03 Jun 1993, 2:00 pm - 4:00 pm

Discussions and Replies Session 3

Ming-Hung Chen
University of Missouri--Rolla

R. C. Chaney
Humboldt State University, California

Wade E. Cooper
Denver Safety and Health Technology Center, Denver, Colorado

John Ferritto
U. S. Naval Civil Engineering Laboratory, Port Hueneme, California

A. Popovici
Civil Engineering Institute, Bucharest, Romania

See next page for additional authors

DISCUSSIONS AND REPLIES

SESSION III

Discussion by Ming-Hung Chen
Graduate student of UMR

on
Earthquake Damage to Fill Dams

Paper No. 3.13

A 1978 survey shown that there are more than 250,000 fill dams in Japan, 75% of the dams are more than 100 years old and generally small , and 80% have a height of less than 10 m. The damage by Oga Earthquake (1939) was surveyed by Akiba. The major conclusion is that a large damage occur to the earth dams with embankment of sandy soil. This report shown no large scale fill dam with height of 15-30 m have suffered heavy earthquake damage, except the case of Manno-ike . The Japanese engineers found that large-scale fills dams have never suffer critical damage, concluding that current dam design method (material characteristic and slope stability analysis method) are technically adequate.

For dams constructed of saturated cohesionless soils are subjected to strong shaking, a primary cause of damage or failure is the build-up of pore water pressure in the embankment and possible loss of strength which may occur as a result of these pore pressures. Methods of stability analysis which seems not consider this pore pressure.

Discussion by R. C. Cheney
Humboldt State University, California, USA

on
Earthquake Damage to Fill Dams

Paper No. 3.13

The author has summarized the damage and performance of fill dams that have heights greater than 15m. This summary was developed from a survey of the literature, and unpublished client reports. A review of the paper tends to indicate that modern fill dams tend to undergo predominantly settlement rather than slope instability during a seismic loading. The author has also indicated that there is a large occurrence of longitudinal tension cracks that develop at the dam crests during a seismic loading. A method that could possibly be employed to handle this problem is to incorporate a series of layers of geosynthetics such as a geogrid in the fill comprising the dam crest. The presence of the geosynthetic would give the fill material a tensile resistance that it does not have at present.

Discussion by Ming-Hung Chen
Graduate student of UMR

on
Liquefaction Case Histories from 1990 Manjil, Iran, Earthquake

Paper No. 3.18

The Manjil, Iran earthquake, Ms=7.7 occur on June 21, 1990. Official estimates indicate that more than 35,000 people lost their lives. The total duration of the record shown that is about 60 seconds the effective duration of interest for liquefaction analysis is about 15 seconds. From the field data of damage areas, shown that the grains size of soil is uniform sand. The value of (N1) over 17 will not caused liquefaction in the earthquake. The following question are interested me.

1. In this earthquake, How many type of failure was happen ?
2. In the liquefaction area, Is there any structures that was no damages, what kinds of foundation were these building used ?
3. After this liquefaction, If the earthquake of the same magnitude happened in the same area, will liquefaction happen again ? The extent of damage will mitigate or worst.

Discussion by Wade E. Cooper
Civil Engineer, Mine Safety & Health Admin.
Denver Safety and Health Technology Center
Mine Waste and Construction Division
Denver, CO

on

Evaluation of Liquefaction Potential of Coal Slurry

Paper No. 3.20

The authors should be commended for their contribution on using new technology for evaluating the liquefaction potential of coal mine refuse impoundments. The results of the liquefaction analysis are highly dependent on the accuracy and reliability of the moisture/density measurements taken with a down-the-hole nuclear moisture/density gauge. However, the paper does not provide sufficient information about the nuclear moisture/density method (such as type and size of radioactive sources and detection equipment) to make a scientific evaluation as to the accuracy and reliability of the method used. Neither does the paper perform a scientific evaluation of the accuracy and reliability of the nuclear moisture/density method to support its conclusion that, "The nuclear moisture/density method presents a reliable technique for determining the density and moisture contents as well as specific gravity and void ratio in saturated materials throughout the full depth of potentially liquefiable materials." It is apparent that additional research needs to be performed to determine the accuracy and reliability of the down-the-hole nuclear moisture/density gauge method for determining the in situ moisture content, density, specific gravity, and void ratio of fine coal refuse in embankments. Especially since these properties can be highly variable within a single borehole.

