Measuring Stress Transmissions in Opaque Cementitious Particulate Materials

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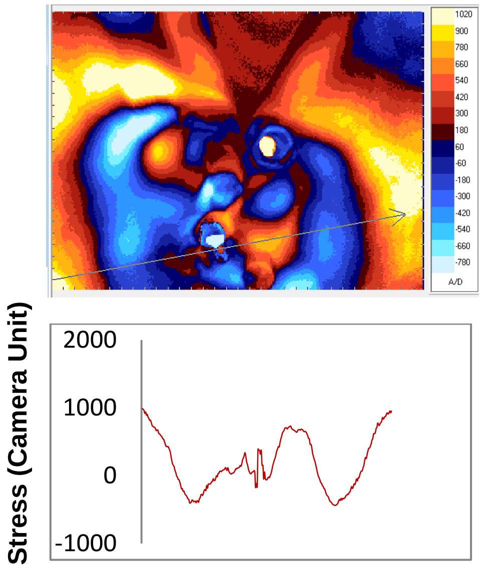
ABSTRACT

An experimental investigation of stress transmission through cementitious particulate structures where visible stress pattern and stress-strain data from rock matrix akin to the problem of rock fracturing still remains as a challenge, and this is addressed in the present work. Here stress transmission through sandstone under mechanical loading is analysed experimentally by applying a thin micro coating of birefringent material (Antony and Chapman 2010). By measuring the retardation of the light components reflecting from the surface of the birefringent coating on sandstone samples and using a reflection type optical tomography, we can relate it to the maximum shear stress under the external loading at any point of interest on the surface of the sample. Strain induced birefringence occurs due to the anisotropy within the grains in the sandstone which result isochromatic fringes. Hence the shear stress map on the surface of the sandstone sample can be visualised. This information is used further to evaluate different micro scale strength parameters. Suitable measures are compared with other experimental techniques including the ultrasound sensors, strain gauges and bulk strength devices.

Analogous to this experiment, simulations using Discrete Element Modelling (DEM) are performed using the measured grain-scale parameters as inputs. Boundary and initial conditions similar to experimental conditions were used to simulate force distribution (Antony 2007) for sandstone under compression. The statistical description of the peak forces associated with breaking the grain-to-grain cementation in experiment agrees excellently with the simulations. This makes it possible to visualise and understand how micro-scale behaviour contributes to the bulk strength characteristics of cementations materials even when they are opaque.

Keywords birefringence, anisotropy, stress, grains

Experimental set up



Stress Response used for Sandstone Calibration.

<u>Experimental-DEM hybrid Technique:</u> The overall strain distribution of the stress contours are isochromatic lines seen as a series of colour bands contiguous to each preceding brand where each band is a reflection of different degree of birefringence or a degree of strain in the material under investigation as such each colour signifies birefringence or fringe order. Hence instant identification of the magnitude of nominal strain or its gradient was facilitated and highly stress areas were differentiated. Our measurement accuracy depends largely on the identification of fringe order and its relation with magnitudes of strains. Thus the stress contours directs users to define mechanical loading/stress on bonded grains structure. Strain occurs all through parts of the coated model sample during loading where the magnitude of the surface strain/stress are usually highest and it is the most significant. The strains are transmitted and seen as isochromatic fringes on the coated sandstone sample. Therefore the crucial objective of these experiments is to extract properties of a grain/particle that purely define elastic behaviour (determined by both elastic wave velocities and grain contacts) of loaded, particulate structures that can be simulated by Discrete Element Modelling. Also, the tension/compression may be simulated numerically and compared to experimental observations. So that real physical rock behaviour can be simulated, since the contact law between cemtitious particulate structure of rock are yet to be revealed.

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