Soil Sampling

Echantillonnage du Sol

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INTRODUCTION

Twenty three interesting papers to be presented at the Specialty Session No. 2 for Soil Sampling, IXth ICSMFE, were compiled in the First Volume of the Proceedings of the Session, published and distributed at cost among the participants in the Conference.

The Papers may be classified as follows:

Sampling of sandy soils	6 papers
Sampling of stiff and soft clays	7 papers
Sampling of unusual type of soils	5 papers
Sampling of marine soils	2 papers
Planning and practice in sampling	3 papers

The Session was opened with the Opening Remarks by the Organizer at 15:00 on Monday, July 11th, 1977. Four panellist reports and five panellist discussions were presented under the Chairmanship of Co-Organizer. After a short intermission, fourteen speakers presented their views in Free Discussion under the Chairmanship of Organizer. The Session was adjourned after the Concluding Remarks given by the Co-Organizer and the words of thanks by the Organizer.

Present report summarizes the Papers presented at the Session and outlines the Panel Discussion, Free Discussion and Concluding Remarks during the Session. For reference is attached a List of the Papers. In the following the number in parenthis refers to the number of the paper in the List.

The oral and written discussions presented during and after the Session are to be reproduced in the Second Volume of the Proceedings of the Session.

Acknowledgement is due to the Chairman, Mr. H. Mori, and the members of the Japanese Committee on Soil Sampling for their kind assistance and support to the Session.

I. SUMMARY OF THE PAPERS

1-A. SAMPLING OF SANDY SOILS

A large diameter sampler developed by Ishihara and Silver to obtain undisturbed sand samples, has a diameter of 200 mm and a length of 1000 mm equipped with a stainless steel screen core catcher near the top of the sampler, and may be penetrated without causing any appriciable disturbance if the S.P.T. N value is not more than 15.

The quality of the sample recovered looked to be excellent excepting a local damage near the core catcher. Visual inspection could identify intact horizontal layers, undisturbed lenses and seams contained.

Several test specimens prepared from the sample by use of brass tubes, were frozen in liquid nitrogen, stored and transported to the laboratory packed in dry ice. It has been proven that the techniques used had little damaging effects on the density and fabric of the sample.

The test results of the samples subjected to triaxial cyclic loading, were considered satisfactory in view of providing undisturbed sand samples below the water table.

Hanzawa and Matsuda report on the density determinations of saturated sand layers both in artificial and natural deposits. By use of a Bishop type sampler, 18 kg in weight and zero percent area ratio, almost 700 sand samples were recovered in three sites located in Kawasaki, Niigata and Chiba.

Authors propose procedures for testing the densities of sands in loosest and densest states and a method for determining a mean relative density for practical use.

After determining the density distributions with the depths at three sites mentioned above, it was concluded in general that dry density increases with the effective overburden pressure, but discrepancies are disclosed between the field values and laboratory test results.

It was found that in a specific site the dry density may be in direct proportion to the N value in the S.P.T. But N values are affected so many factors that it should be used only for qualitative manner.

Marcuson et al. describe the results obtained in a laboratory investigation designed to evaluate the quality of undisturbed samples in non-cohesive materials below the water table, and critically access the S.P.T. as a method for determining in situ relative density.

Specimens, 1220 mm diameter and 1830 mm high of two uniform fine sands were constructed in a stacked ring container. A Hvorslev fixed piston thin wall sampler with 76.2 mm inner diameter was used to obtain samples at three overburden pressusres. Incremental tube densities were statistically compared with as built densities. Curves were developed which relate relative density to N values and effective overburden pressure. It was concluded that the S.P.T. is affected by density, structure and lateral stress.

A linear regression analysis performed on the data available from the study by plotting sampled dry density versus place dry density, indicates that sampling slightly densifies the sand at low relative density and tends to loosen denser sand, irrespective of overburden pressure level.

Correlations between N values and relative density should be used cautiously and mainly in a qualitative sense.

Yoshimi et al. introduce a new efficient technique for obtaining undisturbed samples of saturated sands by freezing.

After inserting an open end thin-wall steel tube with a diameter of 73 mm into the ground removing the soil from the inside and sealing the lower end of the tube, a vinyl tube, 30 mm in inside diameter, was inserted in the steel tube to circulate a mixture of ethanol and crushed dry ice. A frozen soil column together with the steel tube was pulled out of the ground and sawed into pieces for cold storage.

One dimensional and full scale radial freezing tests were conducted in the laboratory, and it was concluded that high quality undisturbed samples of clean sands of any density can be obtained. The quality of the samples can be confirmed by checking radial density distribution. The method is more efficient, but the in situ density may be underestimated, if fine content exceeds a certain limit value.

Tohno describes an experiment on saturated specimens of sands taken by means of block and core sampling and tested under unconfined compression and drained triaxial test conditions in order to evaluate the mechanical properties of undisturbed sand.

A nearly constant ratio of the unconfined compression strength to the content of fine grained fraction was observed. The test on saturated samples of good quality showed increase in values of stress dilatancy with increasing confining pressure at low confining pressures in drained triaxial test.

