The local geological structure of construction sites in the London area is usually difficult to determine because of lack of bedding evidence; indeed the London Clay is frequently portrayed in the geotechnical literature only as featureless and blue/grey/black. Ward *et al.* (1959) interpreted in plan and section a small fold in Central London, but this paper is almost unique in giving background information on tectonic(?) structure. More such information from sites would be helpful.

Imperial College of Science & Technology,
London S.W.7,
18 January, 1967.

REFERENCES

WARD, W. H., A. MARSLAND *and* S. G. SAMUELS, 1965. Properties of the London Clay at the Ashford Common Shaft; in-situ and undrained strength. *Géotechnique*, 15:321–344.
WARD, W. H., S. G. SAMUELS *and* MURIEL E. BUTLER, 1959. Further studies of the properties of London Clay. *Géotechnique*, 9:33–58.
WHITAKER, T., *and* R. W. COOKE, 1966. An investigation of shaft and base resistances of large bored piles in London Clay. *Proc. Symp. Large Bored Piles, Institution of Civil Engineers, London*, pp. 7–49.
WOOLDRIDGE, S. W., 1923. The minor structures of the London Basin. *Proc. Geol. Ass.*, 34:175–193.

From Dr Ing. E. Nonveiller,
University of Zagreb

MECHANICS OF LANDSLIDES WITH NON-CIRCULAR SURFACES WITH SPECIAL REFERENCE TO THE VAIONT SLIDE

(MENCL, V., *Géotechnique*, 16:329–337)

Professor Mencl's paper in the December issue studies the stability of rock slopes in jointed rock considering the implications of stiffness and distortion of the sliding body. It should be noted that this is the first publication in which the stability of the Vaiont slide was treated as a phenomenon of rupture. In other publications on the Vaiont slide only the geologic and tectonic aspects of the problem were elaborated (Kiersch, 1964; Müller, 1964; Selli *et al.*, 1964), although in any case of rupture the final cause of failure is the lack of equilibrium between active and resisting forces.

Professor Mencl endeavours to interpret the collapse of the Vaiont slope by internal arching, formation of a gap and subsequent increase of water pressure in that gap. He obtains the angle of shearing resistance of $\phi = 18°$ for equilibrium of a profile of the slope with the actual failure surface.

The Writer had the opportunity to study the Vaiont slide in some detail. Stability analyses of the slope were carried out based on the actual failure surfaces, as detected by exploration drill holes after the slide, and with the registered piezometric levels. These analyses have shown that the average shearing resistance was not more than $\phi = 17°$ for the section studied by Professor Mencl (in western part of slide; in the eastern part, $\phi = 30°$ was obtained for equilibrium). This is well in agreement with his result, and it can be inferred that consideration of arching and Prandtl's wedges is not necessary to explain the rupture.

The formation of a gap of substantial dimensions on the slip surface, as supposed by Mencl, can hardly be expected in the kind of jointed rock of the Vaiont slope shown in Fig. 1.

Seismic shocks were registered at the dam station during the period of three years of slow sliding motion, coming mostly from a zone of the eastern part of the slide. These shocks show a peculiar incidence with the periods of acceleration of the sliding motion. It can be

