Construction Yard and Hauling Roads

Finally it's expected to utilize an important volume of saprolites for the construction yard (and also saprolitic soils) and the hauling roads.

REFERENCES

(1) Antunes, J.S. & Thielen, F. (1985) " Itá Hydroelectric Project: Dam Selection Studies" - ASCE Symposium on Concrete Face Rockfill Dams, Detroit (pre-print).

DAVID CARRIER (the United States)

I just have a question. Can anyone comment on the use of geophysical methods for exploration for dam foundations in general and for the termite holes in particular? I'm thinking especially of electromagnetic and resistivity methods.

JOHN CADMAN (Brazil)

In Tucuruí we ran several series of seismic and electrical resistivity mapping techniques on both abutments. We did not do any magnetic geophysical work but neither the seismic nor the electrical resistivity surveys showed anything at all that resembled "canalículas". I'm afraid that the target size, although big for the size of the problem, is too small for detection with most geophysical methods.

VICTOR DE MELLO (Brazil)

I've been thinking about what Dr. Cadman said, and on the one hand, I feel that Dr. David Carrier has in mind some of the high resolution modern geophysical methods that have had such a tremendous development and a

fantastic use in new areas such as off-shore platforms and submarine investigations and so on. It seems to me that the question is well put. It is a problem of trying to develop higher resolution methods that might be able to detect these small discontinuities such as are being detected in much more difficult conditions in submarine investigation. I think that that's part of your question. I'd submit to the audience that we look for a development along that line.

CLOVIS R.M.LEME (Brazil)

I'd also like to make a comment on that subject about soils from southern Brazil. We have had many dams built in basaltic areas and it is quite common to find a depression in the foundation. We find a depression in the rock beneath the dam and this kind of depression we kept by using the old fashioned geophysical methods.

MARIO MÁRCIO ALVARENGA (Brazil)

I'd like to remind you that the basic conditions for soil to be collapsible are that it must have a natural moisture much lower than total saturation and have high porosity. Thus, any soil that fulfills these conditions may collapse in spite of its type and origin. Since collapsibility is a structural phenomenon, small deformations should be studied. Soils should be tested in laboratories at the end of a certain loading in the oedometer test when the sample is flooded. In compacted soils, collapse can only take place in the dry side.
In relation to the termite problem, this is not so dire because there is an approximate surface delimitation in organic deposits since termite mounds have a blackish hue. This helps in the preparation of geotechnical investigation programs.

RUI T. MORI (Brazil)

I'd like to comment on the aspects of collapsibility just brought up. Márcio Alvarenga just said that the origin and type of soil does not have any

influence on soil collapsibility. Our experience and certainly that of many others is that soil origin is very important in determining a soil's properties. For example, in sedimentary soils sedimentation produces a different cementation from that in residual soils.

Tests carried out on different basaltic soil samples with similar properties show that surface soils with the same moisture content but which are colluvial are collapsible, whereas the residual soils directly below are not collapsible.

MARIO MÁRCIO ALVARENGA (Brazil)

There are various ways, Mori, to make soil collapsible and one of these is through loss of cementation. What I want to emphasize is that this is not an exclusive property of clayey soils. You can find cemented sands which collapse when the cement is dissolved, not immediately but it will only be a question of time, of solubility, and other factors which I feel we shouldn't go into in great detail here.

VICTOR DE MELLO (Brazil)

Allow me to comment briefly on this subject. I believe you both are right, but the main point is that we would like to try to quantify to what degree the consequences of collapsibility, and differentiated settlement due to collapsibility, not collapsibility itself, would be acceptable in a foundation because engineers know that to a greater or lesser extent this phenomenon exists in various places and under varying circumstances. The problem is to know to what degree it is acceptable or not. In the small dichotomy between collapsible and non-collapsible soils we try to quantify and this is where I think the future will be. Coincidentally, Professor Leonards will hold a seminar at Purdue before the San Francisco meeting at which he will present data on 600,000 cubic yards of compacted material excavated from Teton Dam. He hopes to show that dam cracking was due to collapsibility of the soils placed on the dry side of the dam, etc. I recently saw that slightly decomposed

sandstone with a very small amount of clay is collapsible. A year and a half ago, groundwater in various regions of the state of São Paulo rose exceptionally due to the El Ninõ hydrological phenomenon and numerous factories settled several centimeters due to collapse, an absolutely unacceptable situation. Thus, our problem of knowing which soil is and which is not collapsible is more a question of quantifying the degree of tolerance of collapsible soil.

MARIO MÁRCIO ALVARENGA (Brazil)

Just a comment since you mentioned foundation collapse. I'd like to remind those present that Professor Milton Vargas was the first to bring up this subject in Brazil. He dealt with the collapse of foundations in residual basaltic soils in the state of São Paulo.

CHAIRMAN

Basically we have dealt with two subjects here: termites and collapsibility. There may be other matters which may also be discussed. Would Mr.Viotti like to say something on collapsibility and deformations?

