FOURTEENTH CONGRESS ON LARGE DAMS, CIGB/ICOLD, Rio de Janeiro 1982, Vol. V, pp.343-'4.

DISCUSSION

Chairman: *Merci beaucoup. Je donne la parole au Prof. Victor de Mello.*

Prof. Victor de Mello *(Brazil): I would like to ask a question first to Pierre Londe: what is the dynamic drainage method you were talking about, the method used in order to attempt to solve the liquefaction problem only when it arrives? You say that Prof. Seed has some new dynamic drainage procedure for averting seismic liquefaction?*

P. Londe: *Yes. There was a publication by Prof. Seed and Mr. Booker some years ago showing from computation that it is theoretically possible to reduce the dynamic excess pore pressure during the earthquake by a number of closely spaced drains with a high discharge capacity so that, as soon as the pore pressure develops, the excess water then goes out to the drains. And this works beautifully in finite elements analysis, and then it has been applied. I had a discussion with Harry Seed on that. It has been applied in tne foundation of buildings. Prof. Seed himself does not recommend to use this method under a dam. Not yet.*

Prof. Victor de Mello: *Fortunately, engineering always has to face new situations, otherwise you wouldn't be so interested in it, and it is with creative ideas that working hypotheses are made. But the main problem is when we do not have the opportunity to test that idea.*

And unfortunately in the seismic liquefaction area, we are facing that. Now, just to go back to your graph, I would like to go back to the SPT, which has been unfortunately prematurely crystalized into a dignified position that it does not occupy. And if you go back to Prof. Seed's own findings, you will find that his findings have been continually varying almost year to year. And there's a very obvious reason for that, because SPT is dynamic, therefore somewhat complex, and it also depends principally on some other additional facts besides merely relative density. Relative density itself is absurd, as everybody recognizes, but the additional fact is the interference of a little cementation, that everybody knows about, especially in older soils. And especially lateral pressures. Lateral pressures are much more important than overburdened pressures in determining SPT. Considerable research has demonstrated that; and, as a matter of fact, right now within about 3 weeks there will be the conference of ESOPT II in Amsterdam when some amazing new facts are being shown with respect to the CPT or so-called cone penetration test in which it is demonstrated that all present theories are perceptibly wrong. So, let us take our hats off to engineering for being able to conduct solutions through working hypotheses and, at the same time, maintaining the humility of recognizing that all of them are insufficiently right in a given moment. Now, I really had additional thoughts along the same line but I merely took advantage of your new fact. Thank you.

Chairman: *Now that we are discussing this subject, would you like to say something more?*

P. Londe: *I showed a graph on SPT because it is very well known and popular, but on the site many other tests have been carried out, including CPT, vane tests and laboratory cyclic triaxial tests. It took about 4 years of study so far. Maybe it will take another 4 years. Now, for the value of SPT, we know that it is controversial but our philosophy is to have a number of various test procedures so that we are in a good position to judge, and that is how we definitely selected 3 zones, one with a high liquefaction potential, one with a doubtful liquefation potential which will be the zone of compromise between excavation and treatment, and one, the deepest which is safe. That is enough, and that is the correct approach of the engineer – not looking at the third place figure.*

Chairman: *Merci beaucoup, Pierre, nous allons continuer avec M. Kramer. Mr. Kramer, please.*

FOURTEENTH CONGRESS ON LARGE DAMS, CIGB/ICOLD, Rio de Janeiro 1982, Vol. V, pp.283-'4.

97.2

DISCUSSION

Prof. V.F.B. de Mello *(*) (Brazil): Prof. Wittke practically took the edge of my question. I was going to ask him if those tension stresses he mentioned were really tensions or merely the delta-stress, and I believe he said that it would take more than ten minutes for him to expatiate on that. So, they were really computed tensile stresses. Depending on what assumption of initial lateral stresses, and so on.*

(*) Président, International Society of Soil Mechanics and Foundation Engineering/ *Président de la Société Internationale de Mécanique des Sols et de Travaux de Fondation.*

Prof. W. Wittke *(Germany): Depending on the assumption that the lateral stresses are depending on self rate and topography only.*

Prof. V.F.B. de Mello *(Brazil): O.K. Thank You. Well, that is really a very good question, and since Prof. Wittke is now in rock mechanics and I in soil mechanics, I profit to mention how very similar and considerable are our worries on the same point. There are two points he made that I really want to insist on as extremely important, and I have to go further to a third one. One of them was the extreme importance of recognizing that the simplification of rigid-body analysis, or let us call it the membrane hypothesis plus total stresses, which is a simplification, has nothing to do with real physical behaviour. Physical behaviour is based on effective gravity stresses and effective seepage stresses. So they are mass stresses; and unfortunately, a large percentage of so-called erudite finite element analyses and so forth miss this very important point.*