Discussion by R. C. Chaney
Humboldt State University, California, USA

on
Liquefaction Study Eastern Scheldt Foreshore

Paper No. 3.31

Based on historical information flow slide susceptibility is a function of slope angle, slope height, density, and age of the deposit. The author has used the concept of critical density to evaluate flow slide susceptibility of marine sands. Density was determined by CPT. The author approaches this problem using a series of different methods: (1)deterministic flow slide model, (2) statistical, and (3) probabilistic approaches.

In his discussion the author indicates that old marine deposits are less susceptible to flow slides than young marine deposits. Unfortunately the methodologies employed were not able to discern the effect of age. A possible reason for this discrepancy is that the CPT involves large strains which tend to obscure any small bonding or differences in contact that has occurred between particles.

The presence of either bonding or better contact between particles results in an increase in the materials stiffness and liquefaction resistance (Chaney and Fang, 1985; Saxena, Avramidis, and Reddy, 1988; Seed, 1976; Afifi and Woods,1971 and 1973; Anderson and Stokoe, 1978). Both bonding and the development of better contact between particles are a function of time. The bonding between particles may be due to either adhesion bonding or cementation.

Perhaps a way to approach the problem of identifying the presence of either bonding or differences in contact between particles in old and new deposits is by the use of a seismic cone.

REFERENCES:

Afifi, S.E.A., and Woods, R.D. (1971), "Long-Term Pressure Effects on Shear Modulus of Soils," Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 97, No. SM10, October, pp. 1445-1460.

Afifi, S.E.A., and Richart, F.E., Jr. (1973), "Stress-History Effects on Shear Modulus of Soils," Soils and Foundations, Vol. 13, No. 1, March, pp. 77-95.

Anderson, D.G. and Stokoe, K.H., II (1978), "Shear Modulus: A Time Dependent Soil Property," Dynamic Geotechnical Testing, ASTM STP 654, American Society for Testing and Materials, pp. 66-90.

Chaney, R.C., and Fang, H.Y. (1985). "Static and Dynamic Properties of Marine Sediments: A State of the Art," Marine Geotechnology and Nearshore/Offshore Structures, ASTM STP 923, American Society for Testing and Materials, pp. 74-111.

Saxena, S.K., Avramidis, A.S., and Reddy, K.R. (1988). "Dynamic Moduli and Damping Ratios for Cemented Sands at Low Strains", Canadian Geotechnical Journal, Vol. 25, No. 2, pp. 353-368.

Seed, H.B. (1976), "Evaluation of Soil Liquefaction Effects on Level Ground During Earthquakes," State of the Art Paper, Symposium on Soil Liquefaction, ASCE National Convention, Philadelphia, pp. 1-104.

Discussion by Author, John Ferritto
Naval Civil Engineering Laboratory
Port Hueneme, California

on
"Effects of High Plasticity Clay Deposits on Site Ground Motion Amplification"

Paper No. 3.33

A comment was made that the shear modulus ratio curve used to represent the basic low plasticity clay was out of date. While the author concurs in that statement, basic conclusion still holds. Further analyses were performed of the Treasure Island site for the Loma Prieta earthquake in which the curves reported by Vucetic et al. (1991, Reference 14 cited in the paper) were used to represent the Young Bay Mud layer. Plasticity Index values covering a range from 0 to 50 were studied. Figure 1 shows the curves of shear modulus ratio; Figure 2 shows the site response. As noted earlier, amplification does not occur for the case where the Plasticity Index is 0.0.

The conclusion of the paper remains that deposits of high Plasticity Index materials, such as the Holocene Young Bay Muds, should be viewed as having the potential for high site amplification.

