# Discussion

# An Evaluation of the Shaft Resistance of Piles Embedded in Gneissic Rock

Discussion by:
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The writer would like to offer some comments addressed to the authors of "An Evaluation of the Shaft Resistance of Piles Embedded in Gneissic Rock".

The authors state that the pile base contribution is not considered. Actually, in practice, it is quite usual to take advantage of the toe resistance, provided proper base clean-up can be ensured. Given that the authors have conducted many dynamic load tests, and analyzed them with CAPWAP C, the presentation of such analyses would be of great help to clarify the contribution of shaft and toe resistances (both soil and rock).

The authors might consider writing a paper that reports and discusses, for each of the 5 typical profiles shown in Figs. 13 to 17, the complete results of dynamic load tests, focusing on the contributions from both soil and rock to the ultimate toe and shaft pile resistance.

Specimens for laboratory compression tests on rocks are usually obtained from essentially sound rock fragments. Do the authors believe that this could be the reason for the very limited range of $q_u$ shown in Table 3, as compared to the results presented in Table 2? The correlation between $q_u$ and RQD is quite low for the experimental data of Table 3.

Equation 7, for maximum mobilized shear stress, was derived from Eq. 6, in which the multiplier for RQD is 0.6. Given that the observed average multiplier was 0.8 to 0.9 (Figs. 11 and 12), Eq. 7 seems to be overly conservative as compared to other equations proposed elsewhere for weak rocks.

On page 19 the authors report a displacement of 2 mm for E111, Block 16. In Table 4, and in the figures, that displacement is 4.7 mm.

The statement that NBR 13208, dated 2007, follows the more recent ASTM D4945 (2012) goes against common sense.

Article by E.L. Juvencio *et al.*, published in Soils and Rocks, 40(1):61-74 (2017), e-mail: erisvaldo.lima@gmail.com.

# Closure by authors

The authors would like to thank the discusser for his valuable comments, and will try to respond to all the questions raised.

1. It is generally accepted that the base resistance of piles in rock is considered only if the borehole is completely cleared of debris prior to concrete pouring. If the design is completed before any bidding and contractor selection, it is on the safe side to disregard such resistance. However, if the selected pilling contractor has the means and can assure a proper bottom clean-up, the design engineer can consider the contribution of base resistance, resulting in reduction in the foundation cost.

A detailed presentation of the dynamic tests - with observed shaft and base resistances - can be found in the DSc thesis of the senior author (reference in the paper). In these tests, a contribution of base resistance was definitely observed. On average, the mobilized base loads were 9% of the total mobilized load, but with considerable variation between tests. This variation was due to different load mobilization levels but may also be due to different borehole clearing processes. It should be kept in mind that two processes of debris removal were used: (a) by water circulation (“wet” boring) and (b) by compressed-air (“dry” boring). The latter method is efficient only up to a certain depth.

2. The authors accept the suggestion to present a further paper exploring the contribution of both base resistance and shaft friction in the saprolitic soil.

3. Juvencio’s (2015) selection of specimens for laboratory tests was made after the examination of many boxes of samples (there was practically one boring per column of each bridge), with a wide range of RQDs. As expected, test results indicated a wide range of $q_u$: 14-90 MPa (Table 2). The testing program for the Rio de Janeiro Harbour Improvement (Table 3), on the other hand, used specimens with higher RQDs and, consequently, $q_u$ were in a more tight - and higher - range: 50-90 MPa. The two sets of test results were put together in Fig. 12, and the observed scatter was not too severe, leading to the correlation (on the safe side) of Eq. (5).

4. The authors agree - and this was clearly stated in the paper - that Eq. (7), for maximum mobilized shear stress, is conservative. It is of avail, as mentioned in the paper, when there is no laboratory testing and only RQD values are available.

5. The maximum displacement of E111, Block 16, mentioned in the text, 2 mm, is incorrect. The right value is 4.7 mm, as shown in Table 4 and Fig. 18. This does not change the understanding that the maximum mobilized load was far from failure.

6. The American standard ASTM D4945 was first published in 1989, and served as basis for other national standards, such as the Brazilian standard NBR 13208. When referring to the American standard, the authors used the lastest version of 2012. The correct expression in the paper should be that NBR 13208 *is in accordance* with ASTM D4945.