Well, the second point is of course the question of internal stresses and in soil mechanics we have been initially gratified, but more recently somewhat hampered by a very kind early offer of a solution which only holds for normally consolidated materials, the Jaky solution, $K' = 1 - \sin \varphi'$. *Unfortunately, a large percentage of people continue to think that it is a sort of general rule; it is not. It is only for normally consolidated materials. And if you begin to think of a deposit starting from the "zero condition", the zero condition is one of the most fantastically difficult things to really investigate. So, if you begin to think how even* φ' *changes as a sediment begins to grow towards lithification, you are really lost. So, lateral stresses are most important, and not so easy to estimate.*

A third point that I would like to mention concerns collapsive structures in soils. I do not know how far it affects rock mechanics where there may be such special rocks or vulcanic tuffs that could behave as having collapsible structures. Essentially, all analytical solutions and finite element analyses have assumed generally that when you apply a σ, *stress, there is an expansion, Poisson coefficient, in the other directions. And in many soils, collapsive type of soils, that does not happen. You apply a compressive stress in one direction and the soil may shrink in the other directions. This is especially the case when the* σ' *effective stress is introduced by seepage stresses. And, in effect, the stress-strain behavior of a specimen in triaxial compression under effective stresses caused by external loading is not identical to that caused by effective deviator stressing due to seepage. And most other finite element analyses so far made would collapse on that third point. So I would kindly call your attention to the fact that there are important hypotheses of how materials behave that are implicit in finite element analysis. Thank you.*

Chairman: *Thank you, Victor de Mello. Victor de Mello is from Brazil, he didn't say this, he's from all over the world, and he is now the President of the International Society of Soil Mechanics.*

Prof. W. Wittke *(Germany): It is indeed very important to select a stress strain law relevant to the corresponding case. I like to state, that the*

FOURTEENTH CONGRESS ON LARGE DAMS, CIGB/ICOLD, Rio de Janeiro 1982, Vol. V, pp.367-373.

34 – Prof. V.F.B. de MELLO (Brazil)

Mr. Chairman, Ladies and gentlemen: time is very short, but not so short that I shouldn't recognize first priorities. Eu quero começar por render minha homenagem ao Presidente desta sessão, meu grande amigo Joaquim Lajinha Serafim, um dos maiores engenheiros de barragens que eu conheci e cuja brilhante carreira tenho tido o grande prazer de acompanhar ao longo de trinta e tantos anos de amizade. Muito obrigado pelo prazer e pela honra de contribuir a esta sessão.

Chairman: Mas Victor, isto não é da Questão 53.

Prof. Victor de Mello: Sorry. The first point was made in Portuguese, directed to my good friend. The second point I wanted to make is dedicated to Brazil and to the fact, made known to you by our Minister, that we have so far only developed 20 % of our hydroelectrical potential. Now, 20 % of a life expectancy of 75 years would be 15 years old. How many of you would crystallize all your thinking at 15 years? I hope none. We get back to the problem of doubts and investigations, and the inadequacy of considering adequate what is still inadequate. The main problem we are facing is the stifling yoke of premature standardization of over-conservative and faulty routines, and the absence of an open attitude towards the recycling of data and criteria. I am induced to submit some considerations on problems of grouting treatments in rock foundations of dams. Within the very limited time I must summarize the essence of my Brazilian experience in many scores of dams, restricting my comments to open-jointed granits-gneisses and basalts (in which some modest cavities also occur). The subject has drawn my interest ever since 1955 (Santa Branca Dam, 55 m) during 10 years of both contracting and consulting, followed by 15 years of pure consulting with detailed post-reservoir-filling monitored behaviors. Some thoughts have been published in international vehicles sine the 1st Panamerican Conference on SMFE (Mexico 1959), in the 6th ISSMFE Conference (Montreal 1965), and particularly, in the Rankine Lecture, London 1977, besides many interventions in local conferences and publications.

With all due respect to Lugeon and his pioneering index, I must beg leave to emphasize how solid an obstacle it has now become to wellrecognized advances that are most necessary. Lugeon coefficients are routinely quoted in almost every paper as if it were a constant, a property of the rock. Yet it has been repeatedly demonstrated and emphasized that everything depends on the type of curve of water losses vs. pressures, on the states of stress affecting cracks, on the distance between packers that is implicit in the denominator yielding water loss coefficients per meter, on the pressures at which the test is run and that at which the result is computed, etc. Meanwhile, the very use of the type of index represented by litres per m per min. per atm. can only signify adherence to linear proportionality. It was discovered from the start (cf. Mexico 1959) that the Lugeon test, index, and criterion (of ∋ 1 lugeon considered unacceptable) was specifically to indicate groutability, and *not* need for grouting treatment.

