the settlement ratios for the subsoil conditions on which these buildings are founded. Finally, Klein reports the influence of roughness at the pile shaft and volume displacement on the load capacity. He also reaches conclusions to estimate the skin friction for which he proposes a formula.

1.7.- LADANYI (Canada), proposes a theory to estimate the bearing capacity factor N_c in sensitive clays taking into consideration the stress-strain behavior of the clay, namely: he considers important to take into consideration the peak and residual shear strength values of the soil. He finds from the results of this theory in sensitive clay interesting conclusions. He proposes to reduce the value of N_c as a function of the ratio of residual shear strength to the peak value, and also considering the strain-strain characteristics of the soil. To apply this theory, it will be necessary to determine the shear-strain behavior and ultimate shear strength properties of the soil in good undisturbed block samples of the clay.

1.8.- GRESILLON, FORAY, PENCH AND TERRIEZ (France), propose a semi-empirical method to calculate the ultimate load of a pile in uniform sand deposits. They based their calculations on observational results of model test piles, and on the basis that beyond certain depth no further increase takes place on the ultimate point resistance, also on the basis that the skin friction for unit surface reaches a limiting value for important depths. They take into account the compressibility of the soil on the basis of the relative density. They recommend from their investigations, to use Figs. 1 and 2 in their paper, to find in a uniform sand, the relation between relative density, the angle of internal friction and soil density, reaching to a critical confining pressure considered in their calculation to determine the point bearing capacity of piles in sand.

1.9.- TOHENG AND PANET (France), report the results of a test in a group of piles. The tests consisted in pushing a group of 5 model piles from sand of the Loire, and measuring individually the point resistance of each pile as a function of the depth of penetration. The penetration of the group was performed at constant rate of vertical displacement. The authors reached interesting conclusions, stating that the spacement of the piles on their individual loads is important except when the pile diameter exceeds seven diameters. For close spacing the group acts as a single element of larger diameter, it is also concluded that for spacing below 7 diameters the point resistance is greater than that obtained for an isolated pile.

1.10.- SHERMAN (U. S. A.). The author reports the investigation performed on instrumented piles used to support two monolithic foundations. The monoliths were supported on battered piles driven through a stratum about 4 m thick in fine to medium sand, the end bearing was obtained in stiff clay interbedded with very dense silt and fine sand strata, in which they reached a penetration of 6 m. The observational results showed that practically all the net load was carried by the piles, a small fraction on the order of 5% was carried at the soil surface. Furthermore, it was found that the loads on the piles did not show a planar distribution as usually assumed in design. The load on the piles showed higher at the outer piles than those at the center. Undoubtedly, this pile load distribution was obtained because of the monolithic rigid action of the foundation.

1.11.- GRIGORIAN AND IVANOV, (USSR). The authors performed extensive field investigations of piles driven in loess soils, reaching the conclusion that the best method to install piles in loessial soils is to jet down tube-like concrete piles. The General Reporter recommends to see the figures included in the paper showing the pile design.

1.12.- BUTTERFIELD AND JOHNSTON (England), report the results of field tests on a model pile 10 cms in diameter and 4 m long, driven in London Clay overlaid by 2 m gravel previously excavated in a trench 2 x 2 m. The piles and soil were instrumented to measure the stresses induced when loading the piles. The measurements were performed during continuously jacking the piles into the soil, and also extracting them. The interpretation of their results was performed on the basis of the undrained shear strength profile of the soil. However, they had to take into account small angles of internal friction in their interpretation. The shear stresses and total radial stresses during the process of the tests were measured.

1.13.- BEGEMANN, H.K.S. (Holland). The author reports the results of loading and pulling quick tests performed on I-beam piles. The author reached the conclusion that the frictional force upon loading and pulling of a single pile is approximately equal, and no recovery of the loads was observed after two months rest period. The results are compared with the penetration cone device, where the cone and frictional resistance were determined separately. Finally, the author offers in his paper a number of remarks for the interpretation and the use of this type of pile.

1.14.- CHIN AND VAIL (Malaysia), report a set of simple tests performed on precast concrete piles of 50 to 90 feet long driven in alluvium soils of high compressibility. They performed pulling and loading carrying capacity tests. From the pulling test they determine the skin friction. From tests left to rest up to 116 days after driving, no hardening effects were discovered. They reached interesting conclusions for this type of tests, and establish the load-settlement behavior observed in the piles under tension and compression.

