Shear Strength of Concrete at Elevated Temperature

Concrete design process

Concrete Design → Ambient Temp. (Flexure) → Fire (Flexure) → Shear

Shear mechanisms

Finite elements

- Reinforcing steel bridging tensile crack
- Concrete cover bursting
- Aggregate interlock

Shear is carried in RC through the interaction of:

1. Compressive force paths
2. Concrete-steel bond
3. Dowel action
4. Aggregate interlock
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Experimental setup

16 shear block specimens (ambient $f_c = 29$MPa and $f_t = 1.8$MPa)
- $\varnothing 6$mm smooth steel bars ($f_y = 415$MPa)
- 2 shear stirrups crossed shear plane
- Specimen peak internal temperatures: 17°C, 112°C, 188°C, 390°C, 475°C, and 622°C
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**Results**

- Shear crack fully forms at peak load
- Two groups of post-peak frictional strength
- Frictional strength governed by: concrete-steel bond, dowel action & aggregate interlock
- Initial stiffness & peak strength reduce with temperature, whereas peak strength displacement increases

- Again two clear groups:
  - Low temperatures $\rightarrow$ low displacements
  - High temperatures $\rightarrow$ high displacements
- Low temperatures: diagonal tension cracks formed and then coalesced into a shear crack
- High temperatures: straight shear crack formed
- Extensive cover bursting at high temperature, leading to increased reinforcement debonding and decreased concrete confinement
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Summary

- Residual compressive and tensile concrete strengths decreased with temperature.
- Less pronounced shear strength decrease with temperature, due to steel.
- Residual shear strength of RC is governed by interaction of concrete and steel through shear mechanisms.