



Earthen Construction Symposium: Durham '13

Fracture Energy of Rammed Earth

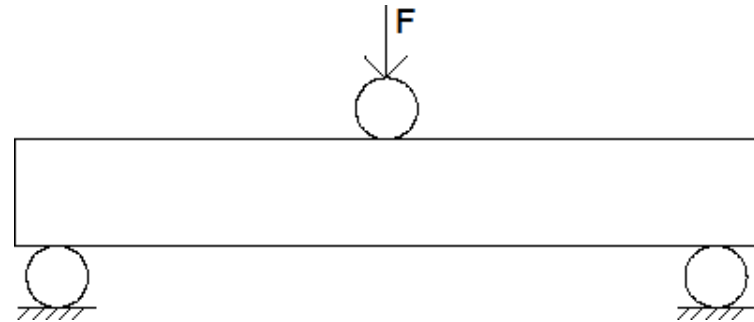
Andrew Corbin



Undergraduate Work

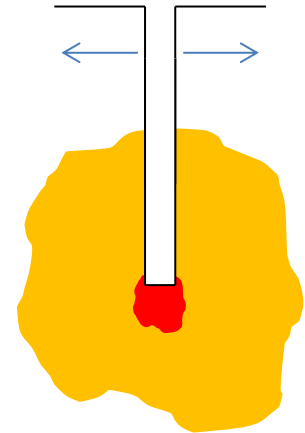
Flexural Strength

- Large samples (150x300x400mm)
- Heavy (approx. 35kg)
- Dried slowly (>2 weeks)



What is Fracture?

- Failure occurs in a material when the input energy exceeds the material capacity.
- Excess energy is transferred to another part of the material through the material structure.
- Energy builds up in an ‘elastic’ zone, concentrated around a pre-existing crack tip.
- Once the material yield stress is reached, a plastic zone forms, which causes permanent deformation to the material.
- The plastic zone size increases until the stress in the material exceeds the stress limit and the crack extends, which relieves some stress.

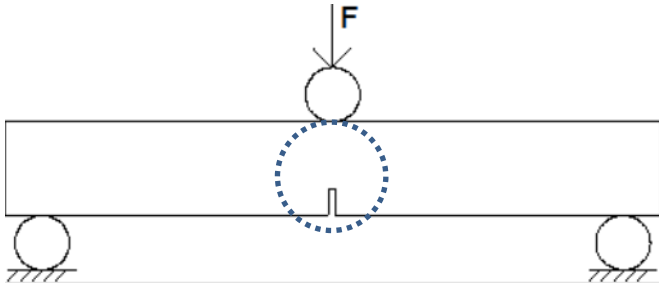


What is Fracture Energy?

- “The energy required to create and fully break a unit surface area of crack”
- Dependent on material properties – ductility, elastic & plastic limits, tensile strength.
- Theories first formed around WWI and WWII.
- Currently still being adapted