The criterion for evaluating the quality of undisturbed sands sample is proposed by the relationship between unconfined compression strength and fine grained fraction content, and stress dilatancy values at low confining pressures in the drained triaxial tests.

New driving and rotary type samplers were used by Seko and Tobe for sampling sands in drill holes. Each sampler has a sealing system consisting of a ball valve, a rubber seat and a pressing spring located at the top of the sampling tube. One of the shoes has the same diameter as that of brass cylinder container, the other a little smaller.

Experiments for sampling were carried out in alluvial deposits to test dropping of the sample, gross recovery ratio, time required and number of blows. Laboratory tests were made to determine wet densities, moisture contents, specific gravities.

In a laboratory experiment, sand was poured into a steel container and compacted. Sampling was made by the samplers and void ratios of the samples were compared.

Driving type sampler might be more suitable for obtaining a sample with void ratio comparable to in situ value. Critical void ratio was around 0.65.

1-B. SAMPLING OF STIFF AND SOFT CLAYS

Begemann describes the influence of sample disturbance on the shear strength of cohesive soils disclosed by the results of a quick stress-controlled and drained type of triaxial test (cell test).

Several results of severely disturbed samples mainly caused by a too low watertable in the borehole are shown. This type of disturbance can be avoided by using the continuous soil sampler deviced by the Delft Soil Mechanics Laboratory.

If the result of a cell test gives an intersection circle which is clearly smaller than that derived from the in situ vertical stress the sample is not undisturbed.

Raymond presents the comparison of consolidated drained triaxial results on sensitive Leda clay sampled by different methods, which are block sampling, Osterberg sampler, Swedish piston sampler, Shelby piston sampler with sharp cutting edge, Shelby piston sampler and Shelby open tube sampler.

It is concluded that the strains at any given yield index defined by the Author were found to increase as the yield stress difference increases. A straight line relationship through the origin would mean a unique drained deformation modulus at any yield index.

The paper by Iwasaki et al. reports the comparison of field and laboratory experiments by use of two different types of double core sampler, one with protruding inner tube like Denison type; the other with retracted inner tube with rotating core bit.

The comparison was made not only for deformation and strength characteristics in laboratory tests but also for field performances.

It has been shown that the double core sampler with retracted inner tube provided better quality of samples than that with protruding inner tube for stiff clays having unconfined compressive strength higher than 3 to 4 kg/cm^2 or S.P.T. N value higher than 6 to 8.

Seko and Tobe report a comparative study on soil samples taken from drill holes in a stiff clay layer by using seven types of sampler; a double tube core barrel for general core boring, four kinds of Denison samplers, a single tube core barrel, a wire line core barrel and a hammering drive sampler.

The S.P.T. N value of the stiff clay layer ranged from 6 to 12. All the samples taken were subjected to the soil tests in laboratory and the degree of disturbance was evaluated mainly from the results of the unconfined compression strength and deformation characteristics. The results of the investigation indicate that the best sampler is the double tube core sampler contrary to the expectation. The Denison samplers were ranked second and the single tube core barrel and the hammering drive sampler were the least.

Burghignoli and Calabresi present an experimental research on the consolidation of a thick layer of soft clay. The samples were taken by use of a static sampler having a diameter of 500 mm and length of about 2000 mm, and formed by flange coupled sections which can be used as containing rings for consolidation tests.

Radial and vertical consolidation tests have been performed on several sections and the results have been compared with those of conventional tests on small samples.

It was found that the effects of small nonhomogeneities and of macrostructures of soft clays on their consolidation characteristics can be exeprimentally examined by testing sufficiently large samples in comparison with the scale of soil features.

The investigation by Holm and Holtz is related to the difference in quality of samples taken with large diameter fixed piston samplers and the 50 mm diameter Swedish standard piston sampler. The large diameter piston samplers used were the 95 mm Norwegian Geotechnical Institute research sampler, the 127 mm sampler developed by Prof. Osterberg and the 124 mm Swedish Geotechnical Institute research sampler.

The laboratory investigations comprised oedometer and triaxial compression tests, as well as a study of a possible disturbed zone by determining the variation in water content and shear strength with the distance from the center of a sample. This study showed no zone of special disturbance inside the studied distance, 0-50 mm from center of a sample radius of 62 mm. It has been concluded that there is no significant practical difference in the quality of the samples taken with the Swedish standard piston sampler and the three large diameter piston samplers.

Nagaraj et al. investigate the sampling marine clays by attempting a closer examination of primary and secondary disturbances to soil samples as interpreted from in situ and laboratory test data.

Fall cone test data were examined for possible assessment of primary disturbance during sampling. Compressibility and strength data along with information obtained by in situ tests have been examined to assess the degree of subsequent secondary disturbance. It showed that the laboratory test data would provide information to assess the sample disturbance for soft and sensitive clays during sampling and handling.