The key thoughts and observations are summarized for more concise visual in Fig. 1, 2 and 3.

Firstly, any test of water and/or grout losses vs. pressures attempts to answer two quite distinct questions, both in design, and in redesign-as-you-go. Secondly, all testing and grouting is inexorably a succession of decision problems, therefore profitably handled by Bayes theorem, if one needs to compute probable effects, and diminishing returns from incremental efforts. The need to use special tests with pinching-in of distances between

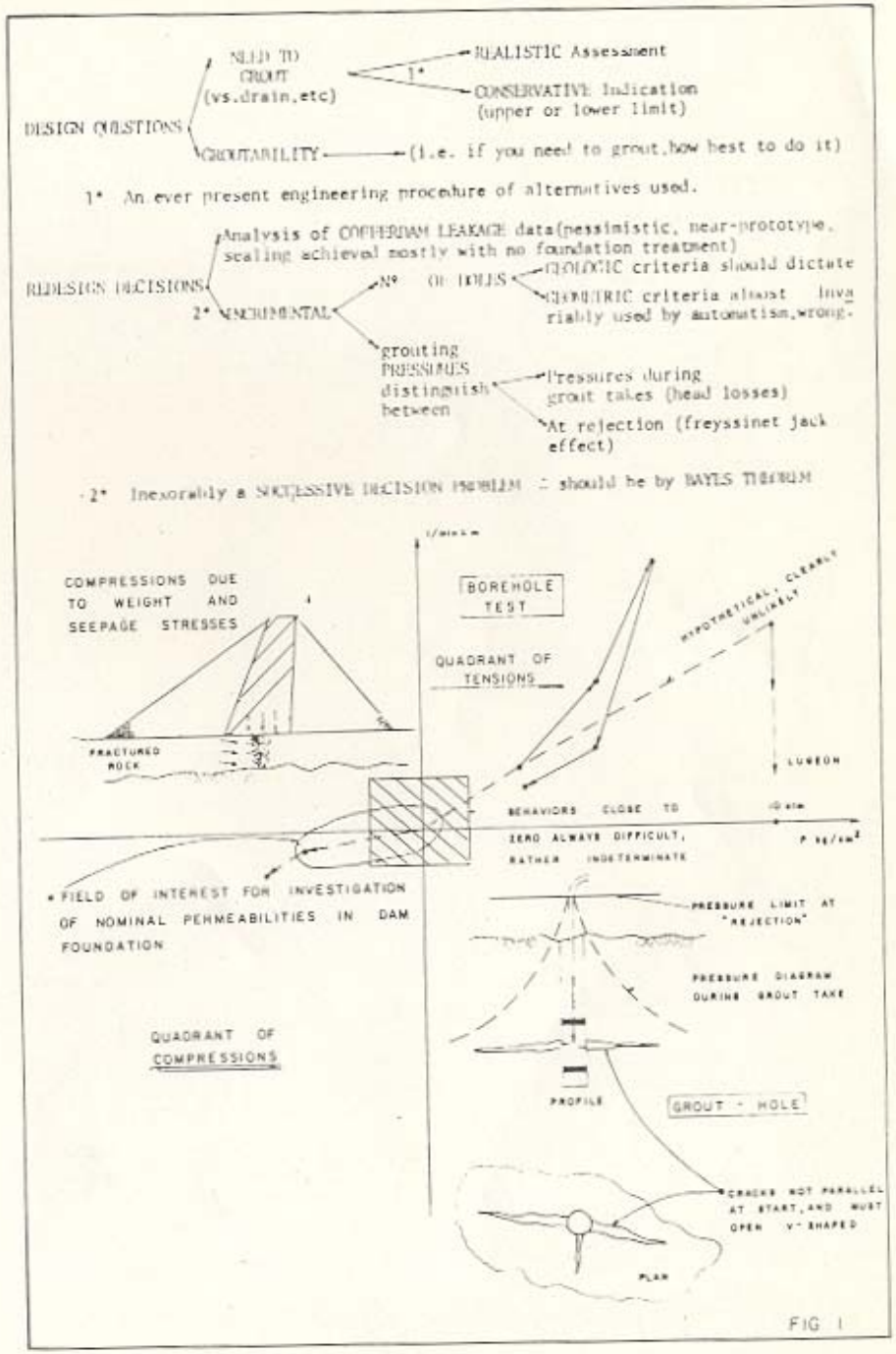

Fig. 1

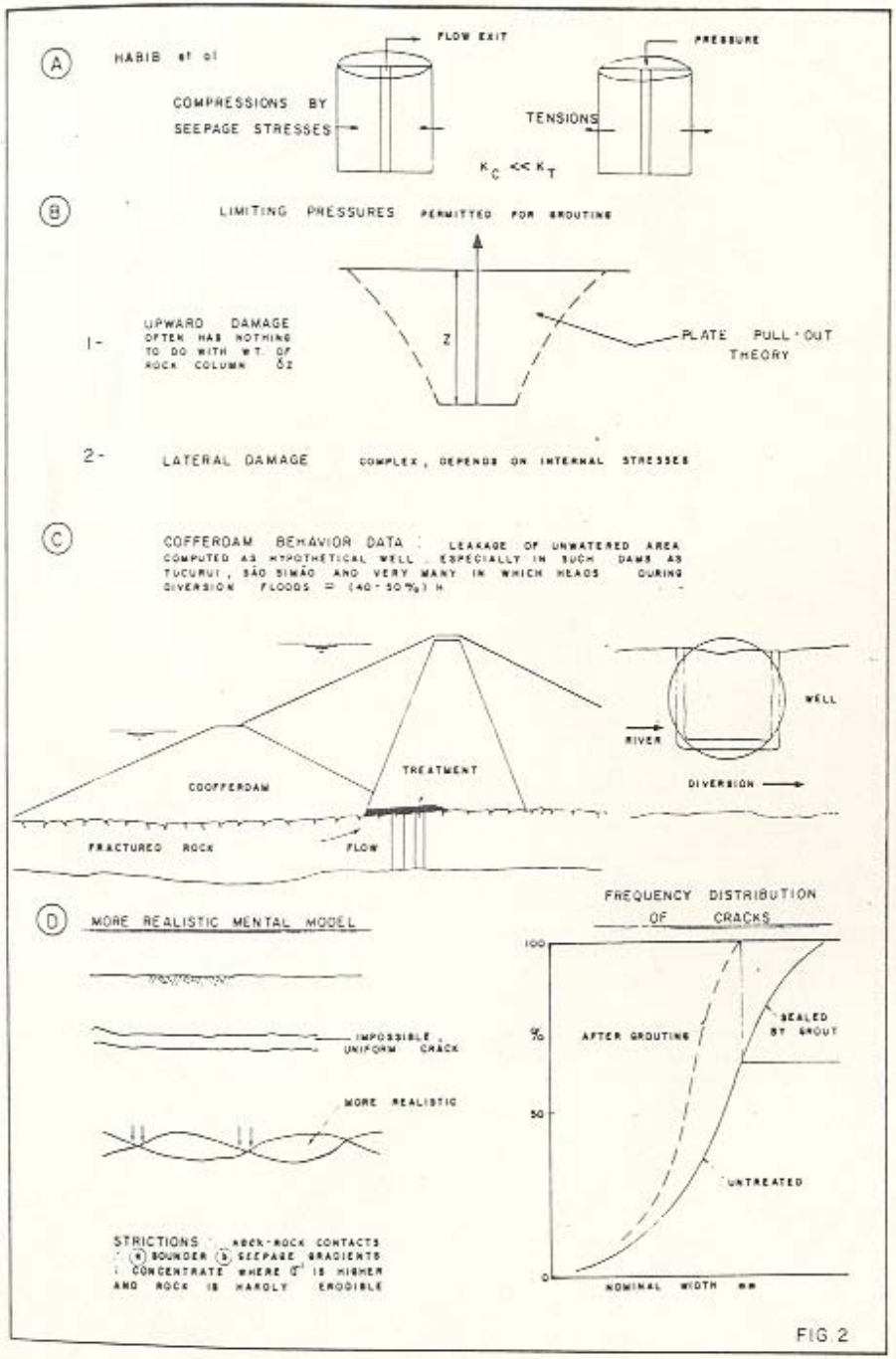

Fig. 2

A) Rationale for grouting Treatment

For

1. SAFETY → ELIMINATE ERATIC wider cracks (extreme value statistics); establish the right to predictable design (averages)

1. SAFETY → PREDICTABLE DESIGN → CONTROL UPLIFT etc. (help drainage)

1. SAFETY → PREDICTABLE DESIGN → AVOID "ERODIBILITY of cracks" *

* chimerical, cf. mental model on strictions

DESIGN PRINCIPLE: what can happen if cracks of mm of weathered material do erode within sound rock? settlement? increased losses?

