FOUNDATION CAPACITY IN INTERMEDIATE GEOMATERIALS
Summary Findings

CONSORTIUM FOR EDUCATION AND RESEARCH IN GEOENGINEERING PRACTICE
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Background:
Materials intermediate between soils and rocks are referred to as Intermediate Geo-Materials or IGM. They are earth materials that typically have SPT blow counts N between 50 and 200 bpf, unconfined compression strength q_{uI} between 0.5 and 5 MPa and pressuremeter limit pressure p_L between 2.5 and 55 MPa. Deep foundations in IGM include bored piles (drilled shafts) and less often driven piles. The ultimate capacity of such deep foundations in IGM is studied in this report.

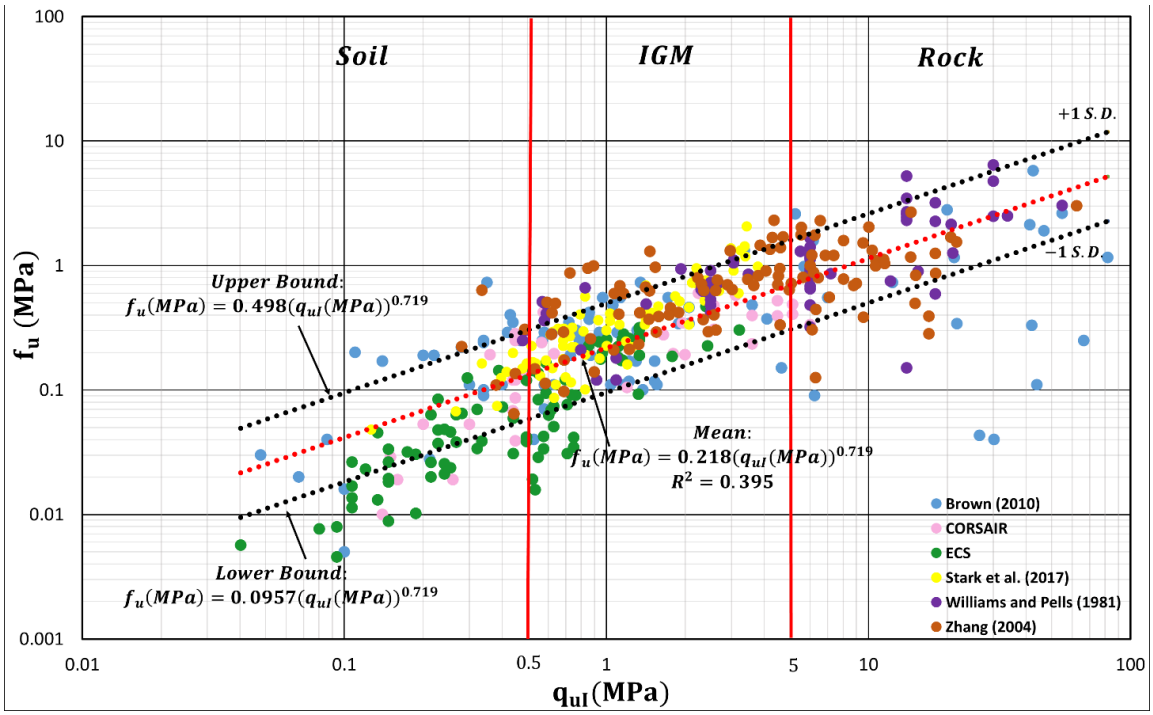
What The Researcher Did:
A database of load tests on instrumented single piles with separate measurement of side shear stress and point pressure is assembled and analyzed. In parallel with the load tests data, the IGM properties are collected including q_{uI} and N. Because the pressuremeter is thought to be the best tool for the characterization of IGM, values of p_L are obtained from correlation with q_{uI}. Correlation charts between f_u and p_u on one hand and q_{uI}, N and p_L on the other are generated to help the engineer select appropriate values of f_u and p_u for IGM. Furthermore, existing guidelines to estimate f_u and p_u in IGM are reviewed and evaluated against the database.