CASSIO B.VIOTTI (Brazil)

I'd like to comment on two aspects related to dam foundations: the behavior of the foundation of São Simão dam with respect to collapsibility and settlement devices. At São Simão dam we have two settlement devices: one on top of colluvial and natural residual soil and the other on top of saprolites. While the reservoir was filling up we had a settlement of 15 centimeters.There had already been thirty centimetres of settlement before the reservoir began to fill up. The saprolitic soil had also collapsed some 4 centimeters. There were no signs of distress to the dam itself. The dam foundation is on basaltic saprolites. We also have an inclinometer at another position in a slightly higher section and at this position we noticed a shear deformation after filling. We saw around two centimeters of shear deformation despite the fact

trench because we run into the kind of difficulties you have presented here. Furthermore, we hear that excavating a trench below the water table would mess up the foundation completely and you end up with a worse product than if you leave it alone. Our practice is to excavate what we call a exploration trench which is a trench that will serve to let us know we are within residual soil and that there are no materials that should be removed. Once we know where we are we proceed as soon as possible to fill up the exploration trench. So this confirms 100% what Professor Mello and Mr.Viotti have said.

Now a comment on the question raised by Mr. Sierra: if the saprolite should be grouted or not. Our experience is that a saprolite does not take grout and you don't gain anything by grouting a saprolite. When we use high pressures all we are doing is destroying the structure of the soil with no practical purpose. When you need grout is when you come to the rock, not the sound rock but the upper part of the rock without open cracks. There is where grout is needed but not in the saprolites. Thank you.

VICTOR DE MELLO (Brazil)

May I comment on that? This is a very interesting point to begin with. Thank you for your support on the thesis that we all agree on.

It's much better to stop on the saprolite as a geometric excavation and never think of going deeper because of all the troubles that Cassio Viotti and others have mentioned.

If you do have to go for any reason, for instance as Mr. Sierra pointed out with respect to very narrow plinths in the case of a concrete face depth, if you do have to go to some rock, then it should also be a geometric excavation, etc. but definitely sound rock and I think we are all in agreement on that account.

Now the basic question that you seem to disagree with but I think that if we go a little deeper we might agree with, is with respect to grouting of saprolites. We all agree we definitely do not grout this soil but saprolites

tend to have weakness planes which are especially low in tensile strength. They are frequently low in schistoing also but especially low in tensile strength and, therefore, they are susceptible to penetration of grout by hydraulic fracturing techniques (clackage).

So you get a crisscross of cement clay, which can be studied to be as close as possible to the properties of the "in situ" material and by doing that you can try to reach such unusual discontinuity such as "canalículas" and so on.

So I agree with you with respect to the damage you can do, especially if you are dealing with sedimentary rocks and so on. But there are conditions where you accept the temporary damage and the surgery as a risk and after the surgery, after the patient has been stitched up, presumably you have improved him.

OSCAR MEJÍA (Colombia)

I just want to make a remark on this. Here we come to a problem which I'm going to refer to as the General Reporter this afternoon and that is: what is the saprolite?

I fairly agree with Victor and I think the lower part of the saprolite was the type of crack up here which I was calling the top of the rock, but it is again a matter of semantics. That is all. Thank you.

VICTOR DE MELLO (Brazil)

Thank you very much and forgive my having committed the gross error because I myself have always insisted that there is no such thing as a saprolite. A saprolite is of something. So we have to say saprolite of gneiss, of sandstone, saprolite of schist or whatever. Unless you say what the parent rock is, there is no such thing as a saprolite. Thank you for reminding me that in trying to be brief I committed a very gross mistake. Thank you.

come across termite mounds during our investigations and we don't find chambers and excavations what do we do? Thank you.

JOHN CADMAN (Brazil)

In answer to your question, I would say the following. There are several small dams in Brazil that have never been filled because of the termite "canalícula" problem. In fact there was a very interesting reference given approximately 150 year ago by Walter Bates, the English naturalist, when he came to Brazil. He remarked about a dam that failed, near Belem. His explanation was the "saúva" ant and not the termite. Today we know it was not the "saúva" because the "saúva" makes very shallow gallery systems. It could well be that failure of this small dam in Belém, 150 years ago was due to termites.

Your question about whether we should be on guard if we find termite mounds; I would say yes, although we must remember that there are thousands of varieties of termites and I'm not sure if all the varieties make such deep subterranean galleries. I would say that in tropical areas, even if you don't see mounds, you should expect that there would be this type of gallery system in residual soils. In the galleries of Tucuruí we never found a single termite in the galleries. We did find termites making galleries recently in Samuel, but in Tucuruí the galleries were what I would call "paleogalleries", excavated, who knows, how many years ago.

I think that this is certainly not a problem typical only of the Brazilian Amazon. I'm sure in other regions of Brazil this type of gallery will be found and I would expect that in certain regions of Asia or Africa they also exist.