1-C. SAMPLING OF UNUSUAL TYPE OF SOILS

Tadanier presents a 51 mm suction compression piston type sampler and a sampling procedure developed for analysing the properties of the loosest layer of calcareous mud in a lagoon area.

By use of the sampler the mud could be retrieved for determination of densities. The main concern was the determination of properties and projected behaviour of a stratum of calcareous mud which forms the major portion of the lagoon sediments on which was proposed the extension of an airstrip.

Reference is made to the geology of the site and its relation to the origin of the calcareous sediments.

Kobayashi and Matsumoto investigate soils with a lot of coral fragments found in the coastal regions on the southern part of Japan. The soils consist generally of 30% coral gravels and 70% particles finer than 2 mm in diameter. Stationary piston samplers with spring core catchers were developed and used for obtaining undisturbed samples.

Triaxial compression tests and consolidation tests were carried out to investigate mechanical properties of the soils. A field test was performed on an embankment for studying the results of the laboratory tests.

Yoshinaka and Onodera report the results of sampling decomposed granite and testing its mechanical properties, especially the stress-strain and strength characteristic under a wide range of confining pressures up to 200 kg/cm^2. The sampling was made by hand cutting and hand trimming on the surface of the ground.

The stress-strain relationship under consolidated drained triaxial compression showed apparent elastoplastic behaviour, and the Poisson's ratio changed continuously as deformation proceeded. Deformation modulus increased exponentially in proportion to effective confining pressure. The Mohr's envelope had a considerable non-linearity. The slope angle of the envelope decreased as normal stress increased at first, but became steeper in higher stress range.

Nishigaki et al. report on the sampling and testing of undisturbed samples of diluvial gravels, in order to determine the bearing capacity of foundation beds at a proposed construction site for a long span suspension bridge.

In a pneumatic caisson shaft, specimens of 10 cm in diameter and 20 cm high were obtained by hand trimming, but in case of the material containing larger particles specimens of 30 cm in diameter and 60 cm high were obtained by trimming and driving. Consolidated undrained tests with pore pressure measurements resulted in that the internal angle of shearing resistance in terms of effective stress has rather smaller value than estimated from S.P.T. N value.

The contribution by Kezdi et al. points out the difficulties in connection with sampling macroporous soils with collapsible structure, such as loesses covering vast areas in Middle Europe.

A comparative test was carried out on samples taken from shafts and boring holes respectively in the loess area in Hungary. Samples from boreholes suffer structural changes and they loose their collapsible character, thus giving false safety factor. The effect can be evaluated numerically with the help of triangular diagrams.

1-D. SAMPLING OF MARINE SOILS FROM SEA FLOOR

Okusa et al. have developed improved piston samplers for obtaining submarine sediments from deep sea bottoms. The samplers can be operated either on a boat for shallow water sampling or on a large oceanographic vessel for deep water sampling.

Various types of soil samples were collected from water depths ranging from 20 to 3775 m, for geological and geotechnical study purposes. The samples were well preserved and satisfactory for geological study.

For the geotechnical study, physical property and shear strength tests were made on samples of 90 cm to 400 cm in length from 17 fine grained cores. The physical properties vary considerably with the depositional environment and geological background, but the shear strengths remain within a limited value. The causes of sample disturbance and remedial measures are discussed.

The paper by Okumura presents a theoretical consideration on the change in stress of soil samples taken from sea floor.

Isothermal changes in effective stress and pore pressure of a normally consolidated soil during sampling are analysed on the basis of Boyle's and Henry's laws and the Skempton's parameters of pore pressure.

The residual effective stress of the sample taken from deep sea floor is affected conderably by the release of high pressure which may reach about a half of the in situ mean effective stress in the extreme case, and may decrease even in the shallow water, possibly become negative, for the sample with air fully saturated in the pore fluid.

1-E. PLANNING AND PRACTICE IN SAMPLING

Alonso et al. deal with the problem concerning to the choice of strategies in reconnaissance studies, a complex problem involving a wide varieties of objectives and decision variables. The problem has been approached within an optimization framework. The ultimate goal in reconnaissance studies is not only a matter of accuracy, but an optimization scheme in which reconnaissance, design and system performance are integrated.

This approach is implemented for the case of buildings on isolated pile foundations and the maximum settlement is selected as design variable. A parametric study provides the basis for the development of suitable reconnaissance and design criteria. The analysis of a few real conflicting cases reveals the existence of very important problems not yet solved today.

In the paper by Soares is presented an application of the statistical method in the control of compaction of soils, based on the laws of characterization of soils of the bollow spots and reception of the compacted layers during the formation of the earthwork constructions such as earth dam. These statistical laws involve the number of determinations and the limit values corresponding not only to the dry density and water contents of the compacted soils but also to the spreading of these values measured here by the standard deviation.

Chaturvedi reports soil sampling and investigation techniques applied at various construction sites of dams, highways and so on in Uttar Pradish, India, during the Fifth Five Year Development Plan.

II. PANEL DISCUSSION

2-A. PANELLIST REPORT by W.F. Marcuson III, Dr., Research Civil Engineer, WES, Corps of Engineers, USA.

