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Discussion: Comment on conventional access inaccuracies and advanced general earth pressure model

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ABSTRACT: Conventional computer models of earth pressure are based mostly or exclusively on the elastiic-plastic constitutive relation (FEM, BEM, DPM) or on the limit equilibrium relations. A number reports presented at the Symposium have dealt with differences between the design analyses or predictions and results of field measurements on underground structures. This discussion paper is aimed to show and explain (within the possible short range available) very serious uncorrectnesses and risks involved in conventional approaches.

1 INTRODUCTION

This discussion paper has originated as a reaction to a number of comparative analyses of retaining structures dealing with the results of design calculations or predictions, the results of site measurements and differences between them. A considerable part of reports and papers on this theme presented the seriously and unnegligibly dissimilar values measured, for example, by Onishi&Sugawara, Siemer et al.,.Powderham, Uchiyama et al.

It was stated in Session 4 (Day, gen.rep.) that with one exception the deformations reported ranged from 0,03 % to 0,73% of excavation depth averaging 0,35%. The deformations of the remaining one case were 2,4 % of excavation depth. Most of these cases (except two) had the deformations highly over the standard limit movement for translative motion specified by EC7 (par.8.5.4/2), i.e.the value of 0,1%, which is the lowest of the three considered types. Only the deformations of two cases were under this limit. On the basis of 18 cases it was also stated that three excavations were particularly successful in controlling deformations, two of them involving the construction of a circular cofferdam excavation type.

It was shown earlier (see p.382) that no standard limit movement can be valid generally for all retaining structures.The acting of active resp. passive earth pressure (due to the mobilization of peak shear strength) along the active resp. passive part of the structure rear face is possible only due to one special combination of the shape of the deformed structure and its movements. This special combination does not depend only on the type of movement, but also on other factors: structure deformation, distribution of movements along the structure and behaviour of soil mass (geotechnical parameters).

Both the conventional computation models and the theory of earth pressure neglect some well known facts and this is often the reason of serious differences between design analyses or predictions and field measurements.

2 NEGLECTED FACTS

Two very important facts are neglected. The first is the possibility of shear strength decrease to the residual value, the second is the passive pressure at rest.

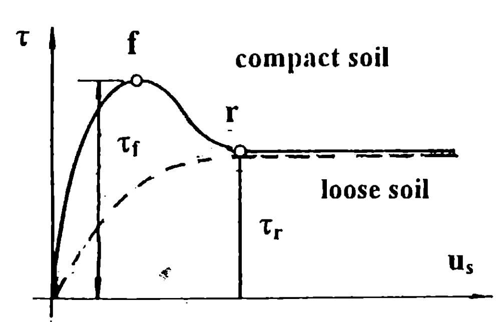

Figure 1. Relation of shear strength on displace-ment for compact soil (solid) and loose soil (dashed).

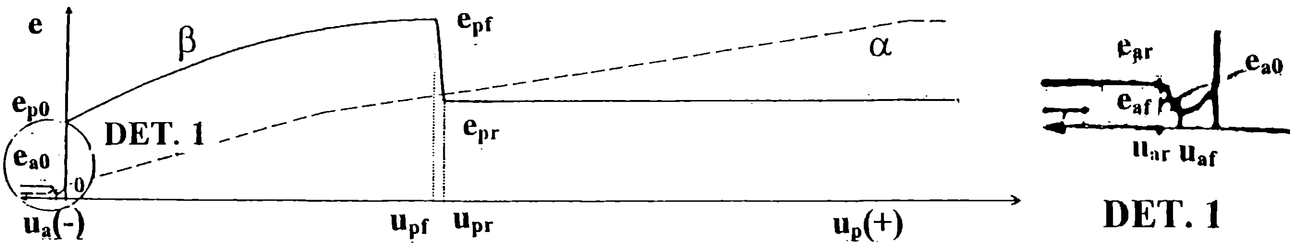

Figure 2. Dependences of earth pressure on movement : α) elastic-plastic, β) non-linear comprehensive.

2.1 *Decrease of shear strength to residual value*

Shear strength is mobilized step by step depending on the corresponding displacement characterized by the well known relations shown in Fig.1. The upper solid curve is characteristic for compact (consolidated) soils and is characterized by two extreme values (except for the beginning). Point „f“ marks the peak value of shear strength, the residual shear strength acts from the point marked „r“ and is significantly lower than the peak.shear strength.

The lower dashed curve characterizes the behaviour of loose .soil. This curve has the only one extreme corresponding nearly to the value of residual shear strength beyond point „r“.

This relation for *compact* soils proves clearly that a getting over the displacement corresponding to the peak value leads to the decrease of mobilized shear strength below to the residual value. This fact means that the equilibrium models based on the mobilization of the peak values even the elastic-plastic models are not in accordance to the mobilization procedure of shear strength (resp. earth pressure) of *compact* soils (also see Fig.2). Logical conclusion, behaviour of *loose* soils is not so dangerous and the named conventional models can be appropriate for these soils (*only*), can apear ilogical for the first view only.

2.2 *Singularity of pressure at rest*

The theory of earth pressure at rest had been developed from the second half of the 30s by many authors (Kjellman 1936, Jáky 1944 and others). Mainly, they investigated its hysteresis (Raju 1967, Fedorov-Malyshev, Plehman, Mach, Pruška 1973) and by the mid the 70s very important relations have been discovered: Jáky's basic equation of the coefficient K_0 of pressure at rest - lower (active) limit

$$K_0 = \frac{1-\sin\phi'}{1+\sin\phi'}\left(1+\frac{2}{3}\sin\phi'\right) = K_{0a} \qquad (1),$$

the formulation of the upper (passive) limit of the pressure at rest presented by Pruška in 1973

$$K_{02} = \frac{1+\sin\phi'}{1-\sin\phi'}\left(1-\frac{2}{3}\sin\phi'\right) = K_{0p} \qquad (2).$$

These equations define the pressure at rest as a singular range of earth pressure for zero or differential displacement. The phenomenon of singularity of pressure at rest can be explained in modern terms by the structural strength of soil and by the direction change of its effect.

3. ADVANCED MODEL

Let us consider a *compacted* soil mass acting against a retaining structure with real shear surfaces. Let these surfaces have arbitrary shapes but, for the sake of simplicity, let the corresponding degree of shear strength mobilization be constant along each surface. The model respecting both these assumptions and the above mentioned facts should be based on relation like that shown by solid curve in Fig.2. The relation has two total extremes for active and passive pressures (marked „f“), two local extremes for active and passive residual pressures (marked „r“) and a singular range of pressure at rest.

The dashed line represents the elastic-plastic model and clearly shows two dangerous areas for the displacements corresponding to residual active and passive pressures.

This model is valid also for *loose* soils (without peak value) after omitting the values of active and passive pressure.

4. CONCLUSION

An adequate application of this advanced model should reduce differences between analyses and measurements.

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