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Evaluation of Biot's Effective Stress Constant for Peak and Residual Strengths for Shikotsu Welded Tuff and Kimachi Sandstone by using Modified Failure Envelope Method

Dassanayake, A.B.N. and Fujii, Y. , Hokkaido Univ.

The Biot’s effective stress coefficient, α, is usually calculated based on experiments within elastic region using poroelasticity theory. However α, for peak and residual strengths is important when using it to evaluate rock failure. Failure envelope method proposed by Franquet and Abass (1999) evaluate α based on peak strength. They however showed just two data for a rock and a tedious and not precise trial and error method was used for the evaluation. The authors propose a modified failure envelope method and use it for peak and residual strengths of Shikotsu welded tuff and Kimachi sandstone. The Modified failure envelope method requires strength data on the effective confining pressure-differential stress plane on samples with zero pore pressure first, and then strength data for samples with specific pore pressures are plotted.

Data with pore pressure can move to the left by increasing α from 0 to 1 (Fig.1). The crossing point can be easily calculated and the α can be obtained from effective confining pressure at the point $P_C{}'$ as

$$\alpha = \frac{P_C - P_C{}'}{P_p}$$

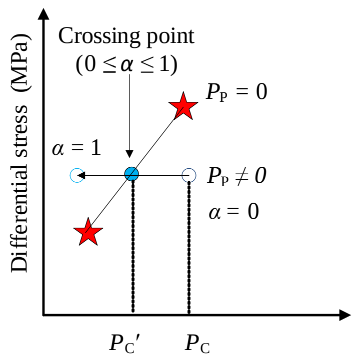

Fig. 1 Evaluation of α by the modified failure envelope method

Triaxial compression tests were carried out under P_C and P_P as show in Table 1 for Kimachi sandstone and Shikotsu welded tuff.

Table 1. Target values of confining and pore pressures

Confining pressure (MPa)	Pore pressure (MPa)				
2	0	1			
5	0	1	4		
10	0	1	4	9	
15	0	1	4	9	14

For Kimachi sandstone, α value for peak strength decreases with effective confining pressure (Fig. 2). α values for residual strength however are almost constant and higher than the case of peak strength.

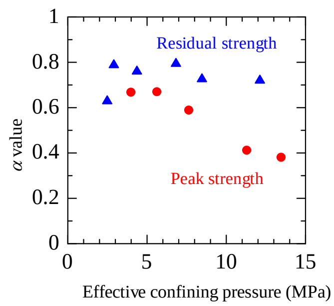

Fig. 2 Biot’s constant variation with effective confining pressure for Kimachi sandstone

For Shikotsu welded tuff, only two data points were obtained for peak strength (Fig. 3), because strength values with pore pressures were larger than those with zero pore pressure in many cases. α value for residual strength decreases with effective confining pressure.

The strange behavior of Shikotsu welded tuff should be investigated further. The method will be applied to other rock types. Comparison with conventional methods will also be carried out.

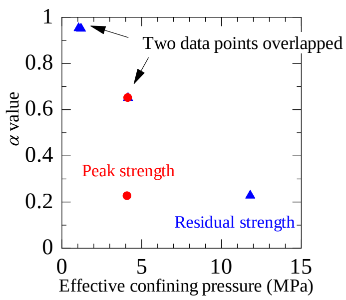

Fig. 3 Biot’s constant variation with effective confining pressure for Shikotsu welded tuff

Reference

Franquet JA, Abass HH (1999) Experimental evaluation of Biot's poroelastic parameter - Three different methods, in 37th U.S. Symposium on Rock Mechanics (USRMS), June 7-9 Vail, CO, Balkema, Rotterdam, 349–355.