MICROPLANE MODELLING OF CONCRETE DYNAMICS

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Microplane Model M7: What did it achieve?

\[ \sigma_{ij} = \frac{3}{2\pi} \int_{\Omega} \left( \sigma_N N_{ij} + \sigma_M M_{ij} + \sigma_L L_{ij} \right) d\Omega \]

What Did Microplane Model M7 Achieve?


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Autocalibrating Microplane Model M7 – Uniaxial Compression

Autocalibrating Microplane Model M7. Application to 4 pt Bending

Mesh A: Finer mesh

Mesh B: Coarser mesh

![Graphs showing force vs midspan displacement for Mesh A and Mesh B, with and without autocalibration.]
Rate-Dependent Microplane Model M7R – Uniaxial Compression

Test Data: Dilger et al. 1978
Rate-Dependent Microplane Model M7R – Triaxial Compression: “Hopkinson Pressure Bar Test”

3 tests at 3 projectile speeds:
- $v = 6.13 \text{ m/s}$
- $v = 12.5 \text{ m/s}$
- $v = 19.23 \text{ m/s}$

Tests: Forquin et al. 2008
Rate-Dependent Microplane Model M7R – Triaxial Compression: “Hopkinson Pressure Bar Test”
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Rate-Dependent Microplane Model M7R – Triaxial Compression: “Hopkinson Pressure Bar Test”

Rate-Dependent Microplane Model M7R – CTT

\[ v = 100 \text{mm/s} \]
Rate-Dependent Microplane Model M7R – CTT
\[ v = 500 \text{mm/s} \]
Rate-Dependent Microplane Model M7R – CTT

\[ \nu = 5000 \text{mm/s} \]

Model M7R

Ožbolt et al 2011
Comminution Theory of Concrete

Abrasions

Compression Fracture

Impact

Increasing energy expenditure
Comminution Theory of Concrete – Basic Concept

\[ \tau \propto \dot{\varepsilon}_D^{2/3} \]

Comminution Theory Applied to Projectile Penetration - 254mm Wall

Comminution Theory Applied to Projectile Penetration – Exit velocities

Simulation of Explosion of 400g TNT on a Plain Concrete Plate
Test Simulation

Simulation of Explosion of 400g TNT on A 50cm Thick Plain Concrete Plate

Simulation of Explosion of 400g TNT on A 30cm Thick Plain Concrete Plate

![Graph showing pressure vs. distance from the explosion]
Simulation of Explosion of 400g TNT on a 30cm Thick Reinforced Concrete Plate

Reinforcement at upper and lower faces
Fiber Reinforced Concrete M7F – Harex Fibers

\[ V_f = 3\% \]

Rate-Dependent Microplane Model for Fiber Reinforced Concrete M7FR – Torex Fibers

Rate-Dependent Microplane Model for Fiber Reinforced Concrete M7FR – Torex Fibers


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Rate-Dependent Microplane Model for Fiber Reinforced Concrete M7FR – Torex Fibers

Conclusions

The Microplane Model M7 solved 3 20-year-old problems:

1. It removes the excessive lateral contraction in tension.
2. It correctly predicts damage in the loading/unloading stiffness in tension.
3. It reduces the number of stress-strain boundaries from five to four.

The model successfully simulates:

1. The quasi-static and dynamic behavior of plain concrete over strain rates in the range \([0,0001 – 10,000]/s\).
2. The quasi-static and dynamic behavior of fiber reinforced concrete over strain rates in the range \([0,0001 – 10,000]/s\).
3. Mesh independence by treating the element size as a material property.
Thank you for your attention.