VICTOR DE MELLO (Brazil)

May I answer the question that was asked of me? I really want to congratulate Mrs. Regina Dias on her suggestion of another index. Basically, what we are gathered here to do is to try to get better indices, practical ones, from all possible fields, to help in creating a new vision of how to face these soils.

Now, in respect to Mr. Pugh's question. In my state-of-the-art paper on penetration tests back in 1971, I tried to suggest that it seems very difficult to solve for at least three unknowns. We have studied penetration resistance. It basically is intended to measure strength. And strength, in general, in soils should depend at least on a c' or ϕ 1 or σ The three parameters should come in. Now, if we faced the SPT with the same level simplicity with the minor changes such as are being introduced steadily in the CPT or CPTU and so on and so forth so as to be able to do a multiple profiling, alternating SPT data with one, two or three samplers that maximize the one case C; the another case σ another case ϕ we could get three simultaneous equations to begin to get some of these intuitions that our neurological and logical computer works out and that can not be proven. Until now I have only been able to prove for sands, pure sands with laboratory condition overburden stresses I have given by USBR test results and incidentally they have been recently confirmed by another paper that is coming out in "Geotechnique" in which they prove my thesis that SPT measures resistance and not compressibility. It is an index more or less. It seems in the same family. When materials are stiffer they tend to be stronger and less compressible but sometimes they can fool you. For instance, the foundations of Guri dam had SPT results going on way up to about 25, 30 or more and they were collapsible. Thank you.

O. MOURA FILHO (Brazil)

My job as a discussion leader is to encourage discussion but I'd like to say I am sure you all have heard what Professor Karl Terzaghi said on one of his trips to Brazil - that it was one of our tasks to study and get to know residual soils better. This is really one of our tasks. I thus propose that we advance the studies and concepts of the structures which will be built on tropical soils so that less soil needs to be removed and treatment processes may be improved. This point of view is held by most of the panel members here today and many of you in the audience. A few steps have already been taken. For example, at abutments, there is less soil removal than at places where the dams are lighter. To be able to make this type of decision it is very important to know how soils behave. We know for sure that porous, lateritic, saprolitic, tropical soils have two typical Mohr envelopes depending on the

VICTOR DE MELLO (Brazil)

I'd like to ask you a question. From your observations, was the rupture due to piping, instability or something else?

CLAUDIO WOLLE (Brazil)

Rupture was problably due to piping through the soil of the abutment, possibly where it meets the main part of the dam although the dam was designed for overtopping and was permeable. The dam was small, some five meters high but the water went over the abutment rather than over the gabion wall of the dam.

VICTOR DE MELLO (Brazil)

I wonder, are we talking about an earthfill or rockfill dam? Could it have been a gabion dam which was basically a kind of a retaining wall?

CLAUDIO WOLLE (Brazil)

That's right. A spilling crest about 5 meters high, in the riverbed and with no special treatment at dam-abutment contact.

VICTOR DE MELLO (Brazil)

Do you think that this was an invitation to rupture or not?

CLAUDIO WOLLE (Brazil)

Yes, without a doubt.

A second point I feel is important is the question of piping; piping is still one of the big worries in dam foundations. Although I agree with Professor de Mello that it is much better to avoid the phenomenon, change the physical universe, as he said in his Rankine lecture, sometimes this is not feasible. We must deal with the problem. Having to deal with the problem, I feel that tests related to an analysis of the piping phenomenon are inadequate because, for example, the pinhole test constitutes rapid loading in relation to . I feel that piping should be carried out by some sort of slow test. As we discuss slow and fast slope stability testing, I feel that in the case of piping we should make a distinction between slow and fast loading, since our physical intuition, common amongst geotechnicians, is developed enough for us to recognize fast loading, but we haven't developed physical intuition in the case of interceptos the cohesion of drained tests. Thank you.

VICTOR DE MELLO (Brazil)

Mr. Chairman, we want to thank the audience for their presence and all their support in this session. As a brief summary, it seems to me that we really face tremendous problems ahead of us, of new indices, of detection methods that may improve our knowledge, and principally, recognizing what the main problems are. From what I've gathered from this session, the principal problems have been pointed out as collapse settlements, which are very unfavorable at a very unfavorable moment, questions with respect to construction conditions and acceptance of level of excavations (everybody seemed to agree to stay as high as possible; the question will be to define how high is possible) and finally questions regarding these many discontinuities that create seepage problems and their consequences, whether they lead to piping or big flows, whether to economic or safety questions. These are the main problems we have to face in tropical sites. Thank you very much for the opportunity of making my summary, and among other things, I have to include in my summary my apologies for having presented some ideas and possibly exaggerations that may lead to wrong impressions. My desire was to stimulate discussion. Thank you.

I want to take this opportunity to thank the Brazilian engineers for giving me the honor of presiding at this session, the General Reporter of which is president of the International Society for Soil Mechanics. I also want to congratulate the engineers of Brazil for the depth and understanding they have shown not only in their scientific publications but also in the works they have accomplished in the country. I hope you'll be able to find your way to be one of the first in all aspects of science, technology and culture. Thank you.