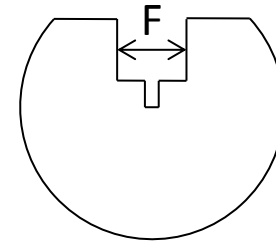
Fracture Tests

Three Point Bending Test



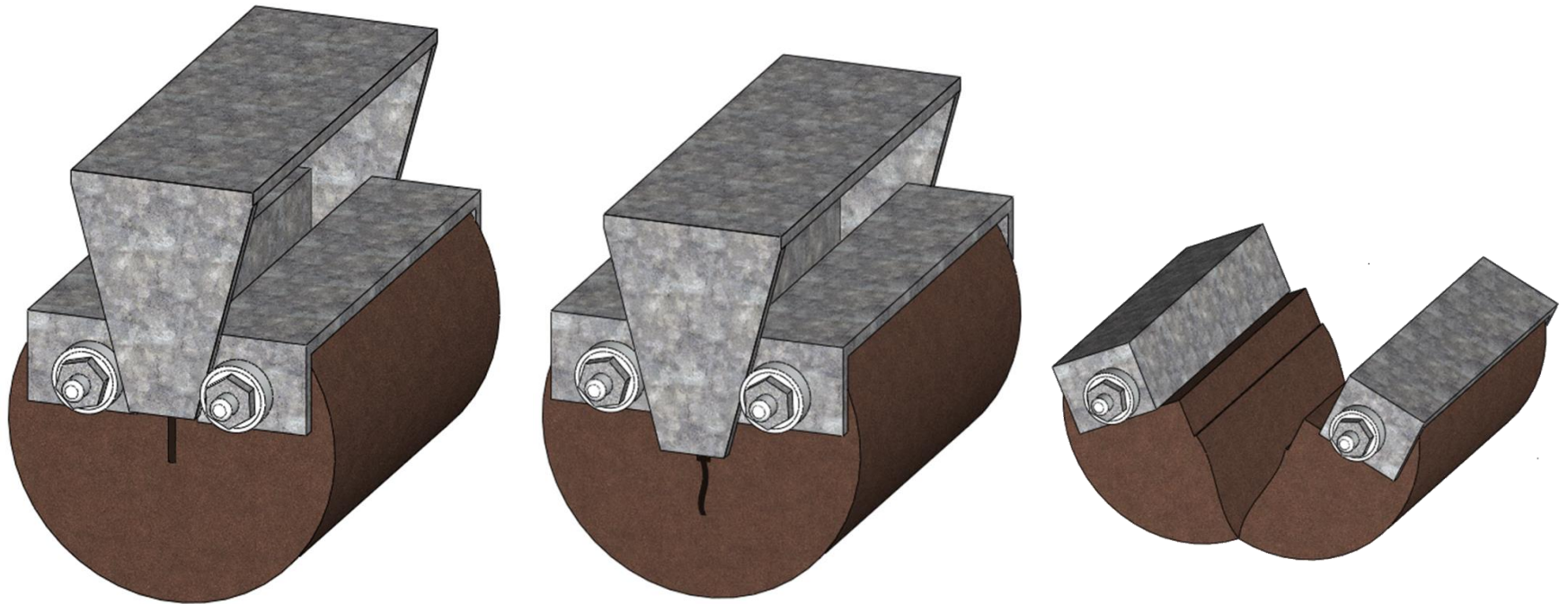
- Large samples (typically 200x400x1000mm)
- Heavy (approx. 80kg)
- Dries slowly
- Testing affected by self weight

Wedge Splitting Test



- Smaller samples (200x150mm \emptyset)
- Lighter (approx. 15 kg)
- Dries quicker
- Testing not affected by self weight

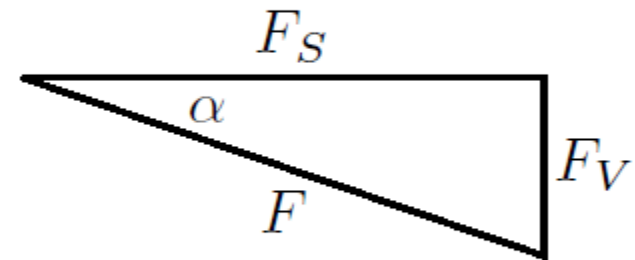
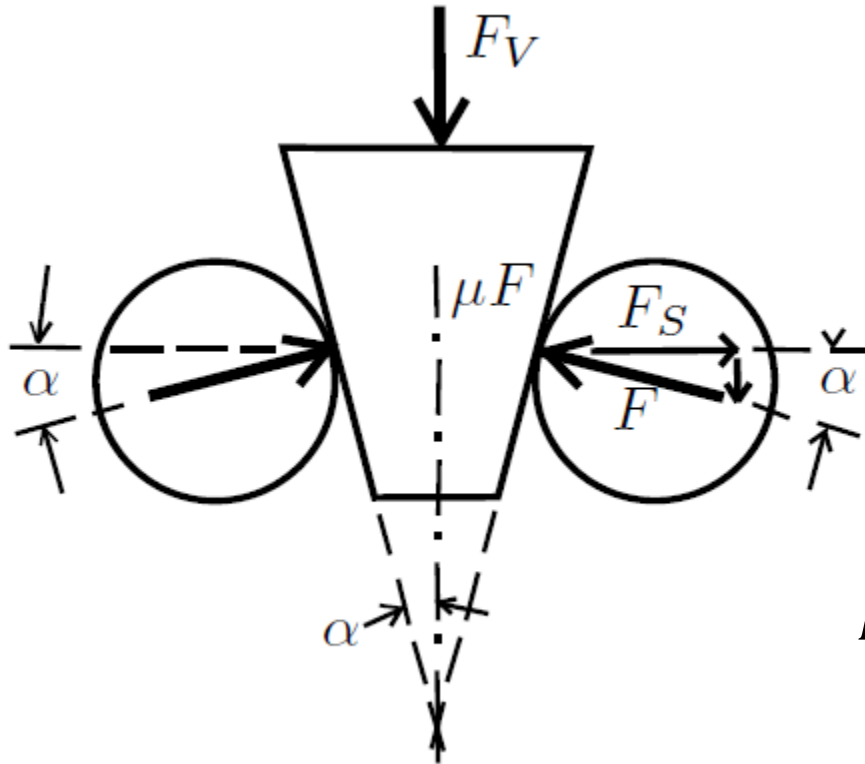
Wedge Splitting Test



