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CONTRIBUTIONS TO THE PAPER DEEP SOUNDING - ITS VALUE AS A GENERAL INVESTIGATION TECHNIQUE WITH PARTICULAR REFERENCE TO FRICTION RATIOS AND THEIR ACCURATE DETERMINATION BY G.A. JONES.

PROF V.F.B. DE MELLO

There is much to be discussed in this very important session of great practical implication particularly in the light of our experiences of the last thirty years during which the principal cities of Brasil have grown at incomparable rates (such as that of São Paulo with an increase of population from about 2 to about 8 million). This has involved an unprecedented rate of construction of highrise buildings because of disproportionately slow expansion of the area served by public utilities. However, because of lack of time I shall restrict myself to three principal items.

The first concerns the paper by G.A. Jones on the use of the deepsounding static cone penetrometer together with the local friction sleeve as a preliminary all-purpose tool for subsoil investigation.

When Begemann presented his suggestion of the friction ratio as "an aid in determining the soil profile" (1965), which could better have been emphasized to be a complement to visual-tactile classification of spoon-sample exploratory borings, I took the liberty to submit a discussion (6th ISSMFE, Montreal 1965, Vol. III p.294) decrying the introduction of mechanistic practices that would wipe out the painstaking gains of the fundamental principle of Soil Mechanics of requiring first the determination of the nature (classfication) of the soil type by direct sampling, and not by indirect inferences.

Mr Jones begins by pitting undisturbed sampling of soft alluvial deposits against the proposed deepsounding procedure. But the latter is an Index Parameter procedure, that should be compared with the alternate index parameter procedure of the exploratory boring: the latter assumes that by visual-tactile classification one obtains principally the determinations of parameters connected with strength as the satisfactorily dominant conditioner for problems both of compressibility and of stability. Moreover, does one forego the need to determine the water level in borings?

Indeed the lure of mechanistic proposals is extremely seductive. And doubtless there will be many a case of pragmatic success. Meanwhile, doubtless the presumed rationalizations employing the index parameters extracted from the exploratory borings do need considerable revision, to redeem them from an accumulation of criticisms on poor predictions. But, can one forego a fundamental principle of directly qualifying the materials, without running serious risks, not merely of practical failures (not yet statistically established because of the limited number of applications of the new method) but worse, of undermining the very roots of the engineering science?

The author is much commended for the improvements introduced and the carefully collected supporting evidence. I should beg leave to request, however, that much greater emphasis be attached to the restrictive hypothese; for instance, on the one hand regarding shear strength estimations, the assumption of fully saturated type of $\phi = 0$ soil (most partially desiccated and preconsolidated alluvia even when cyclically submerged would not satisfy the condition for a small pressure bulb under the cone), and, on the other hand regarding settlement computations, the presumed pseudo-elastic instaneous compression condition of the Buisman-de Beer- Schmertmann computation of sandy soils. The introduction of a new Index Parameter, such as the Modified I_R may improve statistical correlation coefficients; but, with reference to fundamental parameters and the theory of soil mechanics, is there any justification (or can and should one be sought) for the presumed trend, or is it a case of statistics at random? It must be recalled that for routine exploration, the cone penetrometer suffers from the serious drawback of being in essence too sensitive a test, subject to highly localized extreme values. If as much effort of development and correlation were expended on the sampling exploratory boring (such as, for instance, using a static penetration effort and a Swedish foil long-sampling idea), would not the returns to soil engineering both conceptually and pragmatically, have a probability of being much greater?

The second point on which I beg leave to comment is the fact that foundations and foundation design seem to be discussed at this Conference without sufficient indication of the subsoil profile (in a soil mechanics context) or of the magnitudes and distribution of column loadings and I find myself quite at a loss in the attempt to assess comparatively your practices with ours. If I may say so, you seem to be map conscious and geology conscious; in our experience, geology is merely the compulsory context within which to begin engineering investigation, but does not lead to any indices quantifiable to the degree required of engineering decisions, especially in urban foundation engineering concerned with restricted areas and depths and finer property differentiations. For instance, in paging through the Proceedings Volume I could single out two places (pages 194, 244) in which subsoil profiles are complete for foundation engineering, with classification of soil types and consistencies, and three other places (p.84, 257, 264) in which there are subsoil profiles, but without quantification of denseness or consistency.

