Session Chairman's Report

Session 2–Influence of Soil Coditions on the Possibility of Pile Driving and Maximum Depth of Penetration

A. HOLEYMAN

Manager of the Research and Geotechnical Department, Franki
Part-time Assistant Professor at the Universite Libre de Bruxelles, Belgium

INTRODUCTION

The 15 papers included in Session 2 originate from only 4 countries : 5 papers come from France, 4 come from Japan and also 4 from USSR, wheras 2 come from Italy.

The theme of the session "Influence of Soil Conditions on the Possibility of Pile Driving and Maximum Depth of Penetration" is a vital issue for Contractors but also Consultants and Manufacturers. A piled fondation is usually designed for conditions which are not related to pile driving but it is a natural requisite to insure that the piles can be installed according to the design specifications. Further to the feasibility concerns, stands the issue of the prediction of the blowcount diagram which can have a heavy bearing on the reliability of cost estimates.

The possibility of driving piles can be investigated using different approaches :

- intuitive by comparaison
- semi-empirical : by correlating pile driving features to in situ test and by applying driving formulae
- analytical : by using a wave equation program with proper soil properties.

On practical grounds, penetration can be eased by using various techniques : friction reducer, partial displacement, vibration... and these improvement push further the present possibilities of driving, especially in the offshore activities.

On the other hand, driving stresses must be looked at in order to make sure that the integrity of the driven member is guaranteed and this concern limits the energy and driving forces that one might wish to use. Since all of the 15 papers of the session adress at least one of above mentioned issues, it was not evident to define clear-cut categories. That is why the papers will be reviewed below in their order of presentation in the proceedings. For each paper, sallient points will be evidenced and some questions leading to reflection will be raised.

1. On The Embedded Length Of Long Steel Piles With Large Diameter, By T. AKAGI, K. MIURA, K. KAWAKAMI And E. SAEKI (Japan)

This report concerns steel piles used under 3 forms : pipe piles, sheet piles and offshore piles.

The performance record of large and long steel piles is described by condensed tables and charts. From the 42 case studies for which the pile diameter, thickness, length of embedment and the type of hammer are available, a number of statistical relationships are drawn between these features.

Two cases are devoted to the study of stresses occuring in the pile during driving. In situ stress measurements are correlated to a simple analytical assesment of their magnitude.

The influence of the shape pile tip on the blowcount is demonstrated by two other cases. It is found that for a SPT value of 1 to 4 in a sandy silt, the geometry of the pile point has no significant influence on the blow count. However for dense sands ($N \approx 50$) the presence of an outer ring near the tip reduces the blow count by about 16 %.

The last two cases demonstrate that penetration is possible in soft or porous rock. In a diatomous mudstone, it was discovered that friction reducers were ineffective. Pile tips were shown to have buckled during driving into an aerated limestone loaded with fragments of hard limestone.

This report consisely give practical data about the current use of steel piles in Japan. The data about the blowcount reduction due to the addition of cutting devices around the shaft at the base level lead to the natural question of the explanation of such a reduction. In particular, one would be interested to know the effect of such devices on the base resistance as well as on the friction resistance during driving. Such an analysis can be approached by stress measurements at the pile tip, during driving.

2. In Situ Measurement Of Soil Dynamic Resistance, By S. AMAR, F. BAGUELIN, J.F. JEZEQUEL And A. LE MEHAUTE (France)

The purpose of the in situ measurement of soil dynamic resistance is to give means of being able to predict piles and sheet piles driveability. This approach goes to more fundamental features of the soil behaviour than do the conventional dynamic in situ tests.

Up to now indeed, the soil resistance during a dynamic penetration test is measured in terms of blow count. With the equipment presented in this paper, the cone resistance and local friction can be measured directly on the penetrometer sensing tip during driving.