Test Procedure

- Made 6 batches of soil, containing 0 - 10% cement.
- Soil used '613' (sand:gravel:clay)
- Clay used 'Speswite,' 100% Kaolinite
- Water added according to optimum water content (12%) obtained from Proctor Test
- Each batch made 3 cylinders and 3 cubes.
- Cubes for compressive strength testing.
- Cylinders compacted with pre-cast notch.
- Samples air dried for 14 days before testing.
- Displacement-controlled, 0.1 mm/min

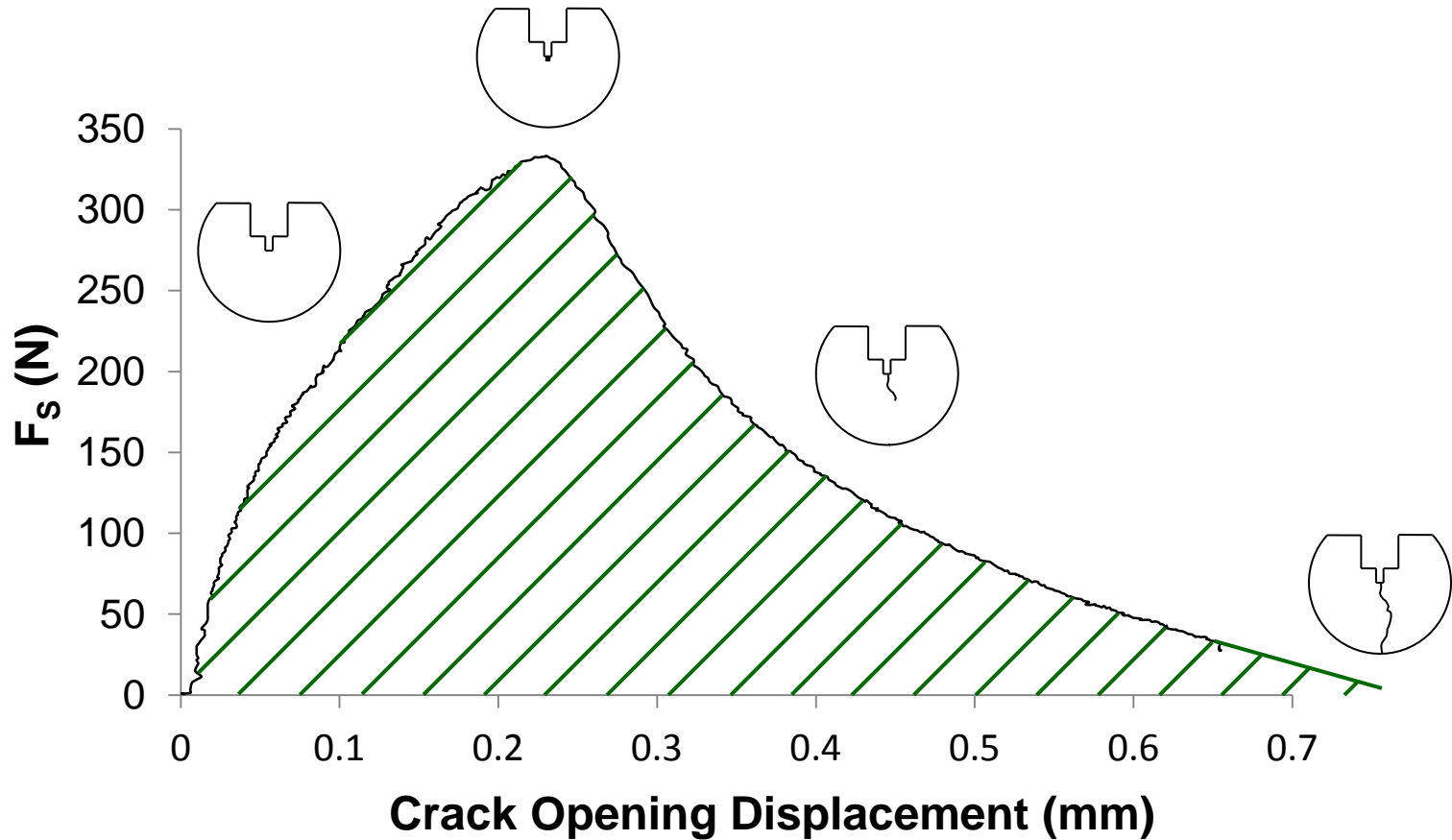
WST forces & stresses



