BRE Centre *for* Fire Safety Engineering

Behaviour of Damaged Reinforced Concrete Structures in Fire

Adam Ervine[1], Dr. M. Gillie[1], Dr. P. Pankaj[1], T.J. Stratford[1]

