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11 – Prof. V.F.B. DE MELLO (Brazil)

Thank you very much Mr. Chairman, Mr. General Reporter; It's interesting to note that I always find time too short.

The last comments made have something to do with what I am going to say right now.

Well, I am going to summarize quickly some of the information with respect to compacted rockfills and how this has been varying with time due to recent experience.

Many a dam and many a publication has contributed to our present views, but I shall draw principally from 5 dams of our recent experience, rather special for sundry reasons. The dams are:

Salto Osorio Salto Santiago Itauba	52 m 80 m 103 m	earth-rock earth-rock earth-rock	High I p Red Clays	Sound basalts
For do Areia	160 m	Concrete-face		
Emborcação	157 m	earth-rock	Medium Ip Red sand-clays	Sound granito-gneiss

I shall not discuss problems of slope stability in compacted rockfills. The General Reporter has kindly mentioned my Rankine Lecture 1977; I am most happy to note that a proposal submitted therein is finding fruition, in that degrees of slope misbehavior tending towards incipient failure are being monitored through indications of rates of lateral deformation. One must guard against too simple a monitorable index. Moreover, with specific reference to rockfills I have emphasized (Symposium on High Embankment Dams, AIT, Bankok, Dec. 1980) that the viable much steeper slopes than have been vindicated under conventional soil mechanics reasoning are not only due to the curved Mohr envelope (Rankine Lecture) but also due to the hysteresis of loading vs. unloading, and due to the intrinsic difference of histogram of stability behavior that forces one to distinguish between a Factor of Guarantee FG of a slope, and the conventional Factor of Safety FS.

Our present interest is in deformabilities, conventionnally discussed as moduli of elasticity E. The accompanying figures serve as visual aids to emphasize the following points.

1. We must consider incremental strains and incremental stresses $\Delta\sigma = I \gamma Z$ where I = influence coefficient; the generally used implicit I = 1.00 is quite inapplicable except for "infinite" lateral dimensions, and has frequently led to the impression of creep deformations merely because the fill directly above the point stopped. At present a first order approxi-

mation is taken from charts of homogeneous elastic medium (Davis and Poulos). Since E varies significantly with σ, one may need second-order iterative corrections.

2. Compaction is equivalent to a precompression, preconsolidation, corresponding to the hysteresis of stored energy. Incidentally, due to the crushing of point contacts of sound angular rockfill, the hysteresis in preconsolidation of clays and in compaction of rockfills appear to be remarkably similar. Thus, in a manner similar to what was pragmatically developed (Casagrande) for clays, we have presumed to detect the compaction precompression pressures of rockfills by using the semilog plot. If this is true it should be of great consequence in planning compactors, and in extrapolation predicted behavior to greater heights. It becomes obvious that a compaction meter that reflects rigidity, such as that mentioned by the GR, should be ideal; meanwhile it explains why the lift compression (increment of density due to compaction, in conditions of crushing of points) should be a better index than the highly variable and erratic index of density itself. All questions regarding influence of grainsize curves, grain shapes, dry vs. wet crushing strengths, spreading-compaction-watering specifications, and so on, can be better understood. It would be of great interest to compact a really high rockfill with a sufficient number of lifts (the compressible thickness) using for each compressible thickness a significantly different weight of vibratory roller; hopefully one would detect the anticipated differences of precompression pressures.

3. The third set of revelations concerns the magnitudes of nominal E values determined from very consistent monitored data. Firstly, to one's utter surprise, the moduli of compacted clays have proved essentially similar to those of the compacted rockfills. And, to some extent even better. Even the residual red porous clays of basalts, of maximum dry density of the order of 1.3 t/m^3 and optimum water contents of about 40 % have surprisingly matched the sound (relatively uniform and clean) dense basalt.

Secondly, the case of the concrete-face Foz do Areia dam revealed that the deformation of the slab due to reservoir loading would correspond to a nominal E value roughly 2 to 3 times higher than the E values derived from monitoring settlements under self-weight. Somewhat surprising theoretically, but intuitions had led the Board of Consultants to prognosticate such a favorable trend. How to explain it? For the present, one can only conjecture. I have schematically shown three contributing hypotheses: one is associated with the difference between "active" and "passive" earthpressure conditions; one is associated with some inexorable anisotropy; and, finally, one may be incorporated into the general term "hysteresis effets" which describes but does not explain. There is yet much to learn, of great importance to higher, wider, larger concrete-face dams.