1.15.-GREGESSEN, AAS AND DIBIAGIO (Norway). The authors report interesting results of an investigation performed in reinforced concrete piles driven in homogeneous loose sand. The piles were constructed in 8 m long sections instrumented and calibrated before driving. The sections were connected to make 16 m long piles. The authors were able to measure the skin friction and total load capacity. From their observations, they found that considerable negative skin friction developed after pile driving. The load transfer at the upper part of the piles was small. The bearing capacity was found to increase linearly with the pile length embedment in the homogeneous loose sand deposit. They report na significant difference in the bearing capacity for a cylindrical and cone pile of equal length and tip diameter.

1.16.- TROGOL, E. (Turkey), reports tests on natural size piles 52.8 cms diameter, and 28 to 30 m length driven into the sea bottom. The subsoil consisted of an upper stratum of soft, organic and highly plastic silts and clays 6 m thick, followed by a series of deposits of low plasticity silty, sandy silt and gravel underlain by a deep bed of stiff clay with dense sand-gravel lenses. Some piles were left with their point one meter above the hard stratum and others permitted to penetrate into it. Pulling tests were carried out in the first piles to determine skin-friction. The author finds good agreement of the measured pulling force with calculations from a formula he proposes. However, the point bearing capacity values found were not in good agreement with computed values using different concepts of the bearing capacity factors. The discrepancies are attributed to the necessity of assessing more accurate investigations of the soil mechanical properties to be used in the calculations.

1.17.- SHIVASTAVA, S. P. (India), reports a theoretical analysis of a pile group subjected to vertical and lateral loads, assuming the piles forming a structural frame and evaluating the stress- displacement behavior using Mindlin's solution for a point load acting in the isotropic infinite elastic solid. The modulus of elasticity of the soil was assumed increasing linearly with depth. From field tests on one instrumented pile of a group of 9 piles, the author compares results with the theoretical analysis. The author reports comparable results, when the soil parameters are properly assessed, and when the load imposed on the piles induce stresses in the ground not larger than one third of the ultimate values.

1.18.- BROMS AND HILL (Sweden): The authors report an interesting investigation on long Raymond step- taper piles made of corrugated steel, constructed in sections 3.6 m long welded together. The piles were driven with a mandrel with the same shape of the shell. The piles had to support Tower foundations with very critical tilting specifications (1/1000). The subsoil conditions consisted of series of deposits of fine non-cohesive materials with standard penetration resistance increasing with depth. At the upper part of the deposit to about 10m depth up to 50 blows/ft were obtained, from 10 to 40m, the minimum standard penetration was of 50 blows/ft, increasing considerably after 40m depth. The test piles were instrumented to investigate point resistance and skin friction. Pre-drilling was used to install the piles using circulating water and bentonite slurry. The authors reached the conclusion that a very small vertical displacement mobilized the skin friction, in contrast with considerably larger displacements necessary to mobilize the maximum point resistance. The piles installed using bentonite slurry as a circulating fluid showed an appreciable reduction in the skin friction resistance.

2. BEHAVIOR OF LATERAL LOAD ON PILES, STATIC AND DYNAMIC

2.1.- ADAMS AND RDHAKRISHNA (Canada). The authors report tests to investigate the lateral soil stress distribution, deflections and coefficients of subgrade reaction for rigid pier foundations subjected to overturning moments. The tests were performed with instrumented model piers up to 4 inches diameter and 20 inches long, embedded in uniform silica sand in the loose and dense states, respectively. A field test was performed on a three feet diameter instrumented pier in the same manner as the model tests. The authors found from their experiments that the elastic theory using the numerical method of "coefficient of subgrade reaction" overestimates the lateral displacements and rotation of the pier. On the other hand, the ultimate capacity induced by the overturning moment was found in reasonable agreement with the earth pressure theory. A method to predict deflections below ultimate conditions is indicated considering the soil mass as a layered system, and giving to each layer its corresponding modulus of reaction based on the geometrical dimensions of the pier and stress level expected, considering non- linearity in soil behavior.

2.2.- FRANKE, E. (Germany). The author states that in order to obtain reliable results on the behavior of laterally loaded piles, the best procedure is to perform natural scale tests in situ. He suggests to perform tests in three piles embedded at different lengths in the soil mass. This procedure will permit to know the critical embedment, and the pile configuration under the lateral loading conditions applied at the pile head. The piles should be instrumented and the lateral displacements and rotation at the pile cap are measured as the load is applied. The pile load should not be greater than 1.5 of the expected working lateral load. The test is performed with static loading and alternating or repeating loads as the case may be. The tests should include the time element to determine the creep effect under sustained loading. From the analysis of the tests results, differentiation may be made, and theoretical calculations are perfomed adjusting the foundation moduli for the soil layers encountered until agreement is met with the configuration pile curve observed in the pile tests. The method is illustrated in the paper.

