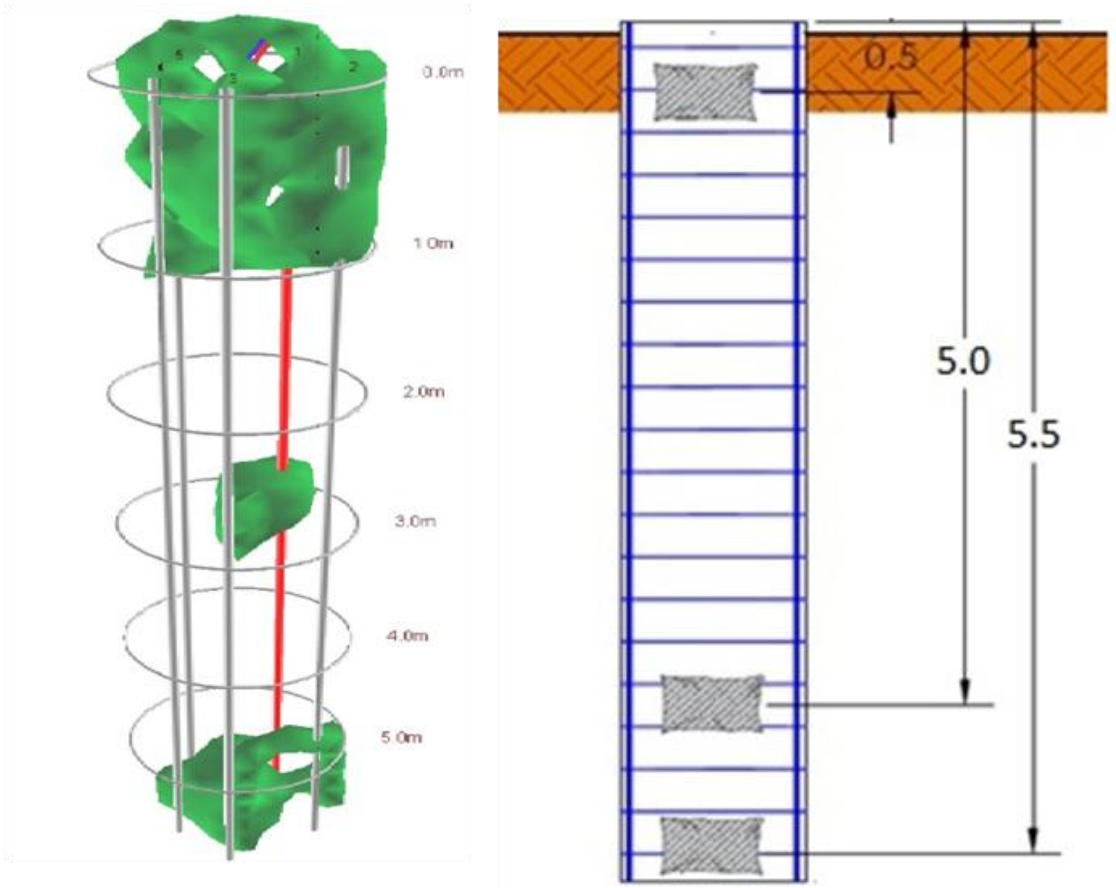

Fig. 2. Pile F3. Results of ultrasonic cross-hole tomography (left) and location of "bag flaws".

4. TESTS ON PILES WITHOUT INTENTIONAL DEFECTS

Eight of the B.E.S.T. test piles subjected to bidirectional and subsequent head-down static loading tests were tested for integrity after the completion of the static tests. Pile A1 was drilled with slurry and equipped with an Expander Base with post-grouting (EBI) and a bidirectional jack (BD) at about 8 m depth, Pile A2 was drilled with slurry and equipped with a toe box (TB) and a BD at about 8 m depth. Piles F1 and F2 which were drilled with slurry and equipped with a BD at about 6.5 m depth. Pile E1, a FDP pile equipped with an EBI and a BD at about 8 m depth. Pile E1 broke shortly below ground in the static loading test. Two test piles that had only been subjected to head-down tests (Pile A3, drilled with slurry and Pile B2, a CFA-pile that had neither an EBI, TB, or BD) were also tested.

The results of the integrity assessments are reported separately in these proceedings.

5. SUMMARY

From the point of view of integrity testing, the B.E.S.T. scheme was far below expectations. The main lesson we learned from this exercise is that future events should be led by a project manager able to produce the piles with the properly planned and executed flaws. This person should be versed in integrity testing techniques and at the same time be free from commercial involvement with either manufacturers or testing laboratories.

A special effort should be made to bring in multiple testing firms and manufacturers with the widest variety of testing systems.

Adopting the above suggestions will undoubtedly lead to more successful testing events in the future.

References

Amir, J.M. and Fellenius, B.H., 2000. Pile testing competitions—a critical review. Proceedings of the 6th International Conference on Application of Stress-Wave Measurements to Piles, Sao Paulo, September 2000, 5 p.