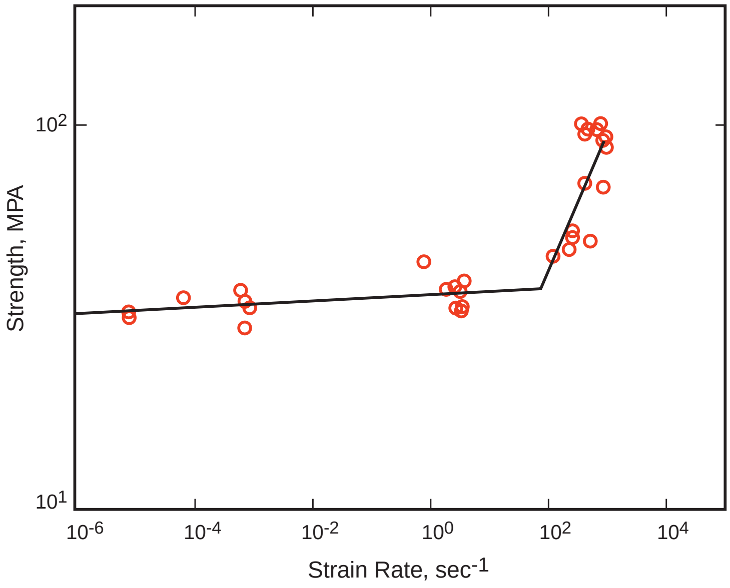
Material Behavior Under Impulsive Loading

Need

Strength and mode of deformation of rock and other brittle materials such as concrete and ceramic depend on the applied rates of stress or strain. The strength of rock generally increases gradually with increasing rate in the quasi-static regime (strain rates less than about 10^{-2} sec^{-1}). For rates greater than about 10^{2} sec^{-1} the effect of increased rate on brittle fracture stress is very strong. Little work has been done in the intermediate range, 10^{-2} to 10^{2} sec^{-1}. Some studies have missed the systematic variation of strength with rate in the high rate regime and have simply extrapolated quasi-static data over several orders of magnitude to a single value of "dynamic" strength. Others have found that the two regimes intersect at a well-defined critical strain rate where a very rapid change in the rate effect occurs. That is, fracture strength is a continuous function of strain rate over many orders of magnitude in strain rate, but the rate-of-change of strength with strain rate is nearly discontinuous and is located somewhere in the intermediate range. Strain rates associated with technological processes cover an enormous range from less than 10^{-10} sec^{-1} for creep of mine pillars, to 1 sec^{-1} to several 100 sec^{-1} for cutting tool-rock interactions, all the way up to 10^{3} to 10^{5} sec^{-1} for near-field explosive applications such as certain oil-well simulations or mine and quarry blasting. Thus, the critical strain rate falls within the range of technological application, and may play an influential role in predictive modeling of such processes.

Description

Both conventional servo-controlled load machines and a split Hopkinson pressure bar (Kolsky bar) are used to investigate rate effects up to about 3000 sec^{-1}. Pulse shaping techniques allow access to lower rates in the Kolsky bar and a novel passive confinement technique provides data on the effect of confinement without the construction of active confining pressure system. Thus, the effect of strain rate on strength, the location of the critical strain rate, and the influence of confining pressure on the strain-rate effect are determined. The figure shows the effect of strain rate on the strength of tuff (a volcanic rock). The break in slope indicates the transition between static and dynamic processes. Predictions of explosive crater size



Effect of Strain Rate on Strength of Tuff.

and depth of penetration of earth penetrators have been improved by incorporating the strong strain rate effect above about 10^{-2} sec^{-1} .

References

Olsson, W. A., The Compressive Strength of Tuff as a Function of Strain Rate from 10^{-6} to 10^{3} sec., International Journal of Rock Mechanics and Mining Sciences, vol. 28, pp. 115-118, 1991.

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