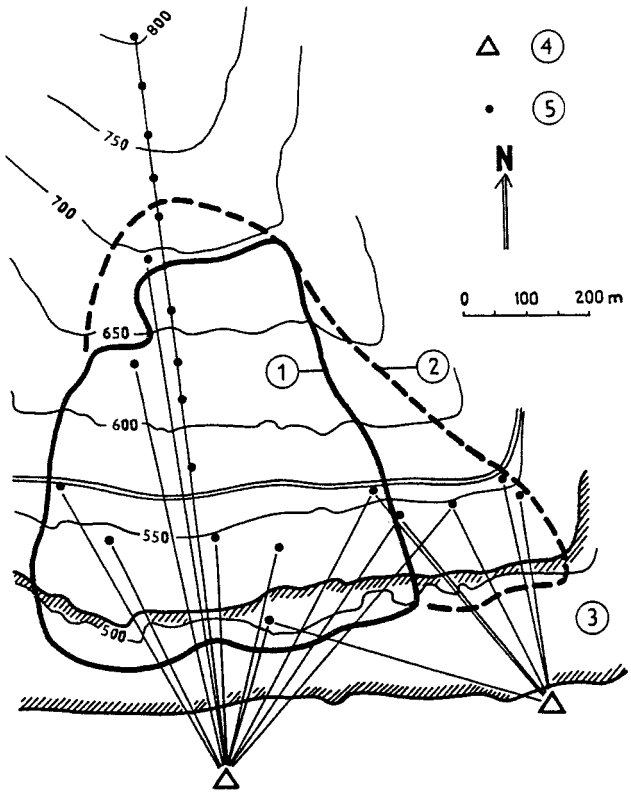

Fig. 3: Scheme of the geodetic control of the Řečice landslide. 1. boundary of the old landslide, 2. demarcation of the potential landslide, 3. Šance reservoir on the Ostravice river, 4. fixed points on the stable slope, 5. control points.

measurement of major areas with the necessary density of points. However, the thermovision technique, available at the present time, allows the elimination of this hindrance. It is to regret that none of the contribuions dealt with these problems. In our department we have just begun trial AGA thermovision measurements, and we hope that the application of this method under suitable engineering-geological conditions will prove to be useful.

Little attention has so far been paid by the participants of the symposium to the investigation methods of hydrogeological conditions although the knowledge of these methods — as has been stressed by the General Reporter — is extremely important for the final static assessment of slope stability. I believe that in the discussion new findings in this respect will be presented.

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Discussion

BULLETIN of the International Association of ENGINEERING GEOLOGY de l'Association Internationale de GEOLOGIE DE L'INGENIEUR N° 17 73—75 KREFELD 1978

RESIDUAL SHEAR STRENGTH OF SOILS

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In calculations of natural slope stability, residual shear strength parameters of soil have sometimes to be applied. To determine them accurately the ring shear apparatus should be employed. Generally, a simpler shear box apparatus — reversely operated — is used. This should be designed in such a way that the load plate above the sample is prevented from tilting. However, even taking this precaution the shear box apparatus may fail in residual strength testing, owing to the limited length of shear path.

In any case, the testing equipment and methods are quite complex. Therefore attempts emerge from time to time to find out suitable correlations between the residual shear strength parameters and the results of index tests simple to perform.

In the STAVEBNÍ GEOLOGIE nat. corp., Prague, relations of residual angle of internal friction ϕ_r to the following index properties were studied: 1. liquid limit W_L, 2. plasticity index I_p, 3. content of clay particles < 0.002 mm, 4. Skempton's coefficient of colloidal activity.

The best correlation appeared to be between ϕ_r and the plasticity index I_p, as is shown in Fig. 1. Fig. 2 shows the same graph on logarithmic scale.

A number of 195 residual shear tests (each with several normal loads σ) have been employed for this study. The tests were made for the most part in the STAVEBNÍ GEOLOGIE, and partly taken over from foreign papers (Kenney, 1967; Voight, 1975). The majority of the former were performed on various Tertiary clays of the North Bohemian brown-coal basin.

