Is CPT a suitable in situ test for characterizing gravelly sands?

Rodrigo Salgado et al. are the Authors of the "Experimental Study of the Load Response of Large Diameter Closed-Ended and Open-Ended Pipe Piles Installed in Alluvial Soils" (FHWA, 03/2019).
This study also examines the accuracy of some authoritative methods (Purdue CPT, ICP, UWA, NGI, Fugro) when predicting the shaft and toe resistance of the cited piles employing the CPT results plotted below (Figure 1) together with those of a SPT, also available (unfortunately the values of both are only digitized).
The CPT, due to the constant presence of gravel in varying percentages, was carried out by alternating drilling and static penetration (cone section 15 cm^2 versus 20 cm^2 of SPT: scale effect?).

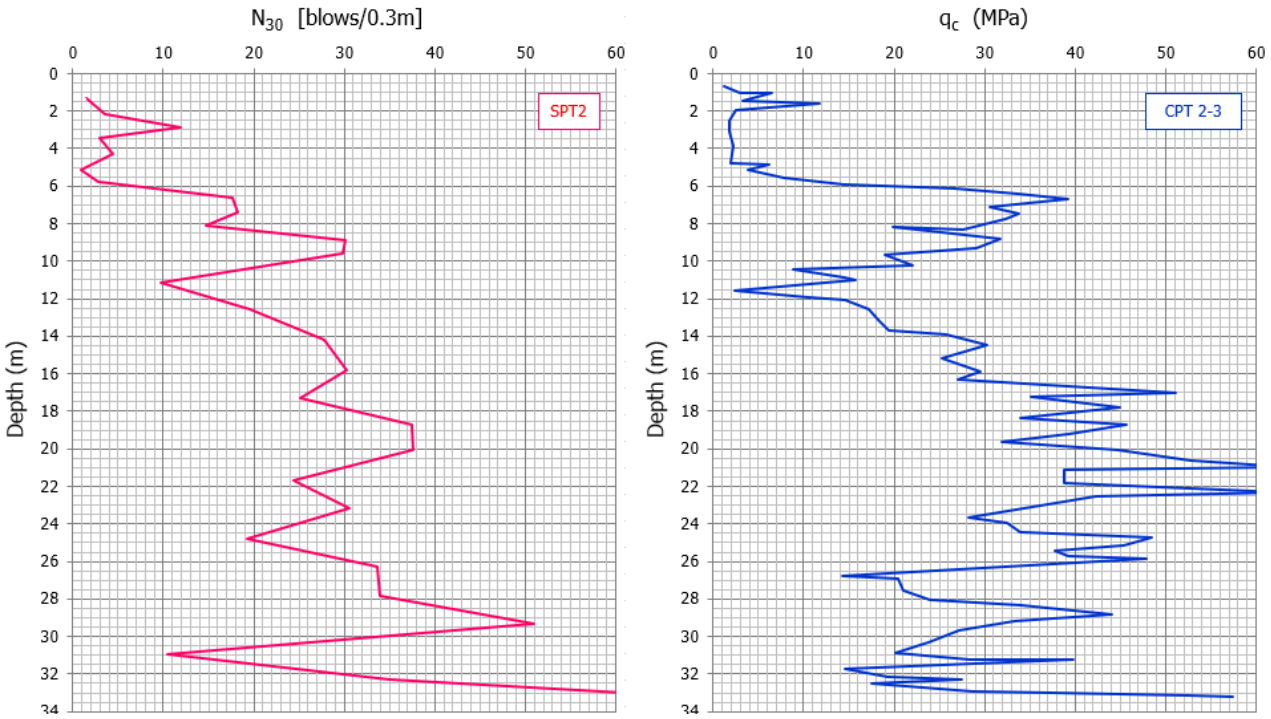

Figure 1

From the comparison of N_{30} and q_c values it seems evident that we have a discrete correspondence only between the lower ones, probably those of the soil matrix, in general not certainly represented by q_c values. Then, the N_{30} values, although rather questionable beyond 10/15m depth especially missing an effective measurement of the involved energy, are anyway to be preferred and therefore used as reference.
This assumption led to convert the SPT2 N_{30} values into $q_{c\ equiv.}$ using four different methods, then to $q_{c\ equiv}$ were added the f_s values (derived from q_c with a personal procedure) and the u_2 values (considered equal to u_0 given the SP soil classification), to get virtual CPTu, processing which, new N_{30} values were obtained to compare with those measured (SPT2), thus returning to the starting point (Figure 2).
The Jefferies and Togliani conversion methods/virtual CPTu which provided results closest respectively to the q_c and N_{30} values measured, were finally used to determine the CEP pile capacity applying:

- the Decourt method by employing not only the N_{30} values measured but also those obtained from the two virtual CPTu;
- the LCPC method, being the precursor among those that only employ the q_c values (the one measured in the available CPT);
- the Togliani methods (q_c & R_f, ISC'3 Proceedings) and (qc & K^*_G, CPT'18 Proceedings), to which was added the one of attempt but applicable on the occasion [the unit friction f_p (kPa) = qc (bar)], all also valid for the OEP pile capacity prediction.

The pile capacities derived from the q_c & K^*_G method which proved, as highlighted in Figures 3 & 4, to be sufficiently approximate in 3 of the 4 cases considered (±20% of the values measured), were used to simulate the correspondent Load-Movement curves by combining the Chen & Kulhawy (2002) and Ratio Function (B.

Fellenius, Red Book) methods, then compared with those measured with fairly well results while considering that these are Class C predictions (an example is illustrated in Figure 5).

