

Shear Strength Characterization of Coal Mine Spoil in Very-High Dumps with Large Scale Direct Shear Testing

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Abstract : The shearing behavior of current and planned coal mine spoil dumps up to 400m in height is studied using large-sample-high-stress direct shear tests performed on a range of spoils common to the coalfields of Eastern Australia. The motivation for the study is to address industry concerns that some constructed spoil dump heights ($> 350\text{m}$) are exceeding the scale ($\leq 120\text{m}$) for which reliable design information exists, and because modern geotechnical laboratories are not equipped to test representative spoil specimens at field-scale stresses. For more than two decades, shear strength estimation for spoil dumps has been based on either infrequent, very small-scale tests where oversize particles are scalped to comply with device specimen size capacity such that the influence of prototype-sized particles on shear strength is not captured; or on published guidelines that provide linear shear strength envelopes derived from small-scale test data and verified in practice by slope performance of dumps up to 120m in height. To date, these published guidelines appear to have been reliable. However, in the field of rockfill dam design there is a broad acceptance of a curvilinear shear strength envelope, and if this is applicable to coal mine spoils, then these industry-accepted guidelines may overestimate the strength and stability of dumps at higher stress levels. The pressing need to rationally define the shearing behavior of more representative spoil specimens at field-scale stresses led to the successful design, construction and operation of a large direct shear machine (LDSM) and its subsequent application to provide reliable design information for current and planned very-high dumps. The LDSM can test at a much larger scale, in terms of combined specimen size (720mm x 720mm x 600mm) and stress (σ up to 4.6MPa), than has ever previously been achieved using a direct shear machine for geotechnical testing of rockfill. The results of an extensive LDSM testing program on a wide range of coal-mine spoils are compared to a published framework that widely accepted by the Australian coal mining industry as the standard for shear strength characterization of mine spoil. A critical outcome is that the LDSM data highlights several non-compliant spoils, and stress-dependent shearing behavior, for which the correct application of the published framework will not provide reliable shear strength parameters for design. Shear strength envelopes developed from the LDSM data are also compared with dam engineering knowledge, where failure envelopes of rockfills are curved in a concave-down manner. The LDSM data indicates that shear strength envelopes for coal-mine spoils abundant with rock fragments are not in fact curved and that the shape of the failure envelope is ultimately determined by the strength of rock fragments. Curvilinear failure envelopes were found to be appropriate for soil-like spoils containing minor or no rock fragments, or hard-soil aggregates.

Keywords : coal mine, direct shear test, high dump, large scale, mine spoil, shear strength, spoil dump

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