Eight papers were reviewed. The papers present an interesting and important description of methods for obtaining and evaluating undisturbed soil samples. There exists great difficulty of communication due to the lack of universally understood terminology and standards of practice.

The authors of the papers discussed herein used soil samplers that ranged from 55 mm diameter by 100 mm length to 300 mm diameter by 650 mm length, and one (4) obtained frozen samples approximately 400 mm diameter by 5000 mm long.

Six of the authors (1, 2, 5, 6, 15, 17) discussed Standard Penetration Test (SPT) N values. The test procedure for SPT is described in an ASTM Standard but leaves many unspecified details.

Two of the authors (4, 6) placed sand in a large tank and then sampled it. Placing sand in a uniform manner is a very difficult task. It would appear that a detailed and accurate evaluation of the material in the tank prior to sampling is required before the effects of the sampling procedure can be evaluated.

Two studies (5, 17) discussed the use of test pits to obtain large samples of the soil material. Test pits are expensive and the changes in stress caused by lowering of the ground water table and by the excavation process may disturb the soil more than the sampling procedure.

In two of the studies (1, 4) freezing techniques were used to obtain and/or transport undisturbed samples to the laboratory. Recent studies emphasize that sand has a structure. Further research is needed whether freezing disturbs the soil structure of the in situ material.

Two investigations (15, 17) attempt to obtain intact specimens of sands which contain gravel particles. The authors are to be commended for sharing their experience with us.

Poor sample recovery was reported in two papers (6, 15). Work at the Waterways Experiment Station indicates that the use of a fixed piston sampler and drilling mud is a most effective way for obtaining high quality undisturbed samples from below the water table.

Hanzawa and Matsuda (2) present a new method for obtaining relative density. It would be interesting to compare maximum and minimum densities obtained by various methods. As a matter of practice the WES uses in situ absolute density whenever possible and resorts to the use of in situ relative density only when it is necessary to compare different materials or different sites.

The author agrees with Hanzawa and Matsuda that the SPT is not sufficiently accurate for final evaluation of the density or relative density at a site unless site specific correlations are developed.

For materials with more than 12 percent fines the term relative density may not be appropriate. Problems associated with the measurement of pore water pressure and obtaining 100 percent saturation in large samples were also discussed (5, 17).

Kobayashi and Matsumoto (15) report that the quality of the undisturbed sample is highly dependent on the operation of cleaning out the borehole prior to sampling. I agree with this conclusion.

Seko and Tobe (6) found that the sampling procedure tended to loosen dense materials and densify loose materials. The critical void ratio appears to be a variable, dependent on soil type, grain size distribution, overburden pressure, etc.

2-B. PANELLIST REPORT by K.H.S.Ph. Begemann, Dr., Deputy Managing Director, Delft Soil Mechanics Laboratory, Holland.

There is no standard test procedure to evaluate the degree of sample disturbance applicable to all soil parameters and all types of soil.

Information neccesary to be able to make a comparison of the results of the test to establish the degree of disturbance can roughly be divided into four groups:

- Group A. In situ tests
- Group B. Soil history
- Group C. Measurement on large scale projects
- Group D. Studies of/or omitting crucial link of the chain from sampling to testing.

Burghignoli et al. (11) describe a large sampler for evaluating soft clay behaviour. To shorten the chain of activities the sampler was subdivided into five sections in such a way that the oedometer test could be performed on the sample in each of these sections (Group D). The large diameter samplers gave the best results as compared with the measured settlement.

The paper by Nagaraj et al. (13) report the sampling of marine clays. Primary disturbance has been checked by comparing the in situ vane shear strength executed in two boreholes with the drained strength from the fall cone test on the sample (Group A). The results of the triaxial test as presented in Figs. 3 and 4 ask for some more explanation.

Hashimoto et al. (9) tested two types of core sampler. Three couples of sample test have been performed in the laboratory on the reconsolidated blocks of one soft and two medium stiff clays. Two couples of tests have been performed in the field on soft and fairly stiff clays. A comparison has been made between the unconfined compressive strength of the core and block samples (Group D).
For this very stiff clay, the very high values in LL and PI, the high q_u values and the relatively low SPT N values seem contradictory.

In the research on stiff clay sampling by Seko and Tobe (10) seven types of sampler have been compared. Unfortunately there are no accurate and reliable undisturb parameters available (Group A, B or C). The criterion can only be used in special cases that the more a clay sample is disturbed the smaller the q_u value and the larger the failure strain will be.

Four samplers have been tested in the study of large piston sampler by Holm and Holtz (12) to investigate if there were difference in quality between the samples taken. For instance, the water content and shear strength over the cross sections have been investigated, but no significant variations have been found. The oedometer test results also showed no significant practical differences in quality.

The paper by Raymond (8) presents the comparison of the results of the five different samplers. The samples were taken at depths of 3 m and 6 m. At 3 m depth a block sample was taken as undisturbed sample for comparison (Group B). Oedometer and consolidated drained triaxial tests lead to conclude that stress-strain relations are most indicative for sample disturbance.