In the first part of the paper, the authors describe the method, the principles and the implementation of the measurements as well as the equipment called "LPC electrical dynamic Penetrometer". In the second part, results are given. Correlations are drawn for different soil types between dynamic resistance as measured by the LPC electrical dynamic Penetrometer and static resistance as measured by conventional testing equipments. A general trend is that the average ratio of the dynamic cone resistance to the static cone resistance measured by the Gouda type equipment varies between 0.7 and 0.8, whether the soil is cohesionless or not. The dynamic friction ratio varies in accordance with the soil character, as for the static friction ratio.

This very interesting paper on the grounds of fundamental behaviour of soil during driving raises the following questions :

- What is the effect of the inertia acting on the mechanical parts of the penetrometer onto the strain gauge measurements ?

- The dynamic friction signal is unfortunately not reproduced, but what is its at rest value ? This can lead to the study of residual stresses.

- It is not possible from the signal given in figure 1 of the paper to determine the at rest value of the cone resistance. Is it supposed to be zero for the interpretation of the electric signals ?

- Would the comparison between the dynamic cone resistance on a ∅ 89 mm cone and a Gouda ∅ 36 mm cone with sleeve still hold if the geometries of the cones were identical ? Can one operate the LPC probe under static conditions ?

3. Penetrability And Soils Characteristics, By S. AMAR, J.P. BRU, M. CARISSAN, J.F. CORTE And E. WASCHKOWSKI (France)

This paper presents the results of a systematic analysis conducted from the observations on numerous sites involving pile and sheet pile driving and encompassing various types of soils. On these sites driving data have been assembled with the results of detailed geotechnical investigations comprizing in situ tests such as PMT, CPT and DPT.

The authors review the main problems associated with the driving and the observations that can lead to their solutions. According to them, wave equation analyses are useful for pile driving prediction but progress has to be made in the determination of the role of driving frequency and of the absorbtion of energy into the soil. They draw our attention on the shape and execution factors (enlarged shoe, jetting...). For vibratory driving, it is suggested that in sands the increase of the frequency leads to a decrease of the lateral friction whereas in clays, a reduced frequency and an enlarged shoe facilitate penetration.

Based on what the authors define as "normal" equipment, a number of empirical relationships are established between pile penetrations and in situ DPT tests penetrations. For the cylindrical DPT, the penetrations are identical to those of full displacement piles whereas for the enlarged point DPT, the penetrations are 2 m in excess of those of small displacement piles.

Another correlation is suggested between the depth of penetration into a bearing stratum and its Menard modulus. CPT test results could not always be correlated because of early refusals.

The practical results and general ideas contained in this report are very useful when making a preliminary assessment of pile drivability from in situ tests. In order to refine this approach, reference can be made to specific cases. One could wonder what is a "normal" equipment. Also one has to be careful about the definition of pile refusal : for example a Franki pile can be accepted with a set of 10 mm because of the high drop of the internal hammer whereas for the top driven piles, a set on the order of 1 mm/blow is more appropriate.

4. Driving Resistance And Soil Condition, By M. APPENDINO, A. NERI, E. TRAMONTIN And L. TRIPICIANO (Italy)

The italian experience drawn from the Porto Tolle site is reviewed under two main aspects : practical and theoretical. The driving technique used for the 42 m long closed end steel pipe piles was modified on the basis of in-depth analysis of the dynamic behaviour of the piles during driving. An extensive instrumentation program was used to measure in situ driving stresses and accelerations as well as other driving features. The data acquired through this program led to a better understanding of the causes of unexpected behaviour.

Significant driving behaviour for pile groups was observed depending on the driving technique (hammer-helmet unit and plug thickness). The interpretation of the recorded dynamic data conducted with standard values (quake and damping) extracted from the literature resulted in the assessment of a high base resistance. This estimate was not in agreement with the interpretation of the reflected wave relative to the incident wave. It was therefore inferred that it was necessary to modify the soil parameters (softer or weaker base behaviour). A parametric analysis was used to back-calculate the actual parameters. The more realistic match between calculated and measured signals demonstrates the necessity to work with interaction parameters obtained from recorded data rather than work with standard values from the literature.

A rational approach to the theoretical modellization of the pile base behaviour is also developped on the basis of the cavity expansion theories for the determination of the ultimate resistance but also for the load-penetration curve, and the damping factor.

