Editorial

Mechanics of Critical State

Experiments in Norwegian Geotechnical Institute have shown that shear strength of rocks does not appear to increase significantly beyond a critical confining pressure. This pressure is found to be about uniaxial compressive strength of rocks at the room temperature. Lot of research has been done at IIT Roorkee in this direction. The critical confining pressure in anisotropic rocks is found to be the uniaxial compressive strength of rocks with horizontal planes of weaknesses. The natural law of critical state is also applicable to the jointed rock masses. There critical confining pressure is also found to be the uniaxial compressive strength of rock blocks. These conclusions are based on over 1000 triaxial tests all over the world. It is postulated that the shear strength of jointed rocks at critical confining pressure is nearly the same as shear strength of rock material at critical confining pressure. Recently Bureau of Indian Standards (BIS) recommended polyaxial strength criteria of rock masses on the basis of the critical state. In sands also, saturation limit of shear strength is reached approximately beyond a high critical confining pressure according to a test conducted at NGI. Like rocks, concrete should also reach saturation limit of shear strength at its critical confining pressure.

So the critical state may also reach approximately in case of the frictional resistance between any two surfaces, as mentioned for soils and rocks. The concept of critical state should also be applicable to the residual shear strength of both soils, rocks and joints at the large strains. Research needs to be done in this area. We should pay attention to critical state mechanics of rocks in the cases of deep tunnels in weak rocks, very deep mines and deep drill-holes.

Similarly, the velocity of flow through pipes, concrete lining in tunnels and spillways cannot exceed the critical limit of erosion velocity of the respective materials. The seepage velocity should also not exceed erosion velocity of soils and rock masses.

It is observed that rocks behave as ductile material beyond the critical confining pressure at great depths below the brittle earth crust, corresponding to the temperature. The top crust is naturally brittle and the underlying crust is ductile. It, therefore, seems that most of the earthquakes should be shallow and their epicenters may lie in the upper brittle crust, as seismic zones are absent in the ductile crust and rocks. The earthquake due to volcanic activity can have deep epicenter. There can be other causes of very deep earthquakes which we engineers do not understand. The same knowledge base should be applicable to other solid planets of rocks. The height of mountains is, therefore, limited due to limited shear strength of rock masses on any planet. Thus, there is limit to the deviator-in-situ stress inside the earth crust.

There appears to be critical limit to every parameter in the nature. Theoretically a force cannot be infinite, otherwise the whole universe will collapse. For example, the relative

speed between any two particles cannot exceed the speed of light. Similarly, there should be limiting value of relative acceleration and angular acceleration between two particles. Theoretically black holes should be free of significant seismicity as confining pressures are very high at even shallow depths.

It, therefore, appears that laws of the nature may be non-linear and linear laws are current approximation of non-linear laws only. Yet the laws the nature must be simple in order to be most reliable to ensure very long life of the universe. What is beyond the laws of the nature? The happiness is beyond the laws of nature deep within.

- *Chairman and Editors*