The investigation of sampling disturbance may be considered fairly complicated matter. To my opinion more resources of information from one group A, B, C or D will be necessary. Information given should be complete, including description of the boring methods used and all soil characteristics.

2-C. PANELLIST REPORT written by Dinesh Mohan, Professor, Director, and presented by R.K. Bhandari, Head, Soils Division, Central Building Research Institute, India.

The eight papers reviewed deal with diverse materails such as submarine sediment (14, 20), macroporous soil (19), fine sand (3), decomposed granite (16) and compacted soil (18).

An improved version of piston sampler described by Okusa et al. (20) was used for obtaining samples of 0.9 to 4 m long in water depths ranging from 20 to as much as 3775 m. In an earlier paper, Fukuoka and Nakase have presented an excellent review on the use of gravity corer, boomerang sampler, free fall corer, spade sampler etc. for obtaining ocean bottom samples.

Tadanier (14) discussed a 14 m thick lagoon deposit, particularly its geology, physical properties, shear strength and settlement behaviour. A suction compression piston type sampler and sampling procedure were developed for obtaining undisturbed samples of calcareous mud.

Begemann (7) has presented test results to highlight the influence of sample disturbance on the shear strength of cohesive soils. The most important factor causing sample disturbance is identified as the out-of-balance pore pressures generated due to altered position of water level in a borehole. Results of drained and stress-controlled undrained triaxial tests were given and a method of finding out if a sample is disturbed was proposed.

In the paper of laboratory study conducted on fine sands Marcuson at al. (3) proposed an equation based on regression analysis relating relative density with the N values, overconsolidation ratio and effective overburden pressure. The equation was found to be in fair agreement with the correlation curves by Gibbs and Holtz. It is pertinent to consider the effect of impact on the relative density of sand in a model tank, when the SPT tests are done succesively at different depths.

Yoshinaka and Onodera (16) have presented stress-strain behaviour of undisturbed cylindrical specimens of decomposed granite. Within the limit of the test performed, deformation modulus increased in proportion to the effective confining pressure. Mohr failure envelope was found to be non-linear. One of the reasons for this appears to be better contact and interlocking of the asperities on the shear plane due to high effective confining pressures.

Kezdi at al. (19) highlight difficulties encountered while sampling macroporous soils such as the loess having collapsible structure. On the basis of exhaustive sampling and systematic laboratory studies on tube samples from boreholes and direct samples from shafts, it is concluded that compressibility of shaft sample was twice that of the tube sample, and shaft samples preserve virgin collapsible structure, whereas the tube samples had slumped at the time of sampling. Use of a phase diagram can represent the structural background of a collapsible soil during sampling.

Soares demonstrates in his paper (18) how statistical methods can aid in controlling soil compaction in earth dam construction. The decision of accepting or rejecting a given compacted layer is made possible by fixing a minimum number of observations of dry density and water content and stipulating permissible range of their values. Normally with increasing number of determinations, the coefficient of variation must decrease. In the case reported reverse trend is seen for dry density and water content. It is questioned if the nature of samples are different, i.e. variability is more in the field samples than in the laboratory specimens.

Alonso et al. (21) present an optimization scheme in which reconnaissance, design and system performance are integrated. Optimization lies in minimization of cost with due consideration to the damage aspect. A new term catastrophic damage has been added to the list of damages proposed earlier by Skempton and MacDonald. It is suggested that the reconnaissance should be planned in different stages.

2-D. PANELLIST REPORT by H. Mori, Chairman of Japanese Committee of Soil Sampling, President, Kiso Jiban Consultants Co. Ltd., Japan.

Reviewing the papers presented to this Conference and also published in other publications, the methods and the equipment for sand sampling are summarized in a table. The sand sampling procedures could be classified into four groups: the thin wall tube sampler with a stationary piston either statically operated or dynamically driven, the modified Bishop sampler, the improved Denison sampler and the special techniques including large diameter sampler, rotary foil sampler and freezing method. Further progress of those different types of samplers and the procedures may depend on the condition of soil and for the purpose of investigation.

The determination of the relative density of sand sample is associated with considerable amount of systematic and random errors. A Committee in the Japanese Society of S.M.F.E. has specified the details of testing to measure the maximum and minimum dry densities of sands. The minimum void ratios obtained by this method were closely coincident with those by ASTM method.

The Japanese Committee on Soil Sampling recently completed a drafting of the standard of the sampling technique by use of thin wall tube sampler with a stationary piston. The specific feature is that the standard designates the dimension of the sampler.

It is considered possible to make any approach to assist a commune code of this standard when any country is going to establish a new standard or to modify the standard.

2-E. PANELLIST DISCUSSION by H. Hanzawa, Research Engineer, Toa Harbour Works Co. Ltd., Japan.

The samplers with relative lightness and compactness, 55 mm in diameter and 18 kg in weight, developed by the authors can readily be used in ordinary soil survey drill rig. During the penetration process in sampling sands the volume change is unavoidable. It has been well known that volume change would vary according to the density of the sand and as well as confining pressure and sampler diameter. A container experiment made it clear that penetration rate is another important element.