Since we have developed all of our routine first-approximation foundation design decisions on the basis of exploratory boring with SPT indices, the boring profiles shown on pages 194 to 197 would appear to indicate conditions for economic shallow footings foundations for buildings of about 25 to 30 storeys; but one must be careful to check against possible gross differences in SPT values that can be produced by unstandardized factors of the test, leading one completely astray in comparisons (which is best avoided by comparing with static cone penetrometer values or by comparing SPT values in a standard material such as clayey fill compacted to similar specifications).

I should therefore begin by requesting that a typical exploratory boring profile of Durban be published in the discussions, alongside referenced information on static cone penetrations and/or fundamental data on plate load testing, and alongside a typical plan of column loads of a highrise building of specified number of floors.

For your reference I may summarise the following first order approximations widely used in Brasil. Reinforced concrete building loads correspond to about 1,2 tons per square meter of area in plan, per floor (thus 1,2 n t/m^2 would be the equivalent average pressure on a hypothetical raft). Rafts have never proved necessary or economincal; if the allowable bearing pressure on pad footings is higher than about 1,8 n and therefore overall pad areas add up to less than 65% of the plan area, pads are more economical than piles of the order of 10 m; the competitive limit of percentage area occupied by shallow pads continues below 100% up to the longest piles used (about 25 to 30 m). For somewhat preconsolidated silty clays and clayey sands with $3 < SPT < 25$, plate load tests have suggested allowable bearing pressures equivalanet to $(\sqrt{SPT} - 1) kg/cm^2$ as being satisfactorily conservative, dispensing with computations of settlements and differential settlements on routine range of variation of column loads. Pier foundations have accepted nominal base pressures (assuming zero friction) of the order of 2 to 3 times the above shallow pad indications. For driven displacement piles, the pile length necessary to permit the design load is estimated on the basis of SPT values along the boring profile, with one value per meter of depth; if the layers are considered capable of concomitant contribution to friction and point, the length is such that Σ SPT = compressive stress in kg/cm^2 on the nominal concrete section (for instance, a 30 x 30 cm pile for 40 tons would penetrate to about $\Sigma SPT = 45$); if there is a significant distinction between soft upper layers and embedment into a dense substratum of point resistance, the substratum will be penetrated to where ΣSPT point = one-half the compresive stress.

Such secret unwritten rules are denied as soon as they are passed along, but have served for most preliminary designs; and since in Brasil most often construction follows rapidly upon preliminary design they may be claimed to have been proven. I submit them merely so that they may be compared, challenged, and put to shame. However, in candid contrast may I question whether the assumptions of c and Ø parameters for "upper strata" and "Cretaceous material" in the paper by Everett and McMillan are not merely cloaked with an appearance of acceptable theorization; the crucial problem of pile or pier foundation design is "how were these parameters established"?

Finally, the third point concerns the all-important "execution effects" both for lateral friction and for stress-strain behaviour of the concreted base. In particular, the effects of bentonite (and presumed bentonite cakes) on skin friction and on base compressions have drawn much attention and testing in the past few years (cf. for instance some papers at the European SMFE conference, Madrid 1973). The papers by Everett and McMillan, and by Wates and Knight, tackle a problem of the greatest interest and concern.

In Brasil, and particularly in the kilometers of deep slurry walls of the São Paulo and Rio subways we have had considerable success in general; but one must carefully guard agianst the new "philosopher's stone" complex. Each case must be examined separately; bentonite is not a cure-all, and there are many cases where it is unnecessary or may even be damaging. Of special note to this Conference is the admonition that in soils above the water table a "dry" perforation technique that preserves the benefits of capillary tension may be very much better, since despite the best of bentonite slurries the contact with free water frequently causes catastrophic damage to the soil.