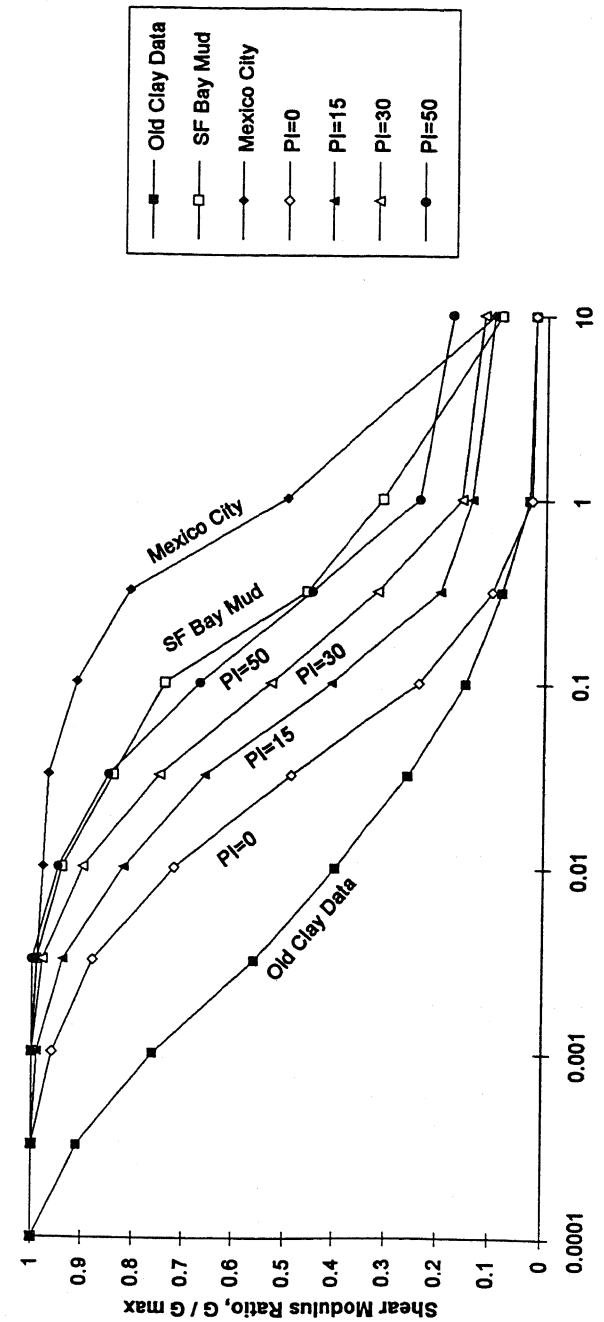

Figure 1. Shear Modulus Ratio

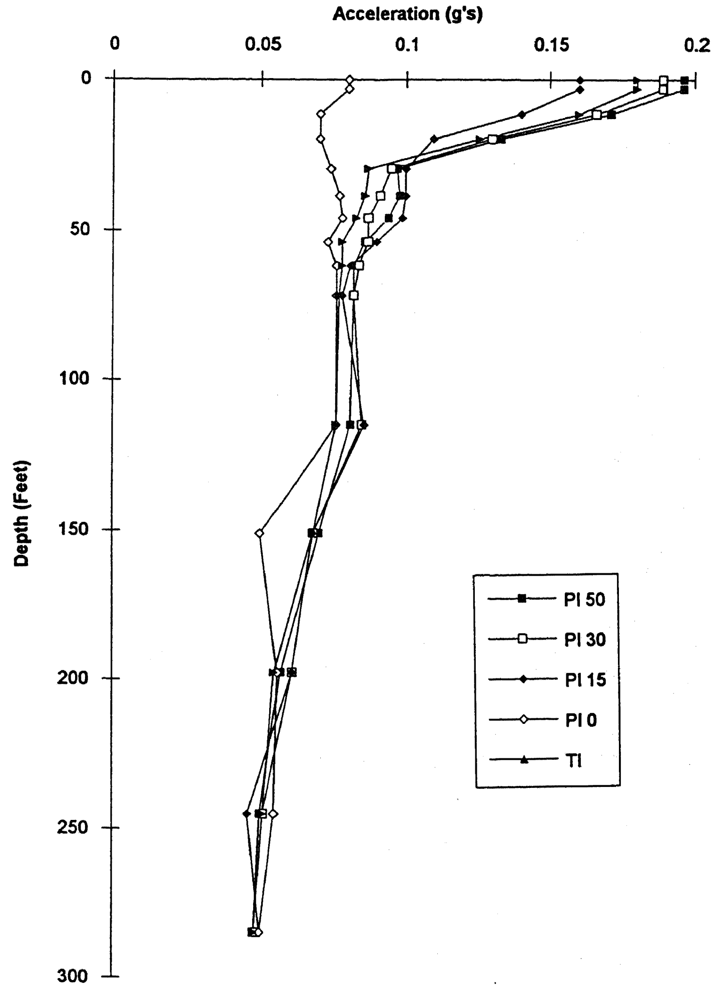

Figure 2. Treasure Island Site Response.

Discussion A. Popovici
Prof., Civil Engineering Inst.
Bucharest, Romania

on
"Comments Upon an Earth Dam Severely Damaged by Foundation Liquefaction"

Paper No. 3.35

The damage of the Draganesti earth dam (H=20m) due to foundation liquefaction during 30th May 1990, Vrancea earthquake has been analyzed in this paper. The cross section of the dam consists of reinforced concrete lining on upstream face, drainage blanket and sand-gravel compacted fill. A uniform fine, loose sand layer thick of 1.20...7.00m with natural relative density D_r -0.15...0.30, potential liquefiable, existent near surface in the foundation soil profile was at the origin of the damage. The relative density of this layer was increased up to 0.55...0.65 by vibrated-compacted gravel microcolumns technology for over 80% of the dam foundation area. The damaged zone was not treated by this technology. The damage consisted of a large slide with about 60m length at the dam downstream face and some cracks and lift-up of the reinforced concrete slabs at the corresponding upstream toe zone. A seismic backanalysis based mainly on GADFLEA computer code elaborated at University of California, was performed in order to explain the damage mechanism.

Replies by Shigeru Tani
Civil Engineering Research Institute
Sapporo City, Japan

on
"Earthquake Damage to Fill Dams"

Paper No. 3.13

Reply 1 (Discussion by Ming-Hung Chen)