The word relative density often used in my paper may be comparative to the consistency index in clays. Expressing the condition of sand with relative density is far more effective than expressing the situation in clay with consistency index. But sampling loose saturated sand is extremely difficult because of the lack of reliable sampling method.

Shear characteristics of sands is mainly determined by confined pressure and density. So I do agree with Dr. Marcuson that in situ absolute density should be utilized. I have doubt as to the point correlating high fine material content with relative density.

It is suggested that in situ density and relative density measurements should be simultaneously conducted at any time.

2-F. PANELLIST DISCUSSION by K. Ishihara, Professor, Faculty of Engineering, The University of Tokyo, Japan.

In connection with the point raised by Dr. Marcuson regarding the effect of freezing, the author presents one of the cyclic triaxial test results.

One group of the undisturbed partially saturated samples of solidified sand was frozen at the site by means of dry ice, another being not frozen and both transported carefully to the laboratory and tested.
It was found that the samples frozen exhibited less resistance to liquefaction than the samples not frozen. This is just to indicate what the effect of freezing could be the case in this specific sand sample. This conclusion may not applicable to freshly deposited sand.

2-G. PANELLIST DISCUSSION by T. Okumura, Research Civil Engineer, Port and Harbour Research Institute, Ministry of Transportation, Japan.

This to explain some examples of relationship between the stress change and mechanical properties of clay, in connection with the report by Dr. Begemann.

A unique relationship between the disturbance ratio and disturbed strength ratio of Hommoku marine clay was derived from simple shear test and triaxial repeated loading test.
The relationship between the disturbance ratio and Young's modulus divided by initial consolidation pressure was also unique.

The consolidation curves exhibited that the more disturbed sample loses its effective stress the more it shifts to the left side and reaches to the virgin compression curve at a higher consolidation pressure. Unique relationships were found between the coefficient of volume compressibility multiplied by the consolidation pressure and the reconsolidation ratio, and also between the modified coefficient of consolidation and the reconsolidation ratio.

2-H. PANELLIST DISCUSSION by R.D. Holtz, Assistant Professor, School of Civil Engineering, Purdue University, USA.

A series of tests was carried out in soft clay layer in Sweden by use of large diameter samplers and Swedish standard piston sampler. The test results have showed from stress versus depth relations that there was not very much difference between the samplers in terms of the particularly important properties P_c/P_o.

The other thing investigated were triaxial test and unconfined compression test. And again there was not very much differences also in the same depth. In conclusion, the practical implications of this work is that the Swedes can very happily continue to use their 50 mm standard sampler.

2-J. PANELLIST DISCUSSION by A. Kezdi, Professor, Department of Geotechniques, Technical University of Budapest, Hungary.

It is generally assumed that natural undisturbed samples are less uniform than disturbed ones. But the test result showed that the scatter of the indivisual test was greater when we had a disturbed sample and the results were more uniform with undisturbed samples. In order to discover the reason of that, experiment was carried out. Three different samples of fine sand were prepared: one undisturbed sample from a shaft, another prepared in the laboratory by thouroughly remoulding the sand sample, and the third one artificially prepared by sedimenting the same material into a container.

By use of a square net on the surface of the enlarged photographs of the samples, one by one counts of grains comming into the square were made and then Gauss distribution curve could be prepared. The results of the countings have shown that the undisturbed natural deposit is much more uniform and the less uniform specimen was the sedimented one. So we can see what geology makes. Slow deposition in great many years of geological history produced a very uniform deposit and in the laboratory it can not be imitated. We have to know that all disturbed fine sand samples are far from being uniform.

III. FREE DISCUSSION

3-A. DISCUSSION by W.F. Marcuson III.

The tank test conducted at the Waterways Experiment Station provided a relationship of relative density versus initial density, which shows that loose sands densify when sampled and dense sands loosen when sampled.

A correction for density due to overburden pressure and also a density correction for location in a sample tube have been established.

The scatter in sample density versus place dry density might be less or might be more if we more clearly understood the characteristics of material in the tank prior to sampling.

3-B. DISCUSSION by H.K.S.Ph. Begemann

I wish to comment on the result of those tests by Hashimoto and others carried out in the field on stiff clay. I wondered why the soil with high q_u value and LL gives N value of only 13. Hashimoto told me that the soil was completely saturated. So may we accept in that case that these values are all correct, but I still think that the SPT N value is a little bit on lower side, if the soil be thoroughly saturated.

3-C. DISCUSSION by R. K. Bhandari

Regarding Professor Holtz's comment on P_c/P_o, we have the experiences of marine clays in India that this is indeed large in the case of disturbed samples. We found that the Skempton's relationship does hold true in most normally consolidated soils, but if the relation does not fit, one must look into the possibility of sample disturbance.

As Professor Kezdi very rightly stated, the structure of undisturbed, remoulded and sedimented soils is absolutely essential. In order to fit upon the correspondence between the behaviour upon undisturbed sample and those remoulded and sedimented, one must look into the question of structure of the material.