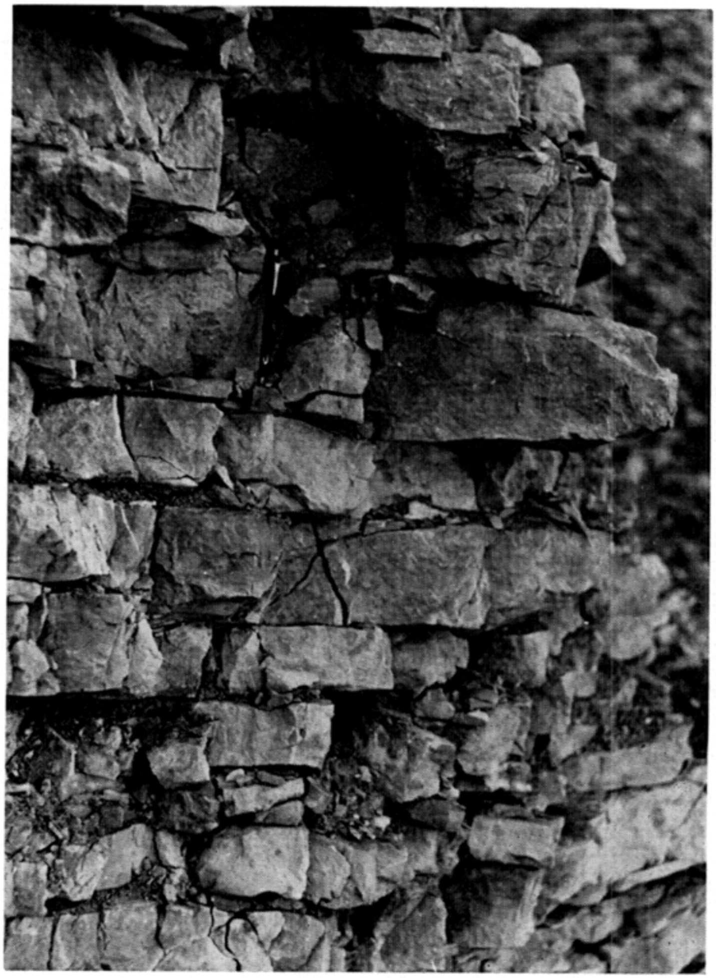

Fig. 1. Red and variegated nodular limestone with clayey beds (Upper Cretaceous), zone of rock above the slip surface

Fig. 2. Lumps of bentonitic clay (in white circles) on slide debris from slip surface

assumed that these shocks were most probably caused by local fracturing of rock in overstressed zones, which is characteristic of a process of progressive failure.

It should also be mentioned that since the appearance of the perimetral fissure along the upper boundary of the disturbed area of the slide in the autumn of 1960 to the day of collapse in 1963, more than 400 cm (13 ft) of displacement were recorded on the observation monuments. It is therefore not acceptable to classify this motion as creep because the average speed of motion was more than 40 times greater than that assumed by Terzaghi as the maximum speed of creep deformation. Besides, in a region of creep no definite boundary of the area in motion can be detected, whereas the distinct perimetral crack clearly limited the zone already in motion from the autumn of 1960.

During an inspection of the site at Vaiont, the Writer has found a rather significant quantity of lumps of a bentonitic clay of very low shearing resistance ($\phi=5°–7°$) within the debris material from the sliding surface (see Fig. 2). Geological evidence shows signs of a prehistoric slide on the western part of the recent slide. The low values of the shearing resistance of the rock masses, established in all available stability computations of the Vaiont slide, could be explained if the following three points are duly considered:

(*a*) in the zone of the previous prehistoric slide in the western part of the slide, the strength of the rock mass was reduced to its residual value due to large strains;

(*b*) the average shearing strength of the nonhomogeneous bedded and jointed rock mass was gradually reduced to a residual value of $\phi_r=17°–30°$ by a process of progressive failure;

(*c*) the variety of clay of very high plasticity and low shearing strength existing in some bedding planes and/or rock zones further reduced the strength on some portions of slip surface to only 5°–7°.

It can be concluded that the study of slides in rock masses needs comprehensive exploration of the weakest constituents in the first place. The rupture phenomena in minutely fractured rock masses seem to be of the same nature as in granular and cohesive materials and the stability of rock slopes can be analysed in the same way.

Zagreb, Kačičeva 26,
30 January, 1967.

REFERENCES

KIERSCH, G. A., 1964. Vaiont Reservoir disaster. *Civil Engineering*, 34:32–39.
MÜLLER, L., 1964. The rock slide in the Vaiont valley. *Felsmechanik und Ingenieurgeologie*, 2:148–212.
SELLI, R. L., G. C. TREVISAN, 1964. La frana del Vaiont. *Annali Mus. Geol.*, Serie 2, 32:1.

From A. K. Parkin,
Soil Mechanics Ltd

INCREMENTAL STRAIN RATE RATIOS AND THE STRENGTH OF SAND IN THE TRIAXIAL TEST
(BARDEN, L. and A. J. KHAYATT, *Géotechnique*, 16:338–357)

The Writer has followed with interest the development of stress-dilatancy concepts in recent years and the paper by Barden and Khayatt is a further addition to the literature on this subject.

The Writer would like to add some comments relating to the section on failure criteria for soils, a topic of rapidly expanding interest in connexion with granular soils. It is now accepted that none of the three classical criteria of failure, which have been inherited from the discipline of metal physics, are adequate to fit the observed behaviour of sands and, indeed, it would appear that there is not even a unique criterion that is independent of porosity. Only in the