What The Researcher Found:
The main findings are listed below.

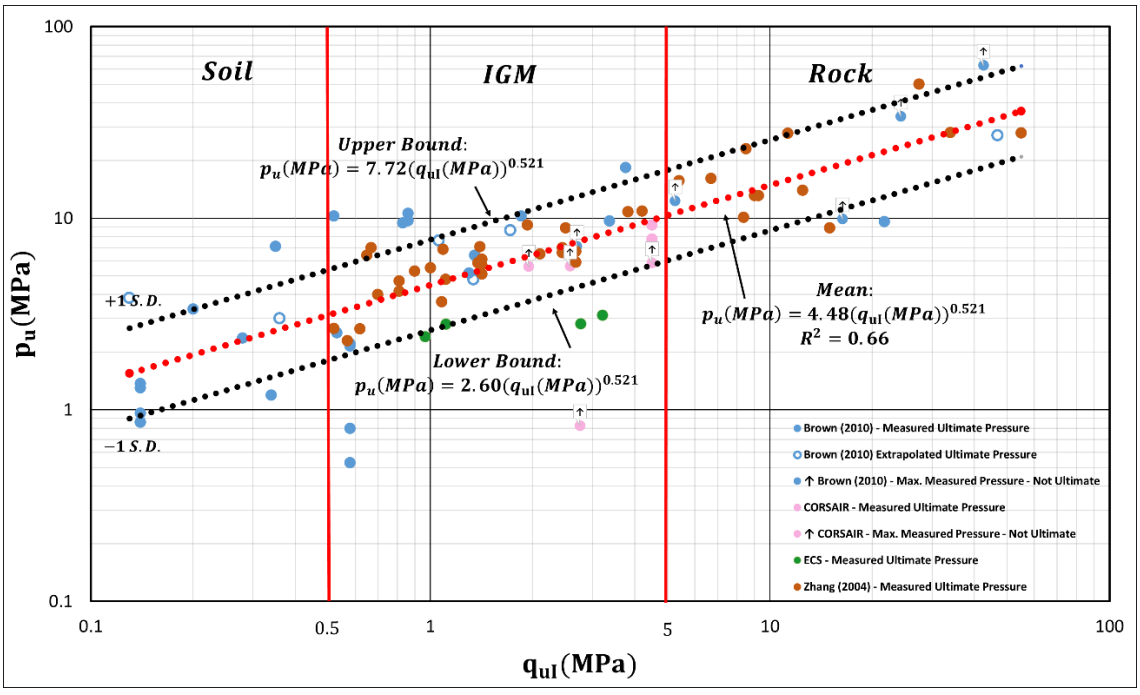
1. IGM are Intermediate Geo-Materials between strong soils and soft rocks. Their properties lie somewhat outside the typical soil properties or rock properties. The unconfined compression strength of the intact material q_{uI}, the SPT blow count N and the pressuremeter limit pressure p_L are selected to quantify the IGM strength.
2. The modulus of the IGM mass E_M tends to be smaller to much smaller than the modulus of the intact IGM E_I. The ratio E_M/E_I is documented by using data from rocks. It is found that E_M/E_I increases from 0.01 to 1 when RQD increases from 0 to 100% and from 0.05 to 1 when RMR increases from 20 to 100%.
3. The ratio of the PMT modulus over the unconfined compression test modulus is also shown to increase with RQD and compares very closely with the plate test modulus. The correlation between the PMT modulus and the SPT blow count is scattered and it is not recommended to use N to obtain a modulus except as a very crude preliminary estimate. A comparison between PMT modulus and limit pressure is presented and a PMT parameter-based IGM classification is suggested.
4. A database of 318 drilled shaft instrumented load tests mostly in IGM was collected and organized. That led to 483 values of the ultimate side shear stress f_u and to 84 values of the ultimate point pressure p_u.