3-D. DISCUSSION Ey T. S. Nagaraj (India)

I would like to supplement some information and also to clarify a couple of points raised by Dr. Begemann.

In my paper (13) black dry clay should read black clay, and with respect to the borehole bluish black dry should read bluish black clay. With respect to Figs. 3 and 4 it was mainly intended to reflect that if the soil structure has some resistance to offer up to the level of the critical stress, there won't be any structural break down.

The points on the y-axis were derived from UU test. There were not any change in strength since the finite conditions still maintain for CU test up to the critical value, beyond that value the state of the material itself would change and the CU test would reflect a different picture.

3-E. DISCUSSION by R. Tadanier (Australia)

My paper (14) deals with material which has an oose behaviour with a void ratio of two and would be subject to settlement just on vibration.

One of the rules I observed is that when you obtain such a sample, you should not try to take it to laboratory, but to take the volume measurement right in situ.

If the void ratio of the material dropped from 2 to 1.5 due to vibration, the consolidation behaviour would become similar to the the theory by Terzaghi.

3-F. DISCUSSION by T.F. Onodera (Thailand)

It is well known in the field of rock mechanics that Mohr's failure envelope is not linear especially at low confining ressure, not at high confining pressure. The material with hard grains filled with soft material would show the failure envelopes in common similar to that of Fig. 10.

Fig. 2 gives that in the region of lower confining pressure decomposed granite has compressibility similar to or larger than soil. However in the region of higher confining pressure the compressibility is similar to that of so called common rock. The mechanism of brittle failure has been clarified by some research works, but failure mechanism of so called soft rock is now under study. The mode of rock failure pointed out by the reporter is the phase of so called rock.

3-G. DISCUSSION by Y. Yoshimi (Japan)

The test results on the effect of inserting the freezing tube into the sand on the density have shown that when the sand was loose intially, the area close to the freezing tube has densified as the result of inserting the tube. When the sand was dense, the sand was loosened near the freezing tube. However away from the tube the sand remained nearly undisturbed.

Concerning to the effect of freezing on the structure of the sand, drained triaxial compression test results exhibited no significant difference in terms of the stress-strain relationship and also dilatancy.

3-H. DISCUSSION by K. Matsumoto (Japan)

In order to reduce the effect of water depth for obtaining undisturbed samples from deep sea bottom, we developed an automatic sampling system, in which the sampling equipment is sunken to the sea bottom and operated by a robot mechanism. The sampler is similar to the Osterberg fixed piston type and workable at the water depth of 30 to 50 m. Every 2.5 m depth one sample can be obtained. The sample diameter is 75 mm with a length of 1000 mm. A foil sampler is now under development.

3-J. DISCUSSION by T. Hashimoto (Japan)

In response to the comment on our paper (9) by Dr. Begemann, I would like to mention that the block samples showed higher values in unconfined compressive strength and SPT N value as compared with the commonly observed ones.

3-K. DISCUSSION by R. Seko (Japan)

In connection with the review of our paper (10) by Dr. Begemann, here is to explain some of the background of the study.

We could not have any established parameter as pointed out by Dr. Begemann. But as we obtained samples from the same site at the same time, the strengths and strains of the samples could be one of the comparative indices. For a saturated clay may apply the general principle that the greater the disturbance of the sample, the less the strength. It was found against our expectation that the samples obtained from double core tube indicated higher strength than those by Denison type sampler.

3-L. DISCUSSION by A. Ellstein (Mexico)

According to the study by Henkel, a sample of normally consolidated clay subjected to the deviatoric stress shows an increase in pore pressure. On the contrary, an overconsolidated sample gives a decrease in pore pressure and an increase in strength. Depending on the degree of distortion in the structure of soil during sampling, may take place an increase or a decrease in pore pressure, which results in a decrease or increase in the strength of soil. This explains that the apparent paradox pointed out by Dr. Begemann may not be in real exsistence.

3-M. DISCUSSION by E. E. Alonso (Spain)

This paper (21) deals with the general approach to reconnaissance and in short trys to answer the question how to plan soil investigation, a difficult question.

The precision of reconnaissance is related to the investigation, design, construction and behaviour after construction. Apparently a good way to integrate all these steps is some optimization concept, and at this moment I think the probabilistic methods are good tool to implement optimization. This systematic process has been applied to a particular case of building project.

3-N. DISCUSSION by P. Le Tirant (France)

A large diameter vibro sampling has been developed by French Oil Institute for several years for the sampling of heterogeneous marine soils. This vibro sampling enables taking of samples up to 300 mm in diameter and up to length of several tens of meters.

This equipment has the power of 100 to 200 horse power. It may function either in vibration or in vibro percussion. One type can be used up to 200 m in depth. Another one developed quite recently goes to a depth of 600 m.

IV. CONCLUDING REMARKS by J. A. Jimenez Salas, Co-Organizer

Mr. Mori mentioned in his report the difficulties in soil sampling of stiff clay, soft rock and cohesionless soil. Most of our recent important works in Spain are related to this kind of materials.