In case of non-linear Coulomb's relation $\tau - \sigma$ or in case of non-zero cohesion intercept, the "secant" angle ϕ_{r3} has been applied, which corresponds to the connecting line of the origin of axes with the point of τ for $\sigma = 0.3$ MPa (τ = shear strength, σ = normal strength; see Fig. 3).

In 160 cases (of 195 tests) the $\tau - \sigma$ relation was found to be linear (up to $\sigma = 0.5$ MPa), being non-linear, convex to σ -axis in the remaining ones. No regularity in the occurrence of this phenomenon has been ascertained.

The soil samples tested have been grouped according to Unified Soil Classification System and the frequency diagrammes of ϕ_r have been constructed in each soil group. Only the CH-group (clays of high plasticity) have shown some regularity (see Fig. 4). The other soil groups showed erratic occurrence of ϕ_r values.

Conclusion

The relations between the residual shear strength of soils and their index properties have been proved. Best correlation appeared to be between the residual shear strength and the index of plasticity. However, the correlation is not enough to enable the simple index tests to be substituted for the complex residual shear tests.

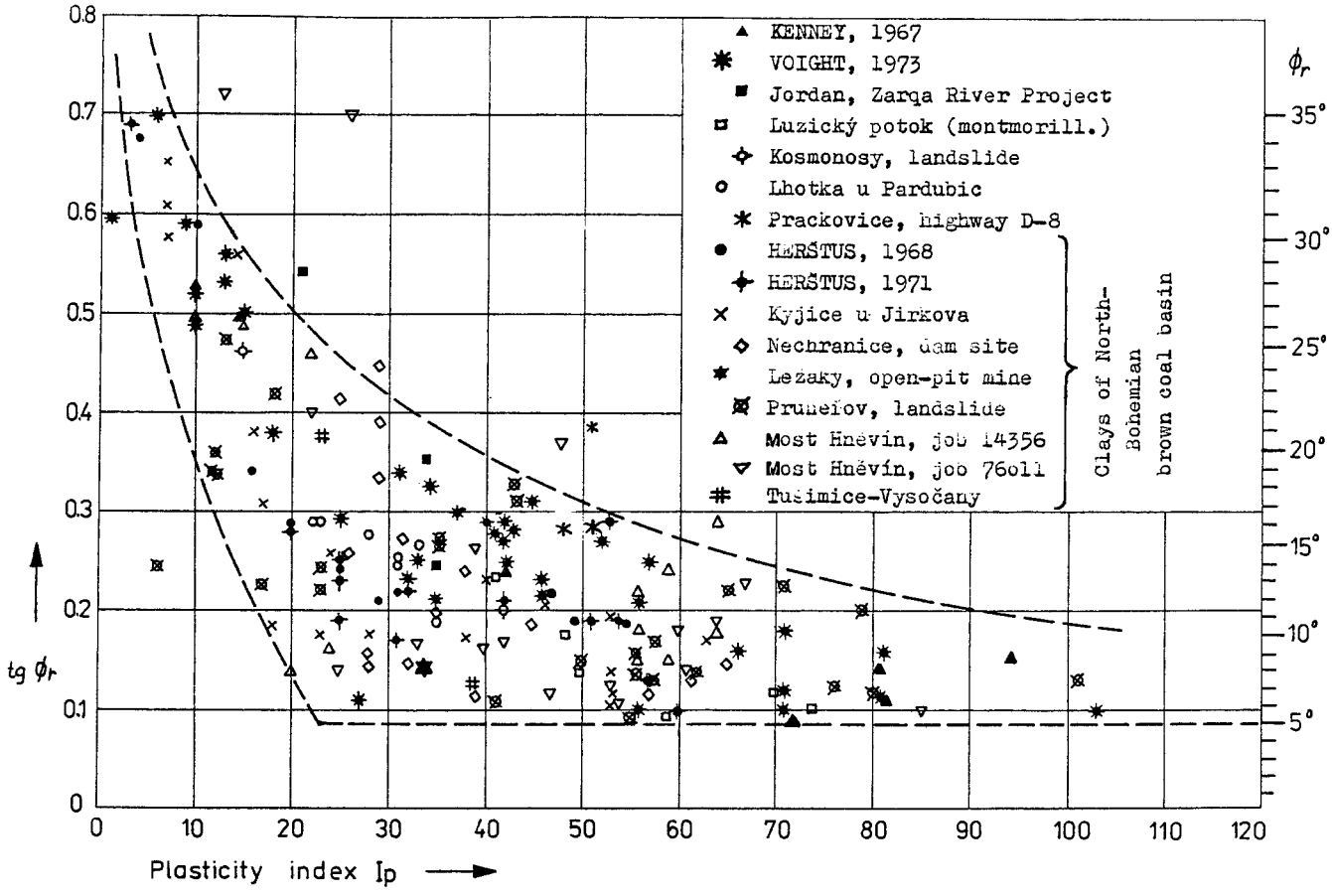

Fig. 1: Relation of residual angle of internal friction ϕ_r to index of plasticity I_P (Atterberg)

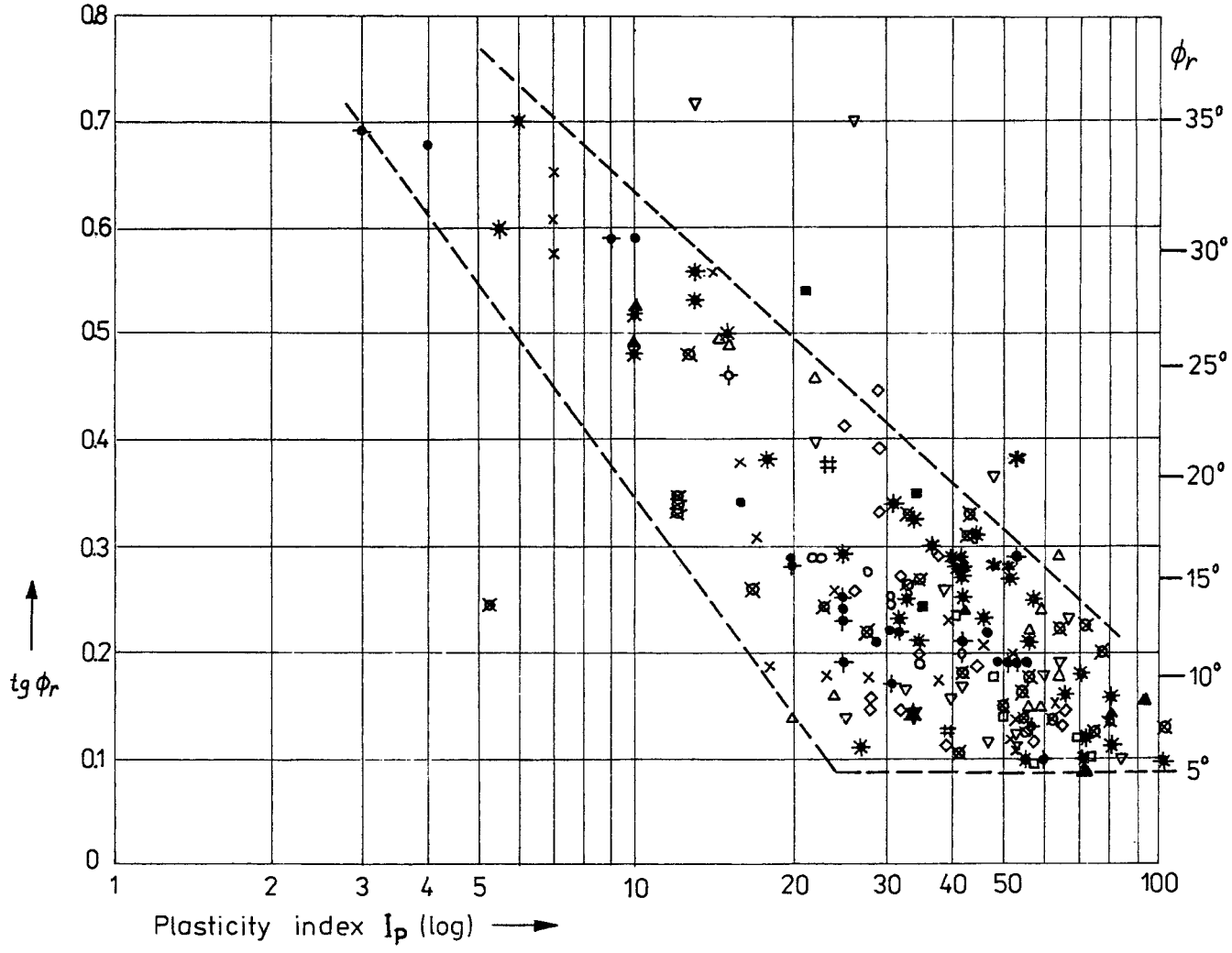

Fig. 2: Relation of residual angle of internal friction ϕ_r to logarithm of plasticity index