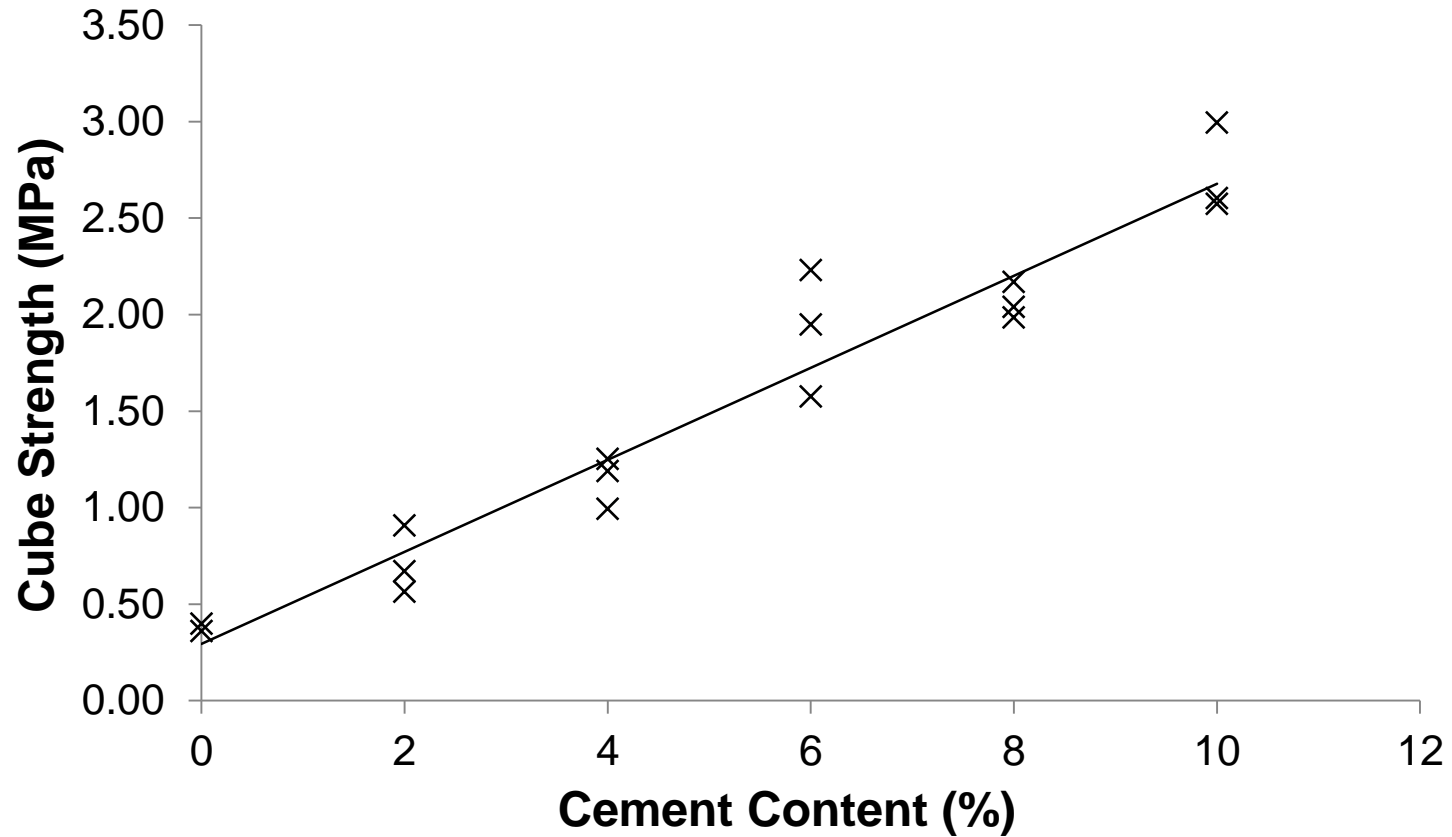
$$F_S = F_V / \tan \alpha$$

$$F_S = 3.73 F_V$$

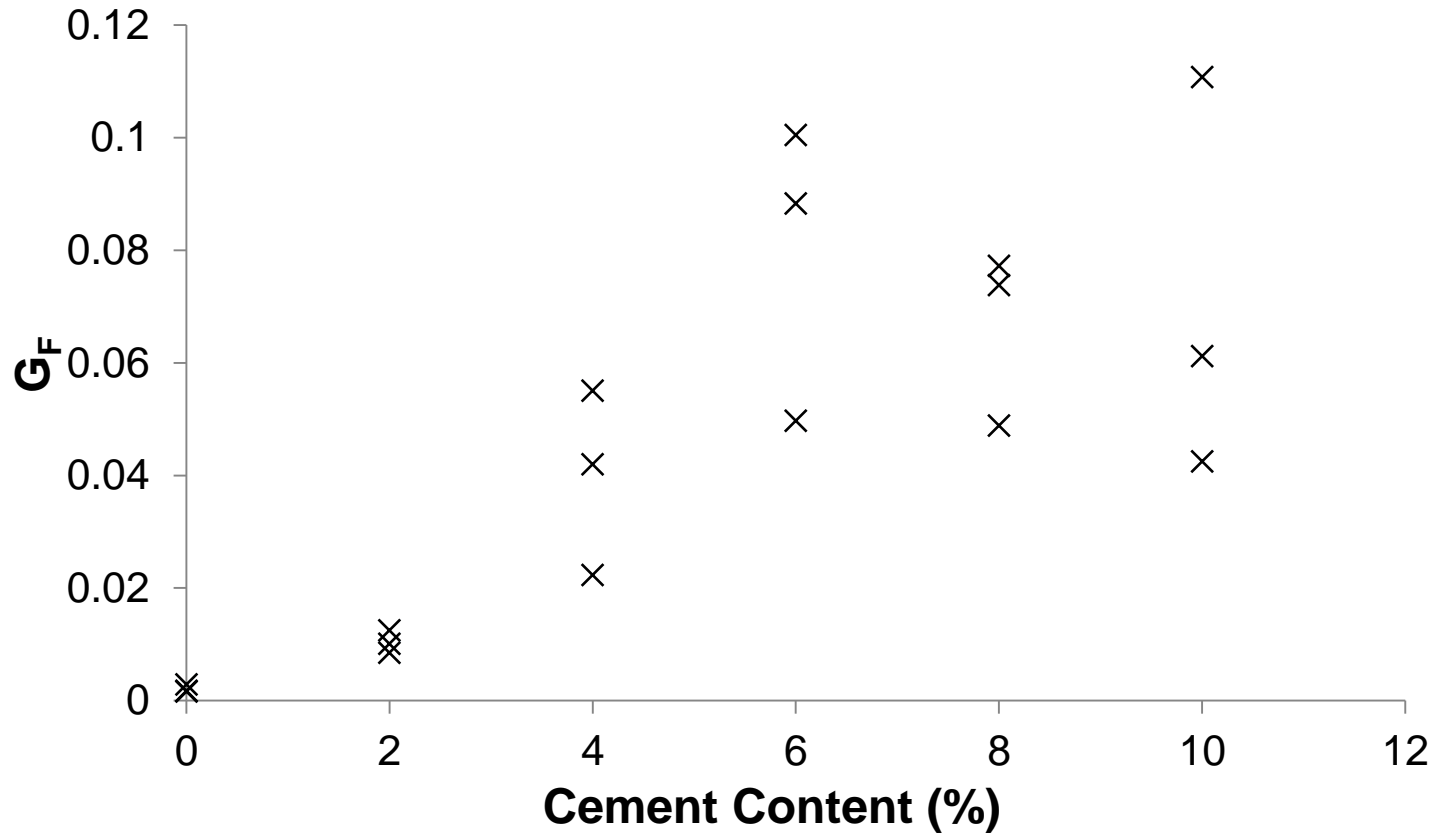
F_s vs COD



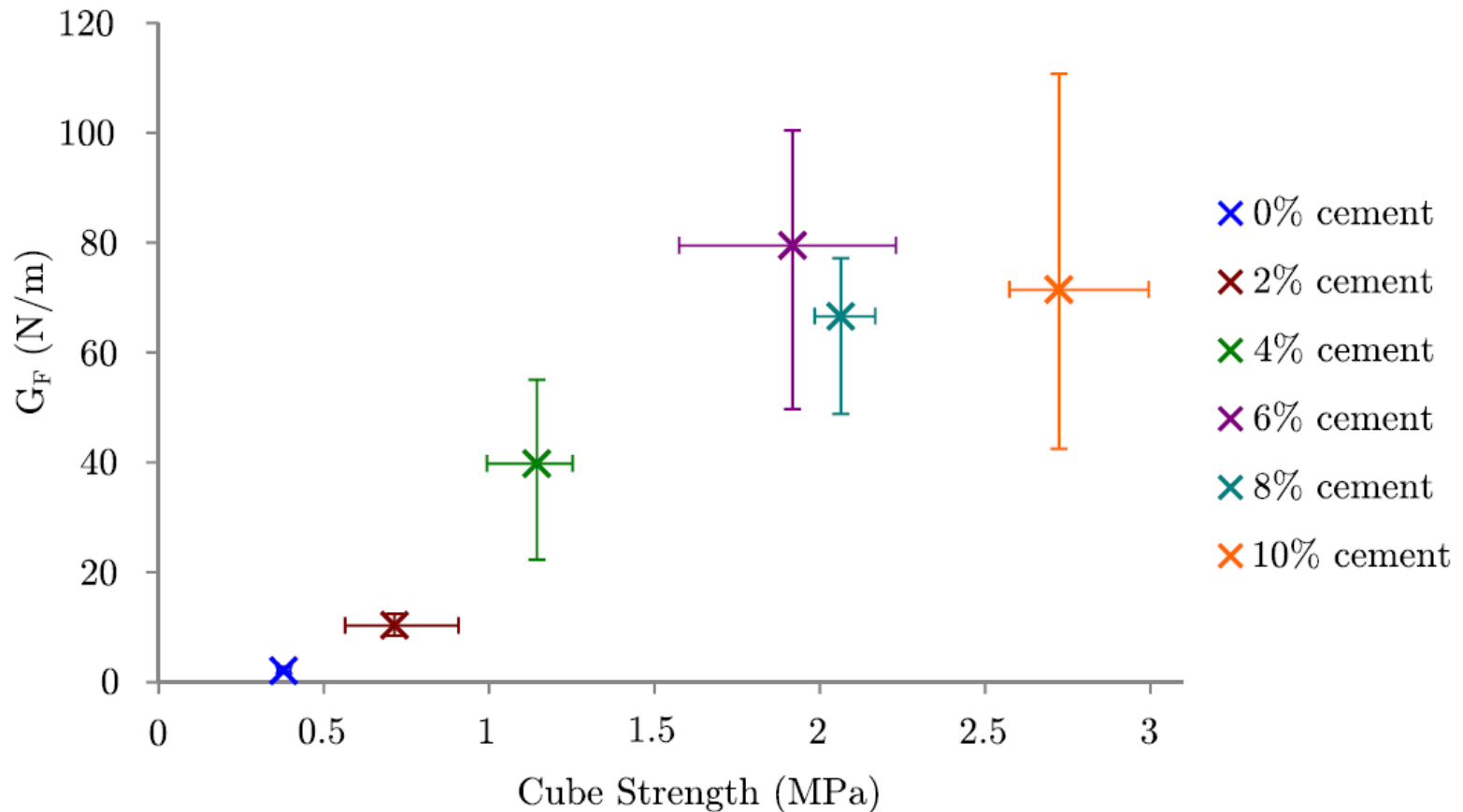