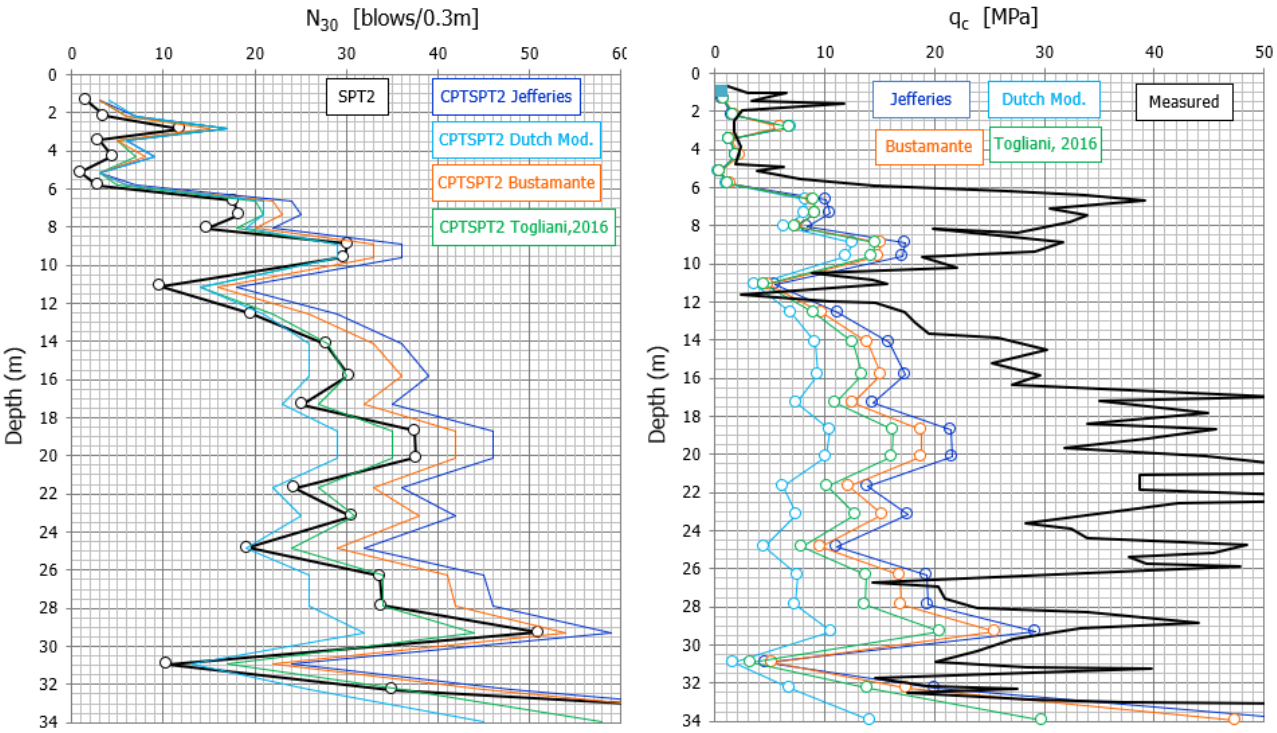

Figure 2

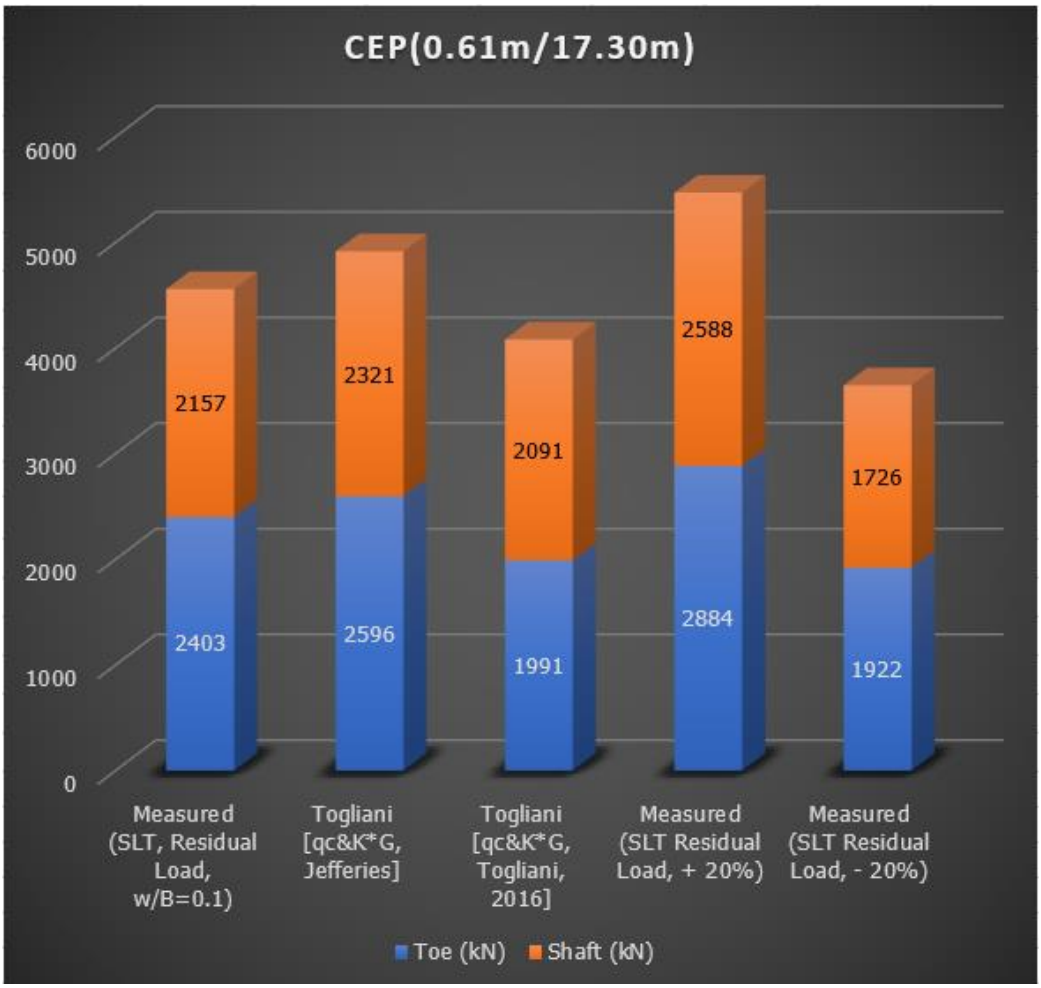

Figure 3

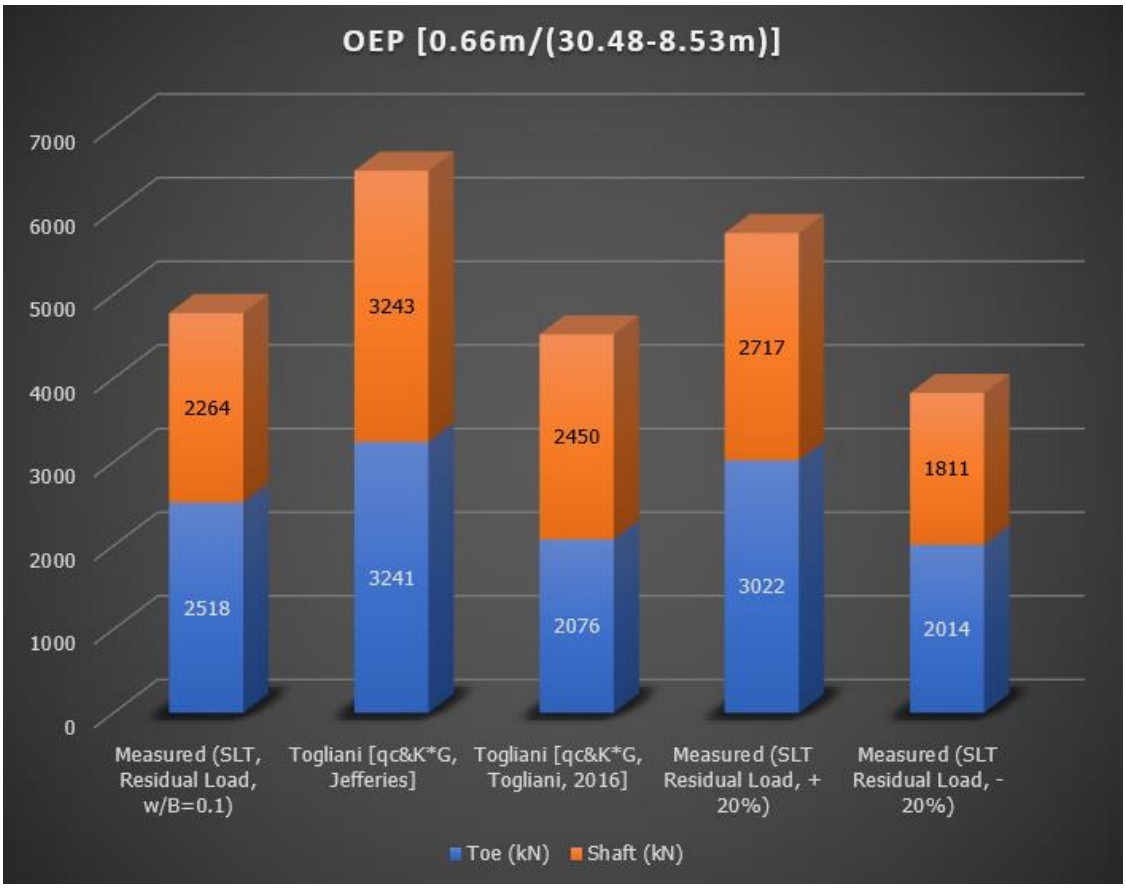

Figure 4

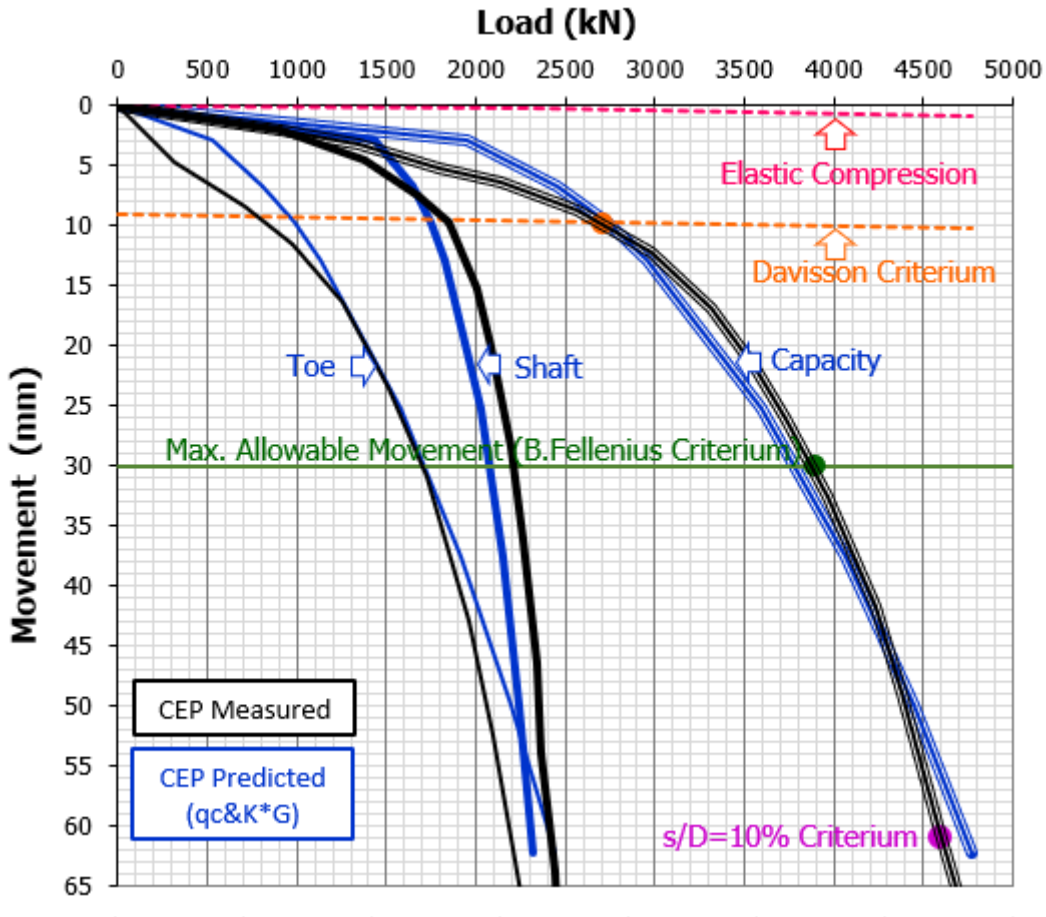

Figure 5

Noteworthy, in the curve of the measured capacity, are the considerable differences between the limit values proposed by some of the most popular criteria that give a clear image of the inexplicable confusion that still reigns today in this regard.
The above observations lead to the following conclusions:

- if an alluvial sand is constantly gravelly, a CPT is not a suitable in situ test to propose, being the static penetration difficult and the emphasis of q_C values very often unrealistic: in the specific case SPT and DPSH are undoubtedly to be preferred;
- it is essential to have at least two types of in situ tests available and to know their potential and limitations to be able to compare their results and choose the best option for the piles design.
- all design methods that uses q_C as primary input value, in this case poorly reliable, can only provide wrong results independently of their scientific status while, if appropriate, even methods with negligible scientific merit can provide sufficiently approximate results: this means that, on the specific matter, intuition and personal experience are again and again crucial, certainly not a good news both for academics and practitioners.

Massagno, 29.03.2021

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