2.3.- KHADILKAR AND COLLABORATORS (India). report a theoretical investigation for piles subjected to lateral loads with different embedments in a stiff stratum underlying an upper soft soil deposit. Dimensionless parameters are used changing the ratio of pile stiffness and soil rigidity, also the relative rigidity of the two soil media where the piles are supposed to be driven. The analysis is based on the theory of "coefficients of subgrade reaction" using the orthodox differential equation of bending of beams on elastic supports.

2.4.- PRAKASH, S. (India). The author reports a dynamic investigation on a Franki pile 40 cms diameter and 28 m long, driven through a deposit of clay with a thickness of 23 m, and average unconfined compressive strength of 0.32 Kg/cm . The tip of the pile was driven into a dense sand stratum. The pile was forced to vibrate with an oscillator. The dynamic response of the pile was recorded at the pile head. The author reports the amplitudes obtained against the frequency of vibration imposed to the pile. Using the elastic beam theory and the concept of the modulus of subgrade reaction, he develops a theory to calculate the behavior of the pile under such conditions, determining the vibration mode shapes of the pile. 2485

2.5.- AGARWAL, S. L. (India), reports the results of a study of dynamic laterally loaded small model piles. The piles were embedded in modelled and real clay. From theoretical considerations using Winkler's spring beam theory and introducing damping, theoretical results were obtained and compared with the results obtained from the tests. The author reports fair agreement between theory and results obtained from model tests.

2.6.- BOTEA, E. AND COLLABORATORS (Romania). The authors report extensive test results carried on instrumented piles up to 1.27 m diameter. The piles were placed in a silt and clayey silt deposit and also in series of deposits of fine and medium sand. The results of the tests are compared with values computed on the basis of Winkler's theory and using a soil modulus increasing linearly with depth; the authors found reasonable good agreement between measurements and computations, thus confirming the validity of the assumptions made. They found also that the value of the "coefficient of subgrade reaction" used decreases as the pile deflection increases due to the non linear behavior of the soil and concrete of the pile. The author report that the values of the "coefficient of subgrade reaction" agree close with those recommended by Terzaghi (1955). Finally, they propose an empirical method to calculate the conventional depth of embedment of the pile. Tables are proposed with tentative values for the embedment in loose, medium and dense sands for different values of the moment of inertia of the pile.

2.7.- OTEO, C. (Spain). The author reports the results of an investigation performed on model piles 0.8 cm diameter and 28 cms long. The model piles were placed in groups of 3 x 3 piles with different spacings in loose to dense sand. The pile groups were subjected to alternative lateral forces up to several cycles. They observed that when the soil was in a loose state, a depression at the surface was formed, and settlement of the pile group took place. The authors propose a set of practical rules for the design of such structures, based also on observations performed in connection with various dolphines constructed in the harbor of La Coruña, Spain.

3. LARGE DIAMETER SPECIAL PILES, CAISSONS

3.1.- BOLOGNESI AND MORETTO (Argentina). The authors describe an interesting construction method of large diameter caissons to support bridge piers at the Parana River, to incease the bearing capacity and reduce settlements. To achieve this purpose, they used grauting under high pressures at the base of the pier. The shaft of the pier is constructed using a reinforcing shell lowered by boring through it. The preloading cell with the form of a basquet filled with coarse gravel, is lowered at the time the reinforcing steel is placed. After confining properly the cell, the gravel basquet is grouted under high pressures, thus preloading and compacting the soil at the bearing stratum. Thereafter, the core of the pile is filled with concrete. The authors obtained important results showing that using this construction method higher bearing capacity may be obtained, and the settlement of the pier supported on the bearing stratum is minimized.

3.2.- DIAMANTI, R. (Italy). The author describes a detailed method to install large diameter piles, from 1 to 1.8 m diameter. The large diameter piles were constructed under water for the supports of the bridge tower at the Parana River in Argentina. The subsoil conditions are water laid medium and fine sands increasing their density with depth. The casing was placed with precast concrete elements 7 m long driven with a casing machine and using bentonite slurry mud to reduce side friction. At the bottom a steel cage with gravel was lowered to be used as a preloading cell, thereafter the cell was grouted under high pressure. The space between soil and casing was also grouted to develop side friction before subjecting the base to high pressures. The authors report very satisfactory results as the bearing capacity of the caisson was increased, and the settlements reduced.