The author understands the question as follows: Earth dams with embankments of sandy soil are subject to earthquake damage due to possible loss of strength caused by the build-up of pore water pressure. Therefore, although the author found that dams with a scale of 15m height or over constructed with the current dam design method are earthquake resistant, damage may occur to them because the build-up of pore water pressure has not been taken into account in the current dam design method.

The author's answer is:

In the current construction of dams with embankments of sandy soil, the firm compaction of the soil prevents the build-up of pore water pressure. Therefore, such a condition as in the question will not occur. A few hydraulic fill dams have been damaged by earthquakes in the past, but as this method of construction is no longer applied, heavy damage to large dams is not likely to occur.

Replies by Shigeru Tani
Civil Engineering Research Institute
Sapporo City, Japan

on
"Earthquake Damage to Fill Dams"

Paper No. 3.13

Reply 2 (Discussion by R. C. Chaney)

The author understands the question as follows: During earthquake loading longitudinal tension cracks develop at dam crests and asks if it is possible to prevent such cracks by using geosynthetics, such as a geogrid.

The author's answer is: There is no need to take measure against the development of longitudinal tension cracks as long as they are shallow, because the author considers such shallow cracks are not destructive damage to the dam. However, in case of deep cracks developing, the application of geosynthetics, such as geogrid, as is mentioned by the questioner, can be preventive measure which might be necessary to use.

Replies by M.K.Yegian, V.G.Ghahraman
Northeastern University, Boston, MA 02115

on

Paper No. 3.18

Start your reply with no indentation. Type only in one column width as shown here.