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

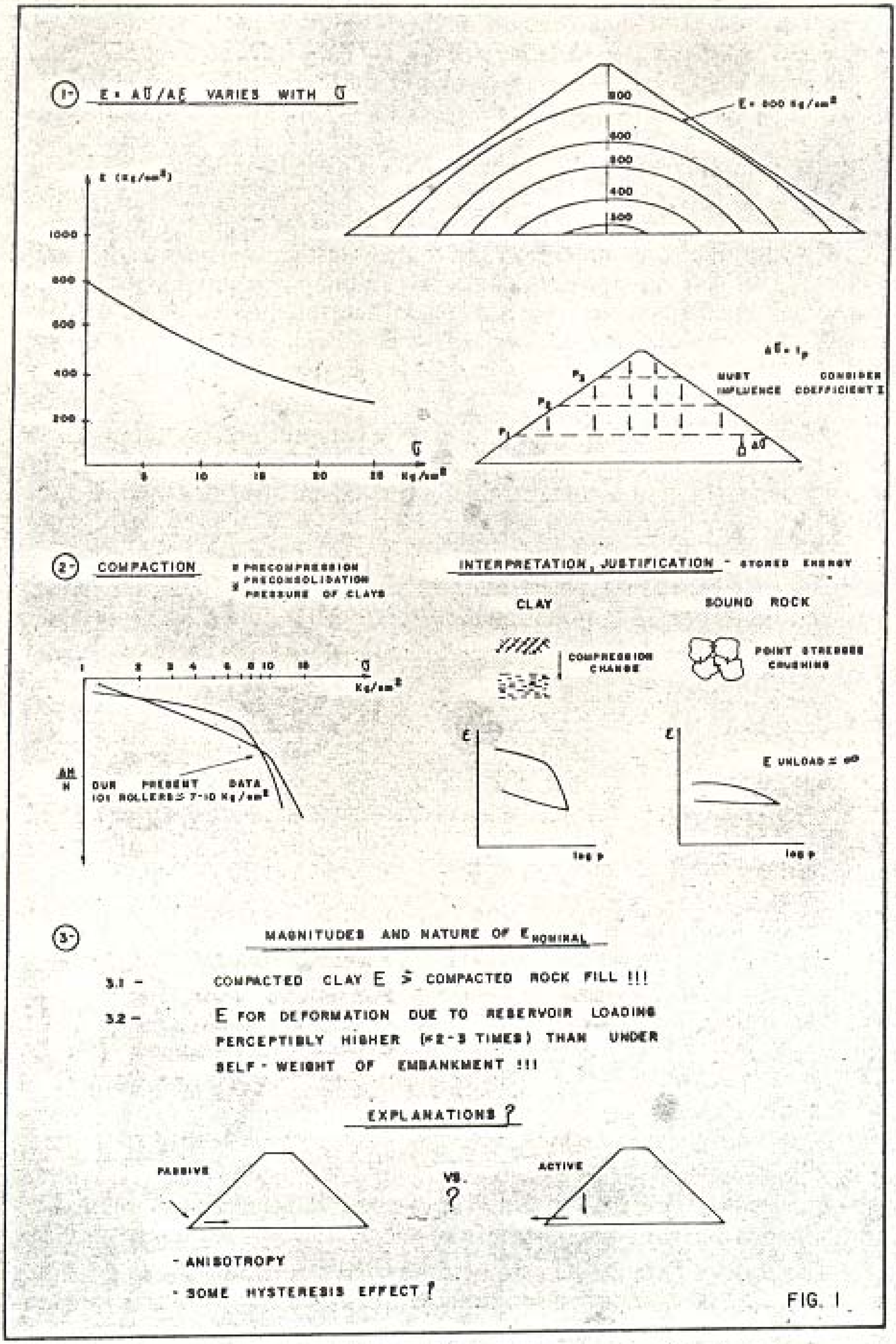
1- E = Δσ/Δε VARIES WITH σ
E (Kg/cm²)
1000
800
600
400
200
5
10
15
20
25
σ Kg/cm²
800
600
500
400
300
E = 800 Kg/cm²
Δσ = I_p
MUST CONSIDER INFLUENCE COEFFICIENT I
P3
P2
P1
Δσ
2- COMPACTION
= PRECOMPRESSION
≅ PRECONSOLIDATION PRESSURE OF CLAYS
INTERPRETATION, JUSTIFICATION - STORED ENERGY
CLAY
SOUND ROCK
COMPRESSION CHANGE
POINT STRESSES CRUSHING
1 2 3 4 6 8 10 15
σ Kg/cm²
ΔH/H
OUR PRESENT DATA
10t ROLLERS ≅ 7-10 Kg/cm²
E
log p
E UNLOAD ≅ ∞
3- MAGNITUDES AND NATURE OF E NOMINAL
3.1 - COMPACTED CLAY E ≥ COMPACTED ROCK FILL !!!
3.2 - E FOR DEFORMATION DUE TO RESERVOIR LOADING PERCEPTIBLY HIGHER (≈2-3 TIMES) THAN UNDER SELF-WEIGHT OF EMBANKMENT !!!
EXPLANATIONS ?
PASSIVE
VS.
?
ACTIVE
- ANISOTROPY
- SOME HYSTERESIS EFFECT ?

FIG. 1