For instance, in Sevilla, South Spain, the works for an underground railway have recently started. The tunnel will pass through a blue clay layer like London one, from which some thousands of samples have been recovered by use of a double or a triple barrel corer called Mazier corer.

We have tested a great number of samples; cubic block samples trimmed in by hand, cylindrical samples taken also by hand in a steel tube and samples obtained with the Mazier sampler. We know since long that the ratio between the real settlements of a structure founded on over-consolidated clays and the calculated settlements found on the basis of laboratory test is in the order of six to ten.

During the works of deepening the pit, a certain number of plate bearing tests were performed, some of them vertically and some horizontally against the walls of small pits at the bottom of the excavation. From those tests the secant moduli of deformation of the clay were calculated. Another value was calculated from the rebound of the bottom of the finished pit under the hypothesis of a perfect elastic material. The best coincidence with the last one comes from the horizontal plate bearing tests. All the results obtained from the samples are plainly unusable.

Similar results are obtained in a sandy clay in the site of a nuclear power plant about two hundred kilometers to the west of Madrid.

The ratio between the moduli found in the horizontal and vertical plate bearing tests is of the order of 2.7 in the virgin load curves and 2.1 in the second cycles of loading. This fact is not due to a real anisotropy of the soils, but solely a matter of an induced anisotropy of the superficial layers decompressed by the process of excavation.

The over-consolidated soils, we are referring to, have some kind of cementation which has a brittle quality, being degraded when the cemented contacts are unloaded. As a consequence, this kind of soil is in a degraded state near the surface. Samples of any kind including the most carefully handled blocks are even more severely disturbed.

We can distinguish two different kinds of layers. The most superficial zone with every bond degraded by tension and shear deformations and another one with vertical bonds more or less degraded, but with the horizontal ones nearly all of them in good conditions. In this situation a vertical plate bearing test integrated the deformation of nearly every degraded bond. On the other hand an horizontal plate bearing test into a pit finds less degraded layers and reaches a zone of intact horizontal bonds both in radial and circumferential directions.

The soils having its origin in decomposed granite become a collapsible soil when excavated and recompacted. It is also very difficult or perhaps practically impossible to make the sampling without changing the pore water pressure state, which can produce this kind of soil collapse. In the case of semi-saturated, especially non-cohesive or slightly cohesive soils, the technique for sampling has a long way to go in my opinion before arriving to a reliable result in the great majority of the cases.

V. LIST OF PAPERS PRESENTED AT THE SESSION

1. Ishihara, K. and Silver, M.L.: large diameter sand sampling to provide specimens for liquefaction testing.
2. Hanzawa, H. and Matsuda, E.: Density of alluvial sand deposits obtained from sand sampling.
3. Marcuson III, W.F., Cooper, S.S. and Bieganousky, W.A.: Laboratory sampling study conducted on fine sands.
4. Yoshimi, Y., Hatanaka, M. and Oh-oka, H.: A simple method for undisturbed sand sampling by freezing.
5. Tohno, I.: Methods to evaluate quality of undisturbed samples of sands.
6. Seko, R. and Tobe, K.: An experimental investigation of sand sampling.
7. Begemann, H.K.S.Ph.: Sample disturbance influencing shear strength of cohesive soils.
8. Raymond, G.P.: Effect of sampling on the drained properties of Leda clay.
9. Iwasaki, Y.T., Hashimoto, T., Hongo, H., Hirayama, H. and Murakami, S.: On the undisturbed sampling for stiff clay.
10. Seko, R. and Tobe, K.: Research of stiff clay sampling.
11. Burghignoli, A.A. and Calabresi, G.: Large sampler for the evaluation of soft clays behaviour.
12. Holm, G. and Holtz, R.D.: A study of large diameter piston samplers.
13. Rao, N.B.S., Pranesh, M.R. and Nagaraj, T.S.: Sampling of marine clays in Mangalore Harbour Area.
14. Tadanier, R.: Exploration of submarine soils at Lord Howe Island.
15. Kobayashi, M. and Matsumoto, K.: Sampling of soil with finger coral.
16. Yoshinaka, R. and Onodera, T.F.: Undisturbed sampling decomposed granite soil and its mechanical properties.
17. Nishigaki, Y., Takahashi, K. and Noto, T.: Sampling and testing of undisturbed diluvial gravels.
18. Soares, G.: Application of the statistical method in control of compaction of soils.
19. Kezdi, A., Kabai, I. and Biczok, E.: Sampling macroporous soils.
20. Okusa, S., Nakamura, T., Sato, T, and Oda, N.: Obtaining submarine sediments with improved piston sampler.
21. Alonso, E.E., Casanova, J., Murcia, J. and Santos, J.: Criteria for the design of sampling strategies in reconnaissance studies.
22. Okumura, T.: Stress change of soil sample taken from sea floor.
23. Chaturvedi, A.C.: Soil sampling in U. P.