The authors appreciate the interest of Mr. Chen in their paper titled "Liquefaction case-histories from 1990, Manjil, Iran earthquake." The following is the response to the questions raised.

1. Multi-story buildings suffered structural damage due to ground shaking; one- to two-story structures experienced settlement and tilting due to liquefaction of foundation soils and major slope slides destroyed villages in the mountainous regions.

2. Our surveys show that in the general region where liquefaction observed, damaged buildings were founded on liquefied sands and buildings that did not suffer damage were founded on clay deposits or very dense sands. Also, typically buildings were founded on individual footings.

3. The SPT values recorded after the earthquake are low enough that a repeat of 1990 earthquake would again cause liquefaction. Such has been the experience in the Marina District in San Francisco after 1989 Loma Prieta earthquake

Author's Reply to the Discussion by Wade E. Cooper on

Evaluation of Liquefaction Potential of Coal Slurry

Paper No. 3.20

The authors would like to thank Mr. Wade cooper for his interest in our proposed technology for evaluating the liquefaction potential of coal slurry, we trust that our answers are satisfactory. It is obvious that no details of the nuclear moisture/ density method were provided; however, the paper was focused on "case histories: and the space available did not allow providing details. The reference, Cowherd and Perlea, 1988, gives more details although it is also a conference paper of limited extend. The nuclear density readings were made with a Troxler Model No. 1351 depth gauge with an 8 millicure Cesium-137 source which provides a ± 0.7 pounds per cubic foot repeatability. The moisture readings were made using a Troxler Model No. 1251 moisture gauge with a 10 millicure Am-241-Be source. The depth Nuclear Density Method is a Standard ASTM Method (ASTM D 5195-91) and uses the same technique as the widely used nuclear measurement of in-place moisture/density at shallow depth (ASTM D 3017-78 and ASTM D 2922-81). This technique has been deemed by most Public Utility Commissions as the most accurate method of measuring coal pile density. A tentative ASTM Method for Bulk Density of Coal in-Storage By Nuclear Back Scatter Method is currently under development by ASTM Task Group 7.02. The discussor is also referred to a paper by Cowherd, et al., Nuclear gages for Coal Pile inventory presented at CIPS Coal Stockpile Inventory Workshop, March, 1987. That paper presents considerable data showing the accuracy of this technique. In order to minimize any effect of material on the measurement accuracy, the instruments were calibrated on the same material as tested in the field compacted to various densities and moisture contents in laboratory controlled conditions. In addition, in each case the calibration curves are checked by taking undisturbed samples for laboratory testing form the location of the nuclear testing. It is noted that the down-the-hole nuclear measurements and calibration curves have been successfully used for many years in determination of coal reserves in stockpiles. The authors concern in determination of relative density of coal slurry deposits is mainly related to the measurement of index densities, which can generate errors much greater than any routine method of moisture/density testing. The standard tests for maximum/minimum index densities are not reliable, especially when applied to materials with a high fines content. Actually, the Standard Test Methods ASTM D 4253-83 and ASTM D 4254-83 are applicable to soils containing up to 15% by dry weight, of soil particles retained on the No. 200 sieve, and 30% of soil particles retained on a 1 1/2-inch sieve. Many deposits of coal slurry contain more fines than this limit, but no other testing method is available. The advantage of the nuclear method applied to saturated material (as explained in detail in the reference Cowherd and Perlea, 1988) is that the specific gravity can be determined and the calculation of the relative density may be based on index void ratios, which are more reliable than index densities. This is very important with coal slurries, which have a specific gravity varying with depth over a large range. In reference to the variability of properties within a single borehole mentioned by the discussor, it is noted that the down-the-hole nuclear method provides average values within a radius of about 1 foot around the borehole. Other available methods (relatively "undisturbed" sampling, standard penetration or cone penetration) provide information for much less material around the borehole.