This fundamental research coupled with practical results is the kind of work that can advance our in-depth understanding of the pile behaviour during driving . About the deductions made by the authors of the reasons explaining why the second driving equipment did not induce damage, one may consider also the lower impact velocity of the single acting compared to the diesel hammer.

5. Driving Piles With Central Rod In Various Soils, By A.A. BARTOLOMEY (U.S.S.R.)

The possibility of driving concrete piles prestressed by a central rod without lateral reinforcement is investigated under the experimental and theoretical angles. The following benefits of such a product are reported : 4 times less reinforcement needed and 25 % increase in labour productivity.

To establish the technical potential of these piles, made out of ordinary concrete, slag-alkaline binder and gravel, an extensive research program is carried out by the Perm Polytechnical Institute, involving dynamic monitoring of the piles under diesel driving.

The results of the site tests show that the relative degree of compressive stress σ/R in the pile head versus the allowable number of impacts N follows a semi-logarithmic law of the type :

$$\sigma/R = a - b \log N$$

Therefore, given a diesel hammer and a concrete section, it is possible to determine the maximum number of blows that the pile can endure before being driven to refusal. From the measurements of dynamic strains, the author observes that the maximum value occurs at the top of the pile and usually increases as the depth of penetration increases.

This type of pile is suggested to be applicable in loams and clays up to "semi-solid" consistency and in loose to medium dense sands. A table also gives soil conditions in which piles can be utilized and penetration depths for heterogeneous beddings. An empirical formula is given to assess the thickness of interlayers of low compressibility which can be penetrated with a given hammer. The dynamic compressive stress is estimated with another formula involving the hammer energy and the elastic and geometrical factors of the pile and helmet.

6. Experimental Determination Of Skin Friction During Vibropiling, By P. BILLET And J.G. SIEFFERT (France)

The study reported in this paper relates to high frequency (1500 to 3000 Hz) vibropiling, with special reference to sheet piling. Previous studies have shown that it is possible to drive sheet piles only at frequency resonances and the results reported in this paper are limited to resonance of the third order.

Simulation of the process is accomplished in the laboratory by a 15 x 1 mm section in a horizontal sand box. The model sheet pile and its mini-vibrator is pushed with a jack and the following features are recorded : the alternating force, the acceleration, the phase angle between both, the force in the jack and the displacement. From these basic measurements are produced a measure of the friction coefficient and the power.

Measurements conducted with the sand box positioned at 3 different locations along the sheet pile model with respect to its vibrating mode indicate that the friction coefficient is not influenced by this factor and that the use of an average value along the embedded length is justified. It is interesting to note that when the energy delivered to the sheet pile increases, the coefficient of friction decreases significantly, and can become as low as a third of the static value. Another interesting feature is that the average coefficient of friction decreases as the length of embedment increases. For identical normal stress, tests conducted with different sand densities show that the denser the sand, the higher the coefficient of friction.

These observations are used to predict the sheet pile refusal, for which the friction is the essential part of the resistance. The suggested formula equates the total dead weight of the driving system to the lateral friction mobilized during vibratory driving. When the proper horizontal stress ratio and the adequate coefficient of friction are used, the prediction of the penetration depth is correct within about 10 %. For the sands considered, the value of the coefficient of friction was between 0.125 and 0.5 and the value of the horizontal stress ratio about 0.4.

This study has presented original and interesting results concerning a subject which should deserve more attention. One may wonder whether the acceleration level is not a governing factor. In this respect, the data presented would gain in generality if one would know the amplitude of movement for the different powers and also whether the power was varied by changing the frequency or the excentric moment of the vibrator.

7. The Influence Of Driving The Piles Into Water- Saturated Clay Soils Upon Their Bearing Capacity, By B.I. DALMATOV AND I.P. SEREDUK (U.S.S.R.)

Experiments dealing with soil heave during driving reported in this paper show that the volume of soil heave approximates 40 % of the total volume of the driven piles. Measurements were taken on bench marks placed on the surface and during the driving of a group of concrete piles 35 x 35 cm spaced at 1.2 m. These indicated that the uplift zone increases as the driving depth is increasing but also that the amount of uplift around an already driven pile increased when a neighbouring pile was freshly driven.