3.3.- GOLOMBEK, S. (Brazil). The author describes the construction of unusually long piles of 1.5 m diameter and 70 m long used for bridge supports. They were achieved driving a reinforced steel casing with a thickness of 1/4" at the upper part and 1/2" in the lower part. The driving was performed using in the upper part earth augers assisted by hammers up to the Delmag D- 22, to introduce the piles throughout a series of deposits 20 m thick of loose to dense sand interbedded with thin clay strata. The sand increased its density with depth. The driving followed into a 40 m thick deposit of very soft organic silty clay with fine sand overlying weathered sandstone. In the weathered sandstone, the casing was excavated drilling about 15 m until reaching sound rock at a depth of 70 m. The stability of the hole was achieved using bentonite slurry. The author explains in the paper all the handicaps that had to be overcome in the construction of this unusual very deep foundation.

3.4.- REESE, O'NEILL AND TOUMA, (U.S.A.). The authors report an interesting study of load transfer in bored piles of 75- 90 cms diameter and 13 to 20 m long. The piles were constructed in a stiff clay deposit underlain by a water-bearing sand stratum. The piles were installed by the slurry method, drilling and casing through the stiff clay and then using fluid bentonite to stabilize the hole in the water bearing sand. The bentonite slurry was kept to about 2m above the ground surface to obtain sufficient pressure to avoid caving. The concrete was placed by the "Tremie" method. The finished pile was extended to certain height above the ground surface to assure that the pile up to the required elevation was no more contaminated with bentonite in its upper portion. The measurements on this instrumented pile showed interesting conclusions. The authors found that the side friction for the bored piles in stiff clay installed by the slurry method, is comparable with those cast by the dry technique. They state that by examination of the material at the interface of soil and pile showed a stabilized coating of sand, thus the natural strength of the soil at the pile shaft prevailed. Small displacements on the order of 0.4 to 0.5cm mobilized the shear strength in the stiff clay, and on the order of 0.5 to 1.0cm in the sand deposits. The authors reached the conclusion that in bored piles using the slurry displacement method the point resistance is greatly reduced because of the entrapment of soft material at the tip of the pile.

4. ANCHORED PLATES AND PILES

4.1.- MEYERHOF, G. G. (Canada). The author reports the results of an extensive investigation on model and field tests of shallow and deep anchored plates and piles performed in clays and sands. The anchors were subjected to inclined pulling loads varying from the vertical to the horizontal position. The author proposes a theory, and formulae based on uplift coefficients to estimate the ultimate pulling capacity of these elements, for clay and sand soils. The investigation showed that the uplift coefficients change with the inclination of the pulling load increasing to a maximum value when the pull is exerted in the horizontal direction. The inclination of the pull becomes less important with the anchor depth. Most interesting conclusion stated by the author is that: "for similar soil conditions and given pull inclination ---- the corresponding uplift capacity increases as the inclination of the anchor plates or pile increases from the vertical direction".

4.2.- NUNES, A. J. AND COLLABORATORS (Brazil), report the use of pre-stressed anchorages successfully used in numerous jobs, either in rock or soils. The authors reach interesting conclusions, and propose recommendations for the proper behavior under the pulling loads, in connection with methods of construction.

4.3.- HARMA AND SPARLES (England), describe the test results of circular anchored plates tested in the laboratory in homogeneous normally consolidated sand. The authors propose an interesting method to obtain more pulling force and less vertical displacements. They achieve these results pre-stressing strongly the sand between a deep dead anchor plate and another surface plate jacked down strongly against the soil surface, and fixed strongly to the lower plate by means of a rigid steel shaft. This effect produces high lateral compression on the surrounding soil forming a highly compressed sand cylinder. They find that the pre-loading has a significant effect on the ultimate pulling force and vertical displacements of the anchors. In their investigation, they have also included the relaxation that may be expected after pre-stressing the sand cylinder between both plates.