REFERENCES

Cowherd, D.C. and Perlea, V.G. (1988), "In Situ Testing of Fine Coal Refuse by Nuclear Method", Hydraulic Fill Structures, A Specialty Conference Sponsored by ASCE, Fort Collins, Colorado, pp. 274 - 289.

Cowherd, D.C., Hoffman, J.G., and Staley, T.M. (1987), Nuclear Gauges For Coal Pile Inventory, pressented at CIPS Coal Stockpile Inventory Workshop, March, 1987.

Replies by T. P. Stoutjesdijk
Project Engineer, Delft Geotechnics
Delft, the Netherlands

on
Liquefaction Study Eastern Scheldt Foreshore

Paper No. 3.31

In the discussion by R. C. Chaney, bonding is put forward as a possible distinction between young and old marine deposits. This would explain the empirically found difference in liquefaction potential between these two types of sands.
It is correctly pointed out, that the methodologies employed were not able to discern the effect of age. The reason however is not the nature of the CPT. A CPT of course produces large strains in it's direct environment, and therefore in this region bonding will be disturbed. However, the CPT is largely used as a means to perform electrical conductivity measurements. The electrical conductivity of water and soil is measured by electric probes which are placed on the cone at a distance of 1.25 m. In this way the electric conductivity of the soil is measured in a region that exceeds the zone disturbed by the CPT. Especially when measuring densities it is of vital importance to reach a large enough zone of undisturbed soil. This aspect has received ample consideration.
It is therefore not as much the field investigation that obscures bondage effects, but the nature of the laboratory experiments, which are performed on disturbed samples. The core of the problem is how to determine the difference in behaviour of young and old marine deposits at the same density. If small bonding differences are important, it is either necessary to obtain samples that are absolutely undisturbed, or to have a measuring method to discover these differences in the field. It is considered difficult to take undisturbed samples in loosely packed sand in a way that all bonding will be intact.

Mr. Chaney mentions the use of a seismic cone as a possible way to detect bonding or differences in contact between particles. In principle this thought is worth further investigation. As a means of detecting differences in for instance static shear modulus there are quite a few practical drawbacks. For a start, it is a dynamic measurement, and therefore reflects on dynamic properties. Application in earthquake response studies is more obvious than is the case in the essentially static problem of flow slides. Secondly, the velocity of the compressional wave is considerably influenced by fluid content and by degree of saturation. Thirdly, the results are influenced by the in-situ density of the soil. The method should preferably be combined with in-situ density measurements. Finally, in-situ stress must be known in order to interpret results. As mentioned in the reply to questions in the General Report on shear wave velocity measurement, the shear modulus is influenced by effective stress. In the paper stress history is mentioned as a possible distinction between young marine and old marine deposits.
The term stress history is used in the sense that for instance the K_o-value increases when overburden is removed. Due to differences in geological history this can make a difference.

Consequently, it is expected that the seismic cone method has a limited ability to detect differences. The differences in elastic moduli between material with and without bonding (or young and old marine deposits) should be large enough to fall within these limits.

Concluding, I would like to thank mr. Chaney for his kind contribution to our problem. I agree that bonding between particles may be a major difference between young and old marine deposits. Although the seismic cone method does have practical drawbacks it is worth considering in future problems of this kind.

Authors' Reply, Theo Stoutjesdijk
Project Engineer, Delft Geotechnics
Delft, the Netherlands