5. A database of 49 driven pile instrumented load tests mostly in IGM was collected and organized. That led to 42 values of the ultimate side shear stress f_u and to 32 values of the ultimate point pressure p_u.
6. Charts giving the ultimate side shear stress f_u and the ultimate point pressure p_u as a function of q_{uI}, N and p_L are presented for IGM along with best fit regressions. These regressions include the mean values as well as the values for plus and minus one standard deviation. These best fit regressions help the engineer select reasonable values of f_u and p_u for IGM.
7. The charts include results for soils and for rocks and show the continuity between soils, IGMs, and rocks, of the relationships between f_u and p_u on one hand and q_{uI}, N and p_L on the other.
8. A number of IGM pile capacity prediction equations are evaluated by comparing them to the accumulated data. The comparisons show that:
    a. The α value for the ultimate side shear stress f_u, which is typically between 0.5 and 1 for piles in fine grained soils, decreases as the strength of the IGM increases and can be as low as 0.1 or less for high strength IGM.
    b. The N_c bearing capacity factor in the undrained shear strength Skempton equation for the ultimate point pressure is typically taken as 9 in fine grained soils. The data show that N_c decreases as the IGM strength increases and can reach values of 2 for high strength IGM.
    c. Many other design recommendations including the Canadian foundation manual, the AASHTO bridge specifications and the French guidelines are evaluated indicating which are conservative and which are optimistic.

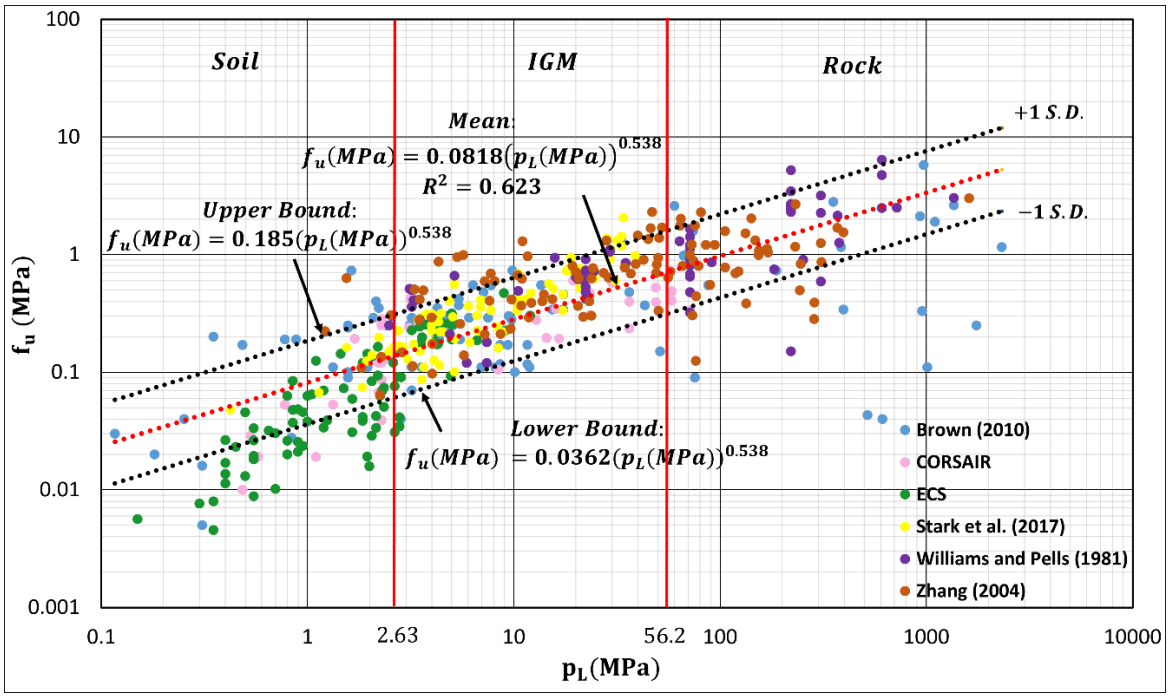
The pressuremeter is one of the best economical tools to obtain IGM properties suitable to predict foundation behavior. Among the reasons are that the volume of IGM mobilized during the PMT test is large compared to laboratory tests, that the PMT test is not unlike a load test, and that the PMT gives IGM properties over a large range of strains and stresses. Since the IGM properties that matter in foundation behavior prediction are those of the IGM mass and not those of the IGM intact material, the PMT is recommended.