4.4. PODSIADLO, H. (Poland) presents a method to determine the ultimate bearing capacity of anchor plates in groups. The author investigated the influence of spacing and depth, and developed a theory to calculate the effort to mobilize the ultimate pulling forces. He proposes a formula based on the weight of soil above the plate and depth at which the plates are buried, the geometry of the plate, and the angle of internal friction in cohesionless soils. To verify the formula proposed, the author performed model tests in which fairly good agreement was obtained.

5. PILE DRIVING, PENETRATION TESTS

5.1.- FAWCETT, A. (England), reports an extensive study from results obtained in the use of resonant pile driving hammers. Several jobs were selected by the author to perform this investigation in subsoil conditions from sand to gravelly soils and clays. The results were studied in conjunction with parameters of shear strength, relative density and rate of penetration. The author reaches interesting conclusions from this statistical study, stating that the performance of the machine is closely related to the nature of the soil conditions, relative density, diameter, weight and length of pile. He concludes that well graded sand close to its maximum relative density is very hard to penetrate. On the other hand, the piles may be driven with the resonant pile driver with relative easiness in sand or gravelly soils with loose to medium density. The author proposes limiting values of grain size and uniformity coefficients in cohesionless soils. For pile diameter spacings of 3D, no special difficulties may be encountered. He concludes that the resonant pile driving hammers offer more advantages than other vibratory hammers in cohesive granular soils, but their efficiency is seriously reduced in stiff clays and well graded sand of high relative density.

5.2.- GRUTEMAN, BARTOLOMEY AND COLLABORATORS (USSR). The authors have performed tests to investigate the bearing capacity of piles in relation with penetration tests. Test piles up to 27.3 cms diameter were used, as well as field driven piles of 30 x 30 cms cross section and lengths up to 6 and 8 m. The authors using a special device were able to investigate separately skin friction and point bearing and reached interesting conclusions from their results. The authors propose formulae and coefficients to be used in them to account for deviations obtained from the static penetration tests, and for different types of soils where the test piles were investigated.

The authors propose a formula for the bearing capacity of a strip pile foundation based on ultimate settlements, taking into consideration the soil density, including also in the theoretical analysis the creep phenomena. From pile tests, they determine the proper parameters for similar subsoil type conditions and different pile lengths. To calculate settlements of this type of foundations, they use the two-dimensional primary consolidation theory, and propose tables to calculate settlements in saturated soils.

5.3.- TROFIMENKOV, Ju. G. AND COLLABORATORS (USSR). The authors report tests performed on different types of piled foundations. They explain methods developed to solve either empirically or theoretically the problems on skin friction and point bearing capacity from the study of a large number of field tests. The authors investigated skin friction and point bearing capacity in relation with the results of cone penetration tests; they found important deviations, consequently, they propose a load capacity formula based on the cone penetration test information using variable correction factors to the point cone resistance and to the shaft friction, obtained by means of this penetration test device. With this improvement, they find better agreement with field loading tests.

The authors propose a dynamic formula including a number of factors and coefficients to take into consideration all possible influences affecting driving. The authors report tests for piles with enlarged points to increase point bearing in weak soils, proposing a formula for this type of piles, also in case of tapes piles.

The authors investigated the behavior of bored piles in clayey, collapsible and weak soils with enlarged bases. Investigations were performed installing loading cells to measure displacement along the pile length. In loess deposits, the tests were performed under natural moisture soil conditions and also with saturated soil. They reached interesting conclusions in this type of soils, stating that friction forces may develop already under settlements on the order of 0.2 - 0.1 cm. They conclude these displacements are compatible with the elastic compression of the soil and pile shaft. They propose a formula affected by empirical coefficients to calculate the load capacity of bored piles. They found the proposed formula corresponds closely to the test results.

5.4.- WISEMAN, ZEITLEN AND COLLABORATORS (Israel), report the test results of a study performed during the installation of a great number of piles of various lengths from 18 to 35 m, some driven to end bearing in sand, others into a stiff pre-consolidated clay. The piles were used for pier construction and driven from a dredge line at 12 m depth below the sea level. The piles were jetted and driven to end bearing using different types of hammers. The

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heaviest hammer used was the Delmag 44, with which they were able to reach the highest penetration. The paper describes the experience gained in the performance of the different hammers used. The authors compared the numerous loading pile tests with the dynamic formulae they propose. They indicate in their conclusions that invariably the failure loads obtained from the dynamic formulae overestimated in about 50% the pile loads in comparison with results obtained from the loading pile tests.