These soil movements have a significant effect on the piles which have been previously driven : they essentially tend to lift up the pile. This results in the alteration of the residual stresses resulting from straight driving. In particular, the mobilization of the base resistance which is normally under compression right after driving can be substantially decreased. The authors estimated that in the saturated clays prevailing on the considered sites the base resistance mobilization could be divided by a factor equal to 1.7. In those cases, retapping the piles reduces the detrimental effect as evidenced by static load tests.

8. Experiences In Italy With Centricast Concrete Piles, By F. GAMBINI (Italy)

The Centricast piles presented in the paper are hollow spun concrete piles, with the possibility to be tapered on the total length or on a lower portion. Compared to solid piles the author mentions that they are lighter and easier to inspect. The typical use in the 500 kN range is for residential and industrial buildings.

The tapered pile is shown to mobilize a higher friction along its shaft than the cylindrical equivalent pile. This comparaison is substantiated by two static load tests and a CPT test with the measurement of the local friction. The role of the taper is assimilated in the design to the role of a stack of small area annular bases located along the shaft. Depending on the soil nature and the angle of the taper, the equivalent skin friction can be increased by a relative amount on the order of 30 to 40 %.

The paper presents also accesories related to the product : a welded joint, a rapid joint with conic pins and a steel pile point derived from an H beam, necessary to drive into sloping hard banks of rock.

One has to agree that in the situation presented in fig. 3 of the paper, the tapered piles has a higher capacity than the cylindrical pile. It is unfortunate that the level chosen for the base is the weak layer after driving through a much more competent layer, because this situation is not representative of the practice. Had the piles been normally driven 1 or 2 m shorter, the cylindrical pile would have had a higher bearing capacity than the tapered one.

9. Choice Of Hammers For Driving Piles Based On The Results Of Static Sounding, By B.V. GONCHAROV And A.H. ENIKEEV (U.S.S.R.)

The effort which is described in the paper is directed towards the increase of the quality of pile foundations through the driving of piles to a pre-determined level rather than to a given set. In this way it is suggested that one can avoid, with the proper selection of driving equipment, the 5 % breakage associated with the other design philosophy.

In the authors' opinion, the choice of hammer must be based on geotechnical considerations and not on usual values of the ratio of the mass of the pile to the mass of the hammer (i.e. between 0.4 and 1.2). CPT tests can be used for the design of piles but the resistance during driving is somewhat different because the velocity during driving (3 - 6 m/s) is largely superior to the velocity of the static penetrometers (1.5 cm/s). The necessary hammer energy is therefore assessed beforehand on the basis of a driving formula. In this formula, the static resistance is converted into dynamic resistance via a multiplying factor whose value is experimentally established around 5. The elastic deformation of the soil included in the formula is obtained from a chart whose input is the consistency index at the point of the pile and the pile cross sectional area.

A rather sophisticated monogram is presented for the selection of hammer in clay : the energy is the result of graphical combinations of governing parameters. These parameters are the size and length of the pile, the skin friction and the base resistance, and the plastic and elastic sets. Another means of obtaining an indication of the time to be expected for driving operation is also presented, involving the energy used for static penetration.

10. Comparisons Between Predictions And Observations Of Driving Sets For Steel Piles, By A. GUILLOUX And F. BLONDEAU (France)

The authors report on the observations made on a large site involving the driving of hollow steel pipe piles into clayey soils.

The soil conditions consist basically of a soft layer covering strata of clays of increasing consitency with depth. 30 m long piles were driven to a set determined with the ENR formula. The blowcount diagrams were used to define 4 different zones on the site.

Whereas two zones indicate a monotonic increase in the blowcount, the other two were characterized by a very slow, if any, pick-up of the driving resistance. A parametric study was conducted on the basis of the wave equation, solved for the case of a uniform lateral damping coefficient along the shaft. It was found that this parameter had a paramount influence on the character of the blow count diagram, which was not the case of the unit base resistance.