Cube Strength vs Cement Content



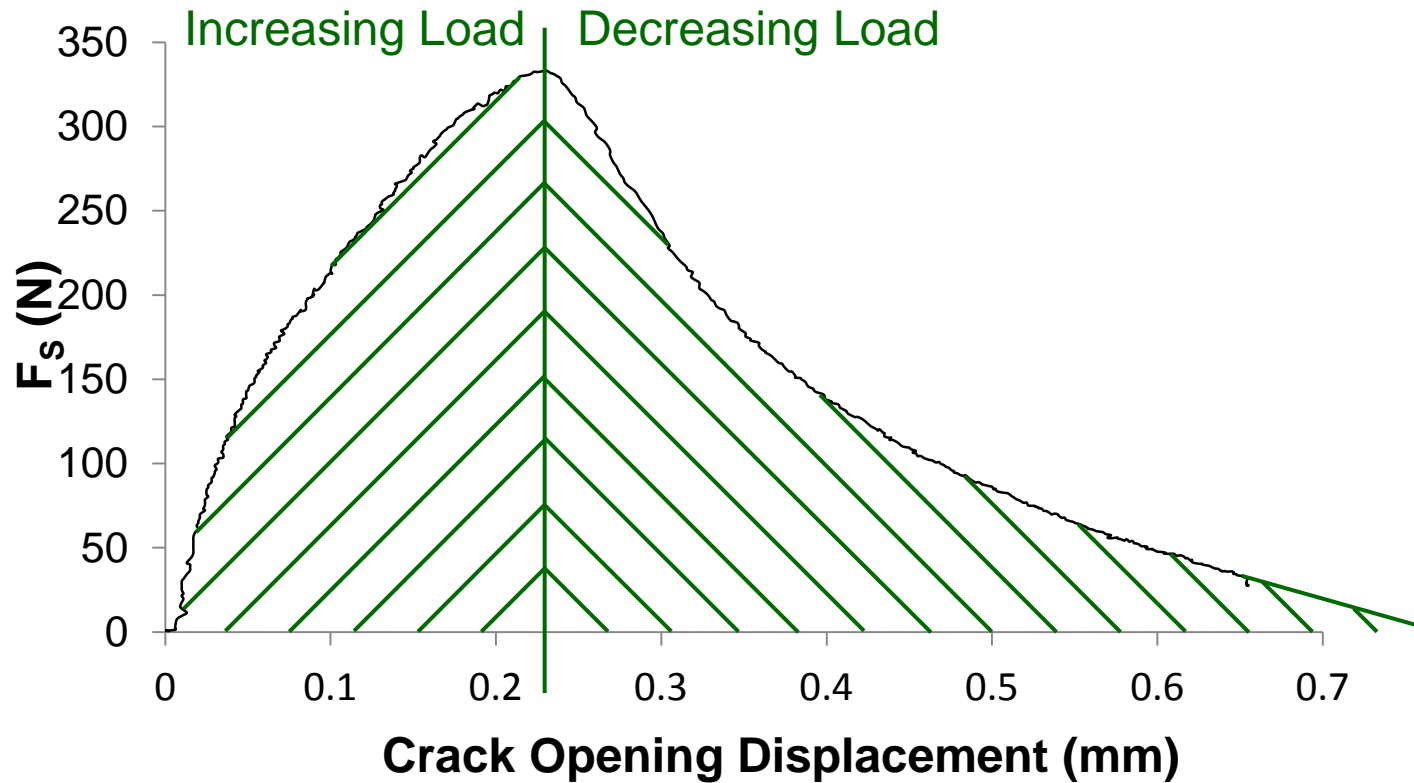
G_F vs Cement Content



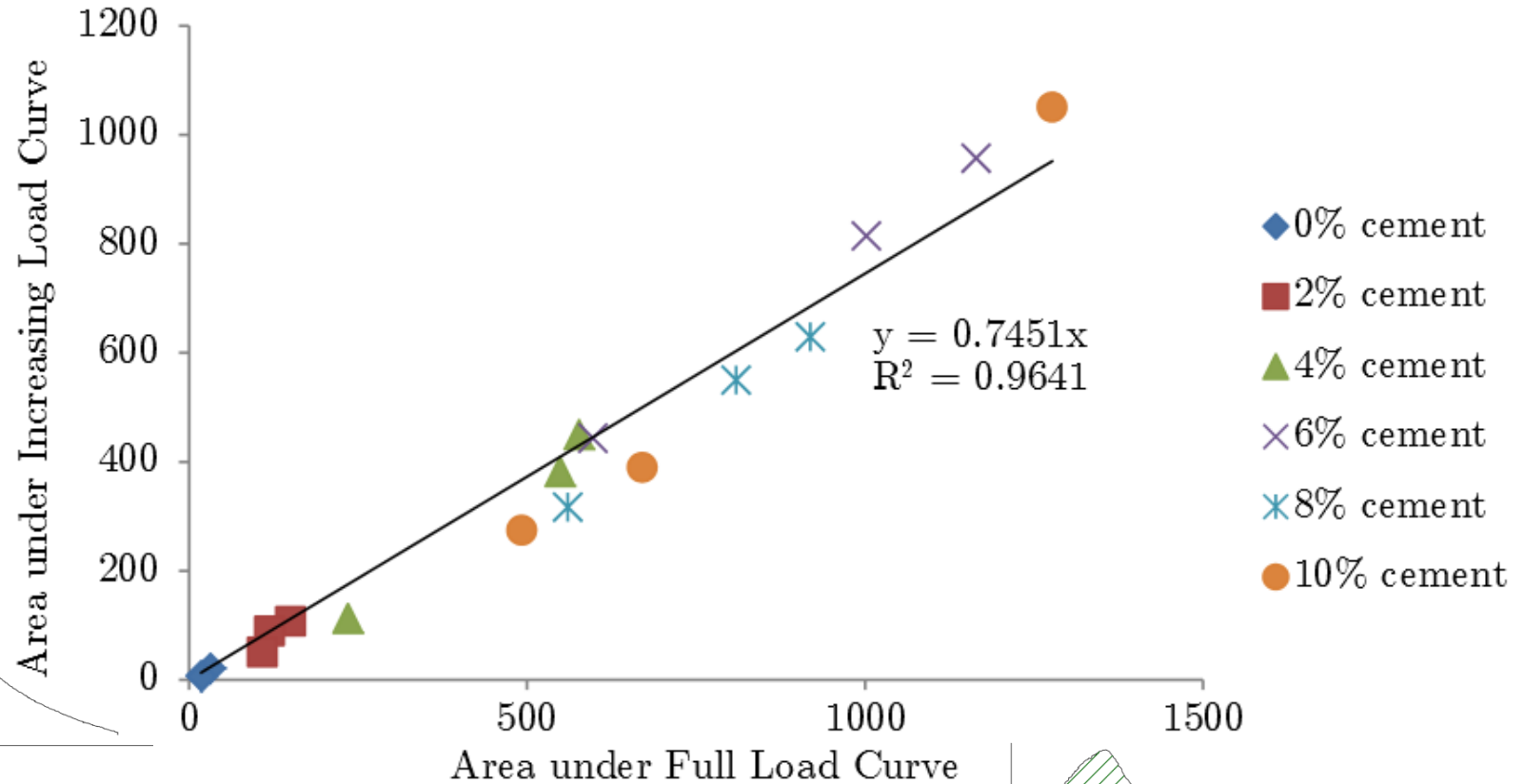
G_F vs Cube Strength



F_s vs COD



Area under curve



Future

- Stabilisation
 - Cement
 - Lime
 - Fibres
 - Computational Modelling
 - Water Minisci
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