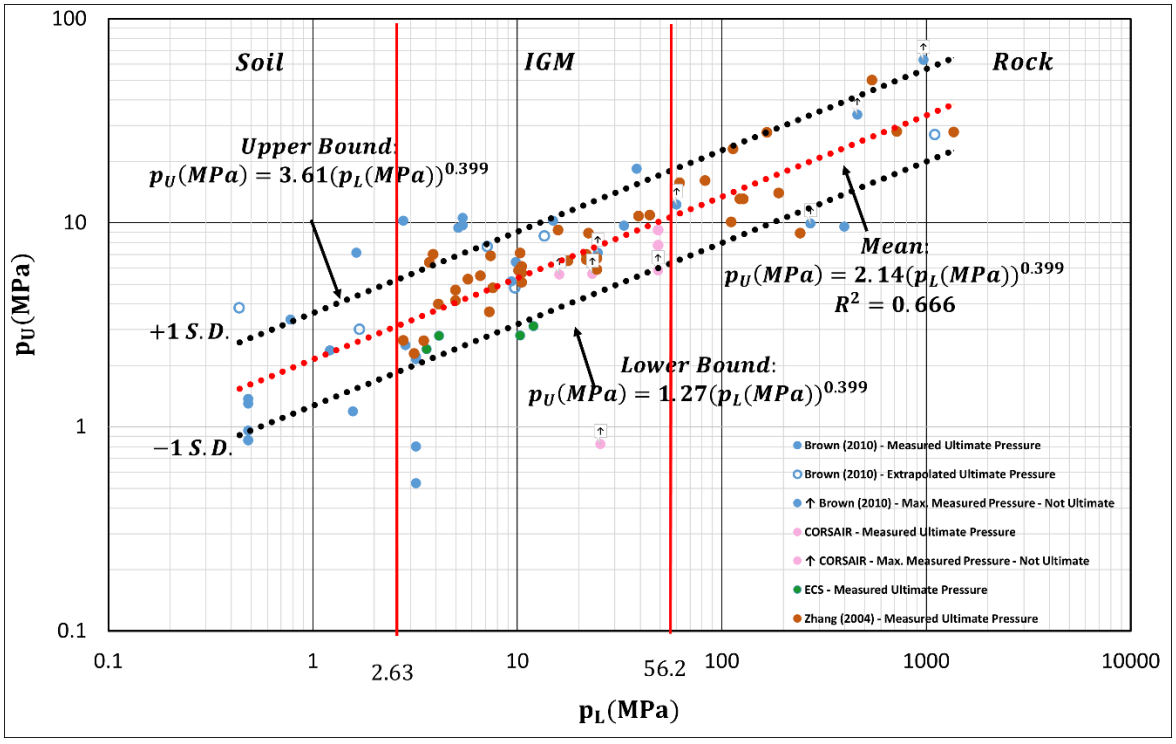
Ultimate side shear stress f_u versus unconfined compression strength q_{ul} for drilled shafts in IGM.



Ultimate point pressure p_u versus unconfined compression strength q_{ul} for drilled shafts in IGM.



Ultimate side shear stress f_u versus pressuremeter limit pressure p_L for drilled shafts in IGM.



Ultimate point pressure p_u versus pressuremeter limit pressure p_L for drilled shafts in IGM