5.5.- YOSHINARI AND SAKGUCHI (Japan), report a study on a great number of driven piles. The authors found that the point resistance is a function of the method to install the pile. They also conclude that the point bearing capacity of a pile may be estimated from the (N) values of the soil surrounding the pile tip. The authors propose a formula for practical use to estimate the bearing capacity.

6. EARTH PRESSURE ON RIGID FOUNDATION WALLS

6.1.- CZARNOTA AND RYMSA (Poland), discuss the use of different formulae that have been applied in the past to calculate the horizontal stresses induced by strip footings loads on rigid retaining walls of deep foundations. The authors compared their results with model research. They reached the conclusion that the stresses on a rigid wall structure limiting a soil medium because of neighboring foundations remain so far theoretically unsolved. The horizontal stresses depend on the mechanical properties of the soil medium. Therefore, there is need of more comprehensive research under different soil conditions to find better correlations, in connection with the proper soil parameters.

6.2.-JOSKE AND PRZEDECKI, (Poland). The authors report a theoretical analysis to find the possibility of correlating a kinematical solution to that of the Rankine assumption for the pressures exerted on retaining walls, on the basis that the soil suffers negligible changes in volume during the motion of the retaining wall. From their theoretical considerations, they calculate the pressure distribution on the wall, and find similar results from large scale model tests. They conclude that the solution based on kinematical considerations gives smaller pressures on the wall than those obtained using the Rankine Theory. Apparently, the wall friction was not included in their theoretical assumptions.

7. SETTLEMENT OF BUILDINGS ON PILE FOUNDATIONS

7.1.- VAN DER VEEN AND HORVAT (Holland), report interesting observations and loading tests measurements for the foundation of a building. The results obtained from end bearing loading tests driven into sand deposits overlain by soft soil are compared with penetration tests results. For many years in Holland, great practical experience has been gained in the use of the cone penetration test with very satisfactory results to decide on side skin friction, and point bearing capacity to be assigned to the piles. The authors state, however, that using the cone penetration tests, the predicted settlements have not still come to the point of obtaining satisfactory results. Settlement estimates usually have to be acertained by the experience of the foundation engineer . The authors state in their conclusions to have obtained, however, tolerable settlements for the structure. Most of the settlement occured during the construction period. For the building investigated, the observed settlements showed two times larger than those obtained on single piles for equal loads.

The authors report interesting results on coated piles with a 1 cm thick bitumen layer, obtaining a considerably reduction in the negative skin friction in the upper soft and compressible soil layers overlying the bearing stratum.

7.2.- DIAZ, B. E. (Brazil). The author offers an interesting numerical method that may be used in a computer program, tc solve the problem of vertical and horizontal displacements, and soil reactions of pile groups. The method is based on elasticity considerations of the soil. The group of piles are assumed fixed at their heads with a rigid slab.

7.3.- HLAVACEK AND PETRASCK (Czechoslovakia), report settlement observations for several buildings. Their results give measured settlements versus calculated settlements. A Table with conclusions is given showing the average settlement ratios for the subsoil conditions on which these buildings are founded.

COMMENTS AND CONCLUSIONS

found a great step forward in the understanding of the behavior of deep foundations since the last International Conference. The engineering profession appears to have been aware in the last years to investigate the answers to these problems, mostly under field conditions. Field investigations are expensive, but the reward is always profitable because of the knowledge acquired, and the ability to diagnose the problems better. This effort is translated in economy, mostly in large and medium size jobs. Therefore, proper investigations on the soil mechanical properties in conjunction with well planned programs of tests in the field should be continued and highly encouraged.

The laboratory investigations carried on in s small and medium size model piles, pile groups and pier-like structures are important, since the academic work is always instructive to discover under ideal conditions, the trend of the behavior to be expected in the field, and be able to have the basis to calibrate theories and laboratory findings with field behavior. Most profitable is when comparisons are performed following as close as possible, those aspects of behavior that may follow similitude laws between model and prototype. The time element is extremely important to consider in cases of impervious soils; the granulometry and grains shape, relative density and uniformity in case of cohesionless soils. The mass forces are important when correlating model tests with field conditions.

The papers dealing with friction have yielded interesting conclusions. In general, it has been found that negative skin friction may be estimated with reasonable accuracy for single pile tests; however, the main concern has been to reduce these forces to gain economy in pile foundation design. This phenomenon is present when point bearing piles are driven through consolidating soft layers. It is agreed, in general, that the use of coatings with bitumen or bentonite, reduces the negative skin friction considerably; however, no established values can be given because of the different methods employed.