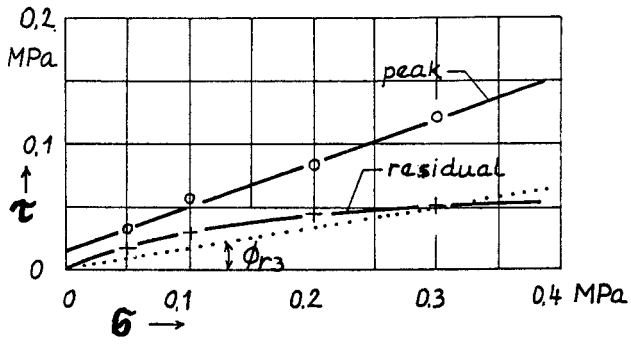

Fig. 3: Secant residual angle ϕ_{r3} for $\tau = 0.3$ MPa in case of non-linear τ—σ relation

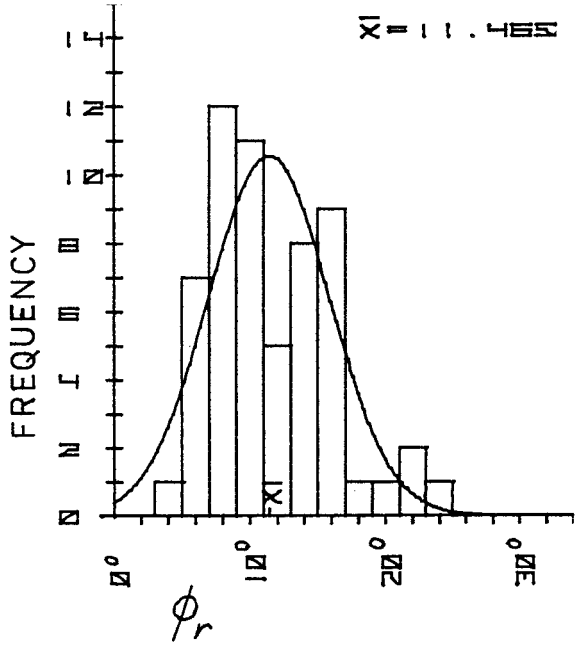

Fig. 4: Frequency diagram of residual angle ϕ_r, soils of CH-group.

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Many years ago I read an article by Prof. Terzaghi: "For construction work concerning the soil it is necessary to make the design as you go". Landslide controlling works are just the case, I believe, and wish to exemplify it by a simple case from my experience. Fig. 1 shows the cross section through a building site. After excavation a landslide took place, the sliding surface is indicated. To stop the movement a backfill was made, but we did not know whether it was sufficient or not. We also wanted to know the direction of the movement.

In order to measure very small movements two wires were stretched. Using dial strain gages with the precision of 0.001 mm, I could determine the movement of the sliding mass with sufficient accuracy after one week, and the next step of construction works could be taken. This method is only a very simple procedure, but I assume that methods of this kind should be developed in order to minimize the period of construction.

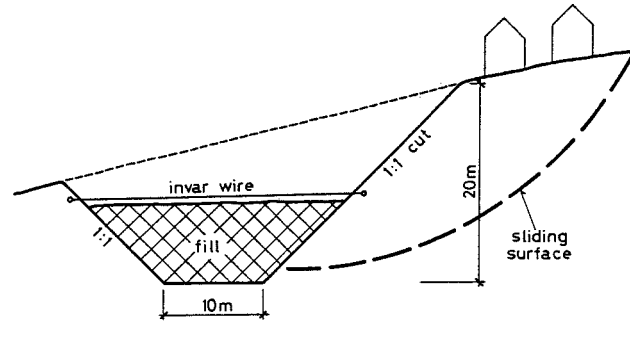

Fig. 1.