2. ECONOMY Reduction of seepage losses, incremental costs and incremental gains, quantifiable

B) Example. Direct observations under Salto Santiago dam, within diversion-tunnels.

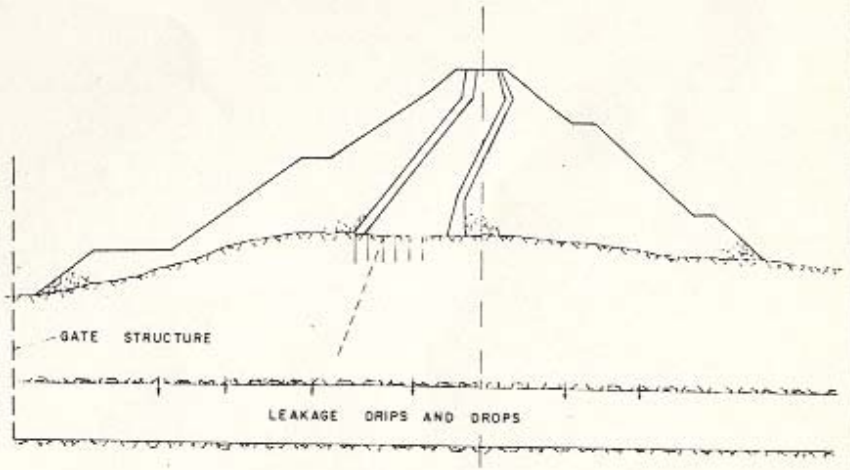

FIG 3

Fig. 3

packer has often been emphasized. Thirdly, ever since the triaxial permeability tests of Habib et al. (around 1964) demonstrating the striking change of permeabilities in fissurable rocks when the seepage stresses are changed from compressive to tensile, it is recognized that whereas pressure tests and grouting from boreholes are analogous in generating tensile fields immediately around the hole, the sresses in the zone of the grout-buffer (cf. Rankine Lecture) tend to be compressive; thus, in qualifying the rock mass as permeable or not to the point of requiring grouting, the pressure tests are conservative to the point of being unfair. Engineering tests commonly have to avoid conditions too close to zero, because of many factors simultaneously contributing to errors and indetermination.

The fact is that one cries as a voice in the wilderness, but because of international publications, and Lugeon index and criterion, nobody observes that the seepages through untreated foundations of dumped cofferdams that face heads of water of the order of 40 to 50 % of the final reservoir head have been insignificant. And nobody stops to debate the fact that in an earth-rock dam, even if there were significant foundation leakages under the downstream shell, there should be no problem. The economic value of the water in decreasing losses from about 0,3 l/min. m dam length m, head, to about one-tenth that figure, is obviously not our concern. Of very special interest beside the cases of Salto Osorio (52 m), Itauba (103 m), Foz do Areia (160 m) and Emborcaçao (157 m) was the case of the Salto Santiago Dam (80 m máx.) in an area where the basalts had major geologic faults. We had the privilege, rarely enjoyed to such a degree, of inspecting the four diversion tunnels after closure, with reservoir full. Despite conditions apparently unfavorable and daring, the observation was of but localized drips and drops of leakages into the tunnels, and no very significant difference of such behaviour in comparing stretches under the three zones of the dam, upstream, core, and downstream.

Finally, the fundamental design principles (cf. Rankine Lecture) are *a*) to eliminate unquantifiable conditions of statistics of extremes (by high pressure exploratory grouting) and *b*) once dealing with theorizable conditions (average), the designer's question must always be "what can happen if a desired behaviour is not met". In this respect, it is sad to see how cruelly the indeterminations regarding "erodibility" and "piping" have been used in maintaining a tone of considerable worry even with regard to a crack of a couple of millimeters, weathered to a silty-clay but backed-up at depth by sound rock. Even if the silty-clay were eroded (not too likely, considering the behaviour of strictions, and of weathering as associated with zero stress, therefore inoperative areas) what could happen? Essentially nothing? I put this thesis to this international audience of experts, in the presence of my country's eager junior geotechnicians, so that it be contested or accepted; it is important to Brazil's efforts at growth.

Truly all our experience has been of over-conservatism and unjustified expense because of respected and unquestioned criteria. The only problems faced, systematically, have been of abutment seepages, principally because

of anistropic high horizontal permeabilities, and lack of dam loading to compress fissures.

Thank you for your attention. Thank you, Mr. Chairman.