So far it appears that the reduction in negative skin friction is a matter of specific investigations,and procedures according to the individual experience gained in natural pile tests from observations performed by investigators in different countries.Laboratory investigations with different coating materials and application techniques appear to be necessary to establish definite correlations with field tests,to determine in advance by means of laboratory tests,the skin friction angle between the pile coating and soil.Therefore, forecasting at low cast the approximate negative skin friction forces in usual foundation design practice,and verifying the design by conventional natural size pile test.

Very important is the general agreement that when driving pile groups, the soil mass heaves corresponding to a fraction of the volume displaced by the piles, and high excess pore water pressures are induced within the soil mass of the groups. However, the excess pore water pressures appear to dissipate rapidly, and the ground surface has the tendency to regain its initial elevation, therefore setting on the piles negative skin friction forces immediately after pile driving, as reported by observations performed by BROMS and HILL, GREGESSEN and COLLABORATORS,and TORSTENSSON and VAN DER VEEN and HORVAT.Observations have shown also that heave is considerably reduced if the piles are driven before the excavation is performed.The General Reporter considers that these phenomenological observations are important to consider in foundation design practice.

Numerous tests on model pile groups have been performed by authors in different countries, finding that when the groups are capped by a rigid foundation,the pile loads are higher at the edges than at the center of the groups. This fact is sustained by field investigations performed by SHERMAN on natural size pile groups loaded with a rigid foundation.

In general, it is agreed that to determine the point bearing resistance, the compressibility of the soil has to be taken into account. This has been done for the time being, relating the angle of internal friction with the relative density in the soil mass affected by the stresses induced under the pile points. LADANYI proposes in case of sensitive clays to reduce the (N_c) bearing capacity factor taking into consideration the ratio of residual to peak strengths. Also it is recommended to learn more accurately on the mechanical soil properties under the pile points, to be able to obtain by means of the usual bearing capacity formulae more accurate values for the point resistance.

General agreement is obtained that small vertical displacements mobilize skin friction along the pile shaft, in contrast with the vertical displacement necessary to mobilize the point bearing resistance. Nevertheless, the General Reporter's opinion in this matter is that this phenomenon depends highly on the compressibility and strength of the point bearing stratum.

The USSR investigators: GRUTEMAN, TROFIMENKOV and COLLABORATORS found that the standard cone penetration tests have to be calibrated with parameters pertaining to the different types of soils, to obtain more accurate results when assigning the point bearing capacity, and the lateral skin friction capacity to the real loads carried by natural size pile foundations.

In large diameter pre-bored piles, the use of grouting under high pressure to enlarge the base and compact the soil at the bearing stratum has proved satisfactory to increase point bearing capacity and reduce vertical displacements. The special technique described by BOLOGNESI, MORETTO and DIAMANTI may be used in pre-bored piles or piers. In pre-bored piles, when using the slurry displacement method, the point resistance is greatly reduced because of the soft material trapped at the bottom of the hole, as reported by REESE and COLLABORATORS. Therefore, in these cases, the method proposed above of pre-loading the base by grouting under pressure provides a solution to this problem.

Extensive tests are reported on model pile groups and single piles subjected to lateral loadings. In general, it is agreed that when lateral displacements are not large, the theoretical methods of subgrade reaction may give satisfactory results, and when the foundation moduli are properly assessed. These results have been confirmed in BOTEA'S paper, where he found good agreement testing a natural size pile driven in fine and medium sand. He assumed the soil modulus varying linearly with depth.On the other hand,ADAMS and RDHAKRISHNA report from model tests that using the "coefficient of subgrade reaction",the lateral displacements and rotations may be overestimated.To overcome this action,they propose to consider each layer contributing to the lateral pier or pile with its proper moduli. FRANKE suggests that in order to obtain proper results in piles subjected to lateral loads and to determined properly the soil foundation moduli,natural size pile tests should be performed with at least three piles with different embedment lengths.From the piles deflection configuration obtained in the tests, one may investigate the real average foundation moduli for the different strata where the piles are embedded.The General Reporter finds necessary to clarify discrepancies in the definition of the "coefficient of subgrade reaction",in contrast with the unit soil foundation modulus,since the lateral loading distribution in the pile shaft,and induced stresses distribution in the soil mass should be considered when one refers to the unit foundation modulus.

Dynamic tests have been made on actual size piles as those reported by PRAKASH,in order to learn on the behavior of piles when subjected to vibration and alternating loads at the pile head,and from there establishing theories learn on the modes of vibration of the piles subjected to the dynamic load action at their head.