For the zones where refusal was encountered, the lateral damping factor was 30 to 40 kPa/ms^{-1} for a unit base resistance of 10 MPa. For the two other zones, a value of 20 kPa/ms^{-1} was more appropriate, which indicated a remoulding of the clay apparently associated with the presence of thicker soft layers above. The discrepancy between the theoretical prediction and the actual driving diagrams led to the modification of the driving criterium. It was found that some hours after driving, the blowcount increased substantially, and even above the initially expected set.

The adequacy of the decision to stop the piles shorter was substantiated by static load tests. These showed indeed that the reference bearing capacity was exceeded.

In this interesting case history, one would be curious to know more abut the nature of the "very stiff clay" to which corresponds a cone resistance between 8 and 10 MPa. Also could have the lateral friction (local or total) obtained from the CPT tests been of some help in this problem governed by skin friction ? How can the failure mechanisms of a hollow pile during driving and during static loading be compared ? All these questions will require more effort to be answered.

11. Statistical Methods Of Determining Pile Lengths With A View To Possibilities Of Driving, By G.S. KOLESNIK, I.B. RYZHKOV And V.M. ENIKEEV (U.S.S.R.)

The method presented in the paper is aimed at refining the estimate of the bearing capacity of piles from CPT tests. The variation of the estimated bearing capacity relative to the measured exact capacity depends on the size of the area considered : the general standard deviation is 1.4 times larger than the standard deviation measured on a 10.000 m^2 area. Correction factors relative to the design load can be introduced once results of load tests are available and in accordance with the magnitude of the deviation from the expected results (see given table).

It is suggested than once the static capacity is closely estimated, the use of driving formulae should allow to pre-determine the total number of blows to drive the piles to the required depth. It is advised that the estimated total number of blows does not exceed the acceptable limit for the material integrity and that the set never becomes smaller than a minimum value. To understand more in-depth the approach suggested in the paper, it would have been interesting to know the method used to design the piles from sounding tests and the type of criterium used to define the capacity of a pile from load tests.

12. Analysis Of Behavior Of Tubular Piles Driven In Sand, By D.R. LEVACHER And J.G. SIEFFERT (France)

The use of tubular piles in marine and offshore works raises the question of the transfer mechanism of the skin friction. It is not clear when a plug will form in sands and especially in carbonated sands. To elucidate these problems, the authors have conducted a laboratory research with model tubular piles with outer diameters of 40, 60 and 76 mm. The tubes were driven in a sand box with a small hammer (5.6 kg x 1 m) and the set and plug penetration were recorded. After driving, a pull-out test could yield the friction. Three different sands including one carbonated sand were used.

The blow count increased with the depth of penetration except for the carbonated sand. The observed filling-up of the model pile during driving exhibits two phases : it is first proportional to the penetration for small depth and less than proportional afterwards. Solid plugging is not obtained for a depth of 1 m. The filling-up of the tube increases with the diameter of the tube, whatever the depth. For a given sand, it also increases with the initial density of the sand enterring the tube. It is established that the way the plug is formed is influenced by the grain size distribution and the nature of the grains.

The lateral friction measured by the pull-out tests increases with the densities of the sands, except for the carbonated sand : the bore walls remain stable thanks to a certain cohesion. It is also confirmed that the lateral friction is larger on closed-end piles than on open-end piles.

13. Improvement Of Driving Penetrability Of Concrete Piles Driven Into Hard Ground, By H. NAKAGAWA And H. MATSUBARA (Japan)

The first part of this paper is devoted to the demonstration that the driving penetrability of long concrete piles into diluvium cohesive soil can be greatly improved by changing the end shoe of the pile from the closed shoe to the half-open shoe. This proposition is substantiated by driving records of hollow concrete piles (ø 600 mm x 68 m) through silty and hard clays ($N = 3 \sim 10$, $q_u = 200 - 400$ kPa) driven with a diesel hammer of 45 kN. The inside diameter of the centrifugal autoclaved prestressed concrete pile is 420 mm and the closing end plate was provived with different openings up to 120 mm to observe different driving behaviours. It was noticed that no pile broke with the open shoe and that the set was in average 1.4 times the one obtained with the totally closed-end shoe. The increase of the diameter of the hole in the bottom plate led to the increase of the set, the increase of the filling ratio and to the decrease of the rebound. It is confirmed that the analogy of the blowcount diagram with the N_{SPT} profile must be obtained, otherwise one can infer that the pile could be damaged.

