DISCUSSION SESSION 3 7th European Conference on Soil Mechanics and Foundation Engineering, Brighton, Sep.1979, vol.IV, pp.112-115.

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cations aux sols, Aubry (1979), et aux liaisons sols-structures, Berthier (1979).

3.15 L. WITTMANN (FRG)

In reviewing the literature, one can see, that introducing safety factors into filter design is an arbitrary task, mainly due to the indirect treatment of filtration. The safety factors involved so far are more or less overall factors of ignorance. The new concept of direct treatment of filtration, presented in my paper to this Conference, analyses the filtration process on the microscopical scale, taking into account statistics of mean values and extreme values. This concept helps in understanding the filtration phenomena and at its different steps of treatment, the introduction of partial safety factors, mainly depending on the input data exactness, is possible. After further experimental data has been collected, the future filter design at its different steps will be:

- geometrical treatment of the porous medium: with parameters for grain-size-distribution, grain-shape, density, void ratio, pore-sizes, filtration-length and anisotropy
- geometrical treatment of the absorbing process: with comparison of pore-sizes and grain-sizes to be filtered. (Stabilization at the interface, particle loss)
- hydraulic treatment of filtration: with geometrical criteria being exceeded, this leads to a comparison of critical hydraulic values and assumed hydraulic boundary conditions.

Depending on the knowledge available and on the importance of the problem to be solved, filter design can thus be performed in different steps with reliability and safety being directly related.

3.16 K. HOEG (Norway), Chairman

Geotechnical engineering has derived its success largely from precedents, and the theories of soil mechanics provide devices for interpolating among specific experiences and provide the means by which the engineer can go beyond the limits of the profession's present experience. We should also realize that the combination of "imperfect" theoretical analyses and "imperfect" material sampling and testing may lead to sound engineering solutions if calibrated against previous experience.

One should keep this in mind when switching over from the conventional total safety factors to the new set of "equivalent" partial safety factors. The latter format is intended to make code specifications and design manuals more rational, and to facilitate the communication between the geotechnical engineer and, for instance, the structural engineer. I agree that many aspects of the new system are appealing, and the work in this direction ought to continue. However, the transfer is not a simple one.

The partial safety factors are imposed on the load and soil parameters as load and material coefficients, but the uncertainties in the method of analysis have so far not explicitly been accounted for. The uncertainty levels associated with different methods of analysis in geotechnical engineering, vary widely. Consequently, the reliability levels associated with the resulting designs may vary widely unless the load and material coefficients (partial safety factors) are re-evaluated for each method of analysis and for different soil types (e.g. brittle vs. ductile behaviour). This ought to be considered in more detail.

In this connection I must emphasize an important point, which, in spite of several discussions in international fora, seems to cause a lot of confusion. For a given undrained loading or unloading situation, the factor of safety computed from a total stress stability analysis is in general not numerically equal to the factor of safety computed from an effective stress stability analysis. This is so because the excess pore pressure traditionally introduced into the effective stress stability analysis is the pore pressure at the degree of strength mobilization correspondong to the computed factor of safety, and not the pore pressure at failure. One can argue which of the two analyses is preferable, however, that is not the point of this discussion.

Let me now conclude this Session 3:

Theory of probability may become a powerful link between theory and geotechnical engineering practice. Furthermore, the Bayesian approach in statistics allows objective information to be combined with subjective judgement.

Probabilistic procedures provide a framework that can assist the engineer to organize, accumulate, interpret and evaluate experience. I will encourage geotechnical engineers to look into the possibilities they offer.

I would like to thank the General Reporter, the Panel Members, the contributors from the floor, and the Secretary for this Session.

3.17 V.F.B. De Mello, (Brazil)+

Insofar as inexorably all data, parameters, correlations etc., must be understood statistically, and as soon as possible so expressed, it follows that our degrees of confidence (Factors of Safety, etc.) in our decisions and solutions must concomitantly be Probabilistic. But it seems to me that we are running great risks of schisms between engineers and probability reliability - theory wielders, as well as of curiously erroneous conclusions and even dangerous errors, if we allow the application of mathematical formulations without starting with a conceptual assessment of Engineering's tasks and responsibilities.

Firstly I venture to disagree with the frequent self-comforting statement that soils exhibit greater scatter than other building materials. It just cannot be so, and I have often been shown data from the collateral fields of engineering materials that would confirm a contrary reasoning. A very weak material subjected over thousands of years to Nature's logarithmically exhaustive processes of degradation obviously cannot sustain as great a variability as a synthetic strong one, unless really close quality control at fabrication rejects the wider dispersions. Agreed, however, that our problems of statistical variations associated with natural soils continue to be greater than those of our colleagues, principally because since Nature's most frequent geomorphological selectivity works close to the survival Factor of Safety of 1.00, even the smaller dispersions in our profession can be of much greater consequence, either in natural soil structures or in more sensitive "brittle" man-made structures interacting with deformable natural soils.