Great interest has been given to problems concerning the ultimate loads of anchored piles and plates, mostly by means of model tests using plates. Interesting conclusions are reported in the authors' papers. More information, however, appears to be necessary to learn on the load-displacement characteristics of anchors used in different soil conditions.

Pile driving equipment has been always the concern of the practical construction engineer to obtain more efficiency and save time during pile driving. The reports indicate that single and vibratory hammers are still useful and efficient. Nevertheless, in sand and gravelly soils, jetting may be necessary to speed up the work and be able to reach the necessary pile depth. On this subject, an extensive study was presented by FAWCETT on resonant pile driving hammers, which are specially useful for certain limiting values of grain size in cohesionless soils where great efficiency may be achieved; however, the efficiency reduces in compact well graded cohesionless soils and stiff clays.

The earth pressure on deep rigid foundation walls appears to be still in the light of discussion and research, to calibrate theories and improve practical empirical rules. The horizontal pressures obtained in model tests under these conditions, appear to be smaller than those obtained by the RANKINE Theory. CZARNOTA and RYMSA propose to study this problem learning more on the stress- strain- time mechanical characteristics of the soils pushing against a rigid non- yielding wall as indicated by their model tests; obviously also the friction angle between wall and soil should be considered.

Concerning settlements forecasts, the standard cone penetration tests still do no give reliable empirical correlations to ascertain with reasonable accuracy the settlement to be expected in different types of soils, as stated by VAN DER VEEN and HORVAT. Therefore, it appears that the only means to calculate and forecast settlements and tilting of structures under eccentric loadings is by learning with more precision,the compressibility properties of the soil layers affected by the estimated stress induced in the soil mass where the piles are embedded,and in the soil mass where the piles transfer their point loads.The General Reporter should add that the settlement given by one single pile tested under the same working load as the ones used in a pile group, does not necessarily comply with the use of an established efficiency factor.Soil properties under different subsoil conditions may invalidate this practice.

Finally,TROFIMENKOV reports the work performed and under way on deep foundations in the USSR.The use of pilefoundations in most cases of foundation problems has been achieved more economically against other type of foundations. Methods have been developed to solve either empirically or theoretically the problems on skin friction and point bearing capacity from large number of tests and field cases. The investigations have been carried out by the Soviet research organizations of specialists sponsored by the government. Practical rules have been set forth, compatible with practice and have been formulated in Building Codes and Standards. The use of specially designed boring machines have permitted to install large diameter bored piles, enlarging the bearing base up to 3.7 m diameter, and reaching depths up to 28m. Most interesting is the work mentioned, using thyxotropic jackets to install large caissons reducing side friction during installation, and achieving waterproofing.

PROPOSED SUBJECTS FOR PANEL DISCUSSIONS

1.- Coatings to reduce negative skin friction. Typical laboratory tests to determine the angle of internal friction between soil and pile coating. In case piles coated before driving, to what extent is the coating preserved during driving.

2.- The necessity of determining by means of laboratory tests, the shear strength and relative density related with the soil compressibility under the pile tips, to learn more accurately on the bearing capacity factors for point bearing piles or piers in soils where the penetration standard devices may give erratic values.

3.- The necessity of calibrating the cone or standard penetration test device by means of correcting factors for different soil types.

4.- The difference of the "coefficient of subgrade reaction", against the unit foundation modulus should be clarified for future use in the literature, and practical application in foundation design.

5.- In case of environmental forces like: high winds, earthquakes and ground surface subsidence, what would be the general recommendations for additional soil testing and theories to be able to foresee in the foundation design the influence of these forces in the deformational behavior of deep foundations.

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Introduction

The General Reporter has compiled a list of selected papers brought to his attention by the National Committees of different countries working on the subject of Session 3 published in the last years; however,some of these publications may duplicate the already selected bibliography or references given by the authors in their papers.The bibliography is given in the order the General Reporter has divided the subjects presented. Each publication was selected from the name of the author,and when given a definite source where published. They add undoubtedly much to the knowledge acquired in the last years on Deep Foundations. The General Reporter,however, wisches to recommend the reader interested in Session 3, to review the excellent volume of the "State of the Art Reports" presented at the 7th ICOSOMEF,MEXICO 68,where extensive bibliography up to that date was reported.An effort was made to select the publications according to the title of the subject presented

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