on

Remarks in General Report on Paper No. 3.31

In the General Report of Session III, the general reporter S. Kramer mentions the possibility of in-situ shear wave velocity measurements as a possible means of measuring differences in the behaviour of different types of soil at low·strains. In this manner aging effects between young and old sand deposits could be reflected.
In the paper, the author reaches the conclusion that, based on laboratory triaxial tests on disturbed samples of loose sand, no large differences are found in behaviour of young marine deposits and old marine deposits. In practice it has been found however, that flow slides (defined as instability of an underwater slope due to static liquefaction) in the Dutch Province of Zeeland generally have occurred in young marine deposits. To explain this incongruency between practical and laboratory behaviour, the author mentions the possible effect of stress history. In other words, the old marine deposits would be less susceptible to liquefaction because their stress state may be influenced by some overburden of the past, that has now been removed. In theory, that would improve liquefaction resistance.
To prove this point, some knowledge is needed about the in-situ behaviour of both old and young deposits. This is where the suggestion made by mr. Kramer fits in. Measurement of shear wave velocity can give information on the value of the shear modulus. To be able to interpret this information for in-situ measurements one also needs to know the in-situ density and the initial deviator stress. This is further illustrated in Figure 1: the same value for the shear modulus G is found on three different curves. The shape of these curves is determined by the density and by the stress level.
Therefore, to succesfully evaluate in-situ measurements of shear wave velocity, one would have to consider several steps. Firstly, the measurement should take place on a horizontal plane, to make sure no initial shear stress is present. Secondly, the in-situ density should be measured with some accuracy. The third step would be to try to reproduce the determined shear moduli in the laboratory on disturbed samples, based on measured in-situ density and estimated in-situ effective stress.
If reproduction fails, this may be an indication that stress history is important at this site.
There is literature available on shear wave velocity measurement methods and analysis. To the knowledge of the author none of this literature concerns itself with stress history or measuring in slope conditions.

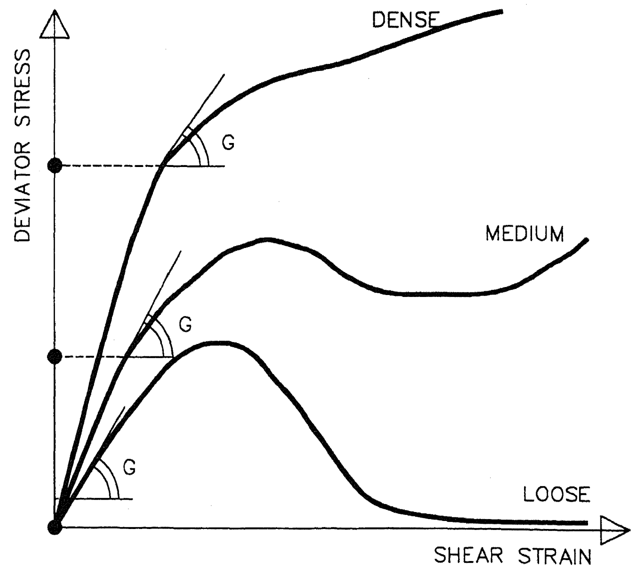

FIG. 1

Replies by A.Popovici
Prof., Civil Eng.Inst-Bucharest, ROMANIA
on
Paper No. 3.35

The damage of the Draganesti earth dam by foundation liquefaction points out the necessity of some constructive provisions in order to reduce the liquefaction risk. As it was presented in the paper, the zones of the dam foundation treated by special original technology for improving their quality (a design of ISPH-Bucharest), especially increasing their natural relative density behaved well during 30 th May 1990, strong Vrancea earthquake.

A large experimental programme on site has been initiated in order to find an efficient technology for both technical and economical point of view. The main conclusions can be the following:

- the direct vibro-compactions is reccomended for fine liquefiable sand layer with 1.5 ... 2.0 m maximum thickness situated above the water table;

- the fine sand layer with 4.0 ... 6.0 m thickness situated below the water table can by treated by technology consisting of:

- vibropressing of a truncated pyramid metallic form and filling of the inside voids with gravel, sand and recompaction and reintroducing of permeable material ;

- vibration injection with water ;

- vibration injection without water;

- gravel columns performed by protection tube equipment with
valves of ϕ = 320 mm ;

- gravel columns performed by equipment without protection tube with valves of ϕ = 320 mm and 419 mm ;

- gravel columns performed by equipment without protection tube, with mobile conic peak of ϕ = 320 mm and 419 mm;

- the most efficient technology for 4 ... 6 m thick layer, according to processing of penetrometer tests resulted that based on truncated pyramid metallic form vibropressing.

We would by very interested to know more about the international experience in this field.