Moreover, should we not begin by a critical self-examination of ourselves and our symbols in a mirror of probabilistically generated images of surrounding "Nature" and "fact", in order to be able to laugh at the fancy-dress we have always taken for definitive without recognizing it as but a reflection of our early needs for idealized simplication and deterministic-dualistic perception-cognizance? In order to reach more convincing results should we not cross-examine whether the practical probabilistic treatments are really close enough to a complete fresh start in the thought process rather than merely grafting a change of method upon a tree already well grown?

There are many reasons why hitherto most probabilistic treatments on Safety, although presumably consistent in their internal mathematics, fail to insinuate realism in the face of our engineering endeavours.

For instance, many a mathematical formulation ipso-facto starts imperceptibly with the most common deterministic root-assumption, that of initial homogeneity no-matter with regard to what parameter.

Many intrinsic variabilities in Nature's status quo should not matter ... they exist in a compensated fashion, in Nature's long-term temporary equilibrium. Nature's selectivity and those of our cultural indices do not necessarily have anything in common: the apparent heterogeneities really arise from a differentiated reaction to a homogenizing action. For instance, a given homogeneous erosive action creates the histograms of many a sedimentary formation, and it is the same weathering action that creates the apparent widely dispersed reaction histogram of weathered products in saprolites. The appearance of wide differences occurs with regard to our visual-tactile destructive test indices: but surely in the face of the weathering process and its stress-strain consequences the reality must be of a temporary undifferentiated equilibrium. In the difficult step of transitioning from homogeneous-dualistic deterministic thinking to the statistical-probabilistic one we stumble on this very frequently. For instance, in predicting the compressibility settlements due to a constant Δp on a histogramic soil we automatically assume that the initial stress is uniformly deterministically γz, forgetting that in Nature's equilibrium there must have been an adjustment essentially to equivalent strains (de Mello, 1971) so that the more rigid soil elements already have higher initial stresses then the average γz (as is presently well recognized in the silo effect in earth-rock dams). There are built-in compensations, and they are cause-effect related and not random.

Moreover, in a professional sense the engineer is obviously much less taken to task because of variations in the existing conditions, than variations in what is done in the engineering project or in significant occurrences after the project goes into operation; that is the distinctive importance of variations, probabilities and risks associated with the changes of conditions which one has purposely sought, produced, and paid for.

Is it not deterministic to use rigid-plastic limit equilibrium statics? Is it not deterministic to adopt for definition of failure, even for probabilistic analyses, the condition FS=1.00? Is it not deterministic to adopt Safety Margins (Athanasiou-Grivas and Harr, 1979) or Indice de Securite (Salembrier, 1979) as bounded at the condition ≤ 0, which implies a definite deterministic acceptance level?

As regards variations, are we not deluding ourselves when we recognize the variations on material properties, loads, and even analyses, but forget that the greatest variation of all may well be on levels of acceptance to be established by "experience", especially if we honestly recognize that our parameters are but nominal?

When we substitute a graphical procedure for a mathematical one (Salembier, 1979), or even an idealized mathematical one for the uninhibited variability, are we not really excluding tail ends (which, however, may indeed be more appropriate, depending on the problem)?

When we propose new Indices to our undesired closeness to discomfort (Kezdi, 1979) should we not examine carefully the nature of the function? Many a function is automatically linear: this would seldom be appropriate in the face of physical behaviours and exponentially increasing discomforts; on the other hand, linearization of the presentation of the truly exponential function would tend to facilitate our subjective evaluations.

Should we not recognize a difference between Factors of Guarantee and Factors of Safety? For instance, if we compare an estimated pile capacity of 100 tons with the anticipated load of 50, we deal with the accepted denomination of FS = 2: if the pile is preloaded to 100 and accepted for a maximum working load of 50, is it still a Factor of Safety, or would it be a Factor of Guarantee that could be accepted in a much smaller numerical index? Such a distinction is important to the design principle of permitting construction conditions to be more critical than during operation. (de Mello, 1977).

In short, as we move away from the deterministic rigid-plastic or elastoplastic failure symbols, the probabilistic formulations will have to be based on Satisfaction Indices (de Mello, 1977) to be established on the basis of really numerous observations pertaining to other symbols (e.g. deformations in some soils, micro-acoustic emissions in more rigid soils, and so forth). The histograms for such Indices may only be extracted from the more frequent conditions of engineering works, to be associated with nominal computational indices (FS etc.), and not from a few "failure" cases back-analysed and assumed to belong to a common statistical universe.

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\+ Written contribution which was not presented verbally at the Conference.

* Edited version of verbal discussion (no written version provided), or severely edited account of written version.