The second part of the paper is devoted to the demonstration that the driving penetrability can be improved by increasing the weight of the hammer ram to a maximum extent, but within the range where the concrete pile is not damaged. This well-known proposition is substantiated by the comparison of driving records of offshore piles with 3 different types of hammer : a diesel K45, a diesel K60 and an hydraulic H80. The driving of the partially open-end concrete pile is easier when the energy per blow is higher. Also, the hydraulic hammer, though delivering an energy per blow of about the same magnitude as the lighter K60, gives a lower blowcount. This observation is specially prevailing in hard driving conditions.

This last proposition is a widely observed fact and one would like to make sure that this proposition cannot be altered by the use of different helmets. In this case, it would be interesting to know wether different properties of the helmets used with 3 cases could have altered the conclusions.

14. Penetration Resistance Of Jacked Piles, By O. SAKAGUCHI (Japan)

This is the only paper of the session devoted to the installation of piles by the quasi-static jacking system. This type of pile is a full displacement pile with very low noise and low vibration levels, which is indicated for undepinning because of the availability of reaction.

Four sites are described by their geotechnical profiles with the help of SPT test and C_u measurements. The piles used on these sites were steel piles ranging in diameter from 318 to 457 mm and in length from 8 to 45 m. They were jacked either with an open or with a closed end. The penetration resistance was calculated using the formula for driven piles specified in the code established by the Architectural Institute of Japan. The geotechnical input of this formula is N and C_u, depending on the nature of soils.

After examining the discrepancy between the initial prediction and the actual record, it was determined that the penetration resistance of a pile pressed into soft ground is about 1/5 of the ultimate bearing capacity (estimated and measured by a load test). For cohesionless soils, the measured values are approximately in line with the calculated values.

For heterogeneous subsoils, the penetration resistance diagram varies in accordance with the calculated values. When the pile base enters into a very hard stratum, penetration resistance increases very quickly until the loading capacity of the jacking system is reached and no further penetration is possible. Diagrams giving the pressing force versus the distance from the depth of final penetration indicate that the pattern of load increase is rather independent of the type of closing shoe used.

One always appreciate receiving information on the quasi-static pushing of piles because it is one of the best tools to study the full scale in-situ bearing capacity of piles. Of particular interest in the paper is the evidencing of the scale effect when penetrating dense layers of limited thickness. In this respect, one could hope correlating the jacking diagram with the interpretation of CPT tests, which are in fact the scaled down model tests totally representative of the installation technique. There should be also a way to analyze the influence of the jacking speed on the penetration resistance of such big piles.

15. Penetrability Of Open Ended Steel Pipe Piles On Land, By K. YAMAGATA, T. FUKUYA And S. OMOTE (Japan)

The authors are of the opininion that driving test records should be used to predict the drivability of piles. The object of the paper is to extend some conclusions established from the study of H piles to the case of open ended steel piles. The first study had indicated that penetration resistance during driving comes mainly from the point whereas the skin friction can be almost neglected. Consequently, the cumulative blow count could be used to determine accurately soil stratifications.

Results of driving tests on steel piles in Anagasaki (1962) are reviewed. 3 particular piles are extracted from a pile group of steel piles (Ø 500 mm x l 30-40 m) driven with a 49 kN steam hammer with a drop height of 1.1 m. The piles differ by the shape of the tips and these differences are reflected in the cumulative blowcount diagrams. These diagrams can be readily interpreted to identify different layers of soil because of the linear trends evidenced at various depths. From the fact that the diagrams can be approximated by a straight line in each stratum, it is concluded that the skin friction of the pile is roughly negligible and that the penetration resistance is nearly equal to the point resistance. The plugging is considered not to occur during driving.

More recent pile driving records of open ended steel piles in Japan are analyzed to show the relation between the final set of the pile per blow and the ratio of the embedded length of pile in the bearing stratum to the pile diameter : L/D. For rock, it is demonstrated that the penetration is dependent on the weathering profile. For gravelly and sandy soils, the final set is distributed in the range 1-8 mm with a tendency to reduce as the value of L/D increases. Different zones in the diagrams of the set versus L/D are identified to different ranges of the SPT blowcount. For stiff clays, the sets are distributed in the range 5-15 mm for an N value of 10 to 20. A table summarizes the limiting values of L/D for open ended piles according to the soil type and Standard penetration test value.

Because of the small distance between the piles (1.5 to 2.2 m inferred from fig. 1), it would have been interesting to know the sequence of driving of the pile group in order to better understand the situation at the time of driving of the 3 piles used for the demonstration. It is interesting to note that there is no plug effect during driving, even in dense sands ($N \approx 50$). One could wonder whether the linear trends of the cumulative blowcount diagrams could be the result of compensated combinations of various resistance terms, or the result of the wear of the friction modulated by the effects of the cutting shoes.

REFERENCES

AKAGI T., MIURA K., KAWAKAMI K. and SAEKI E., (1985) - "On the Embedded Length of Long Steel Pipe Piles with Large Diameter", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/1, pp. 69-72.

AMAR S., F. BAGUELIN, JEZEQUEL J.F. and LE MEHAUTE A., (1985) - "Mesure in Situ de la Résistance Dynamique des Sols", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/2, pp. 73-76.

AMAR S., BRU J.P., CARISSAN M., CORTE J.F. and WASCHKOWSKI E., (1985) - "Pénétrabilité et Caractéristiques des Sols", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/3, pp. 77-80.

APPENDINO M., NERI A., TRAMONTIN E. and TRIPICIANO L., (1985) - "Driving Resistance and Soil Condition", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/4, pp. 81-84.

BARTOLOMEY A.A., (1985) - "Driving Piles with Central Rod in Various Soils", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/5, pp. 85-88.

BILLET P. and SIEFFERT J.G., (1985) - "Détermination Expérimentale du Frottement Latéral en Vibrofonçage", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/6, pp. 89-92.

DALMATOV B.I. and SEREDUK I.P., (1985) - "The Influence of Driving the Piles into Water-Saturated Clay Soils upon Their Bearing Capacity", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/7, pp. 93-96.

GAMBINI F., (1985) - "Experiences in Italy with Centricast Concrete Piles", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/8, pp. 97-100.

GONCHAROV B.V. and ENIKEEV A.H., (1985) - "Choice of Hammers for Driving Piles Based on the Results of Static Sounding", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/9, pp. 101-102.

GUILLOUX A. and BLONDEAU F., (1985) - "Comparaisons entre les Prévisions et les Observations de Battage des Pieux Métalliques", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/10, pp. 103-106.

KOLESNIK G.S., RYZHKOV I.B. and ENIKEEV V.M., (1985) - "Statistical Methods of Determining Pile Lengths with a View to Possibilities of Driving", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/11, pp. 107-108.

LEVACHER D.R. and SIEFFERT J.G., (1985) - "L'Analyse du Comportement des Pieux Tubulaires Battus dans les Sables", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/12, pp. 109-112.

NAKAGAWA H. and MATSUBARA N., (1985) - "Improvement of Driving Penetrability of Concrete Piles Driven into Hard Ground", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/13, pp. 113-116.

SAKAGUCHI O., (1985) - "Penetration Resistance of Jacked Piles", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/14, pp. 117-122.

YAMAGATA K., FUKUYA T. and OMOTE S., (1985) - "Penetrability of Open Ended Steel Pipe Piles on Land", Proceedings of the International Symposium on Penetrability and Drivability of Piles, San Francisco, Vol. 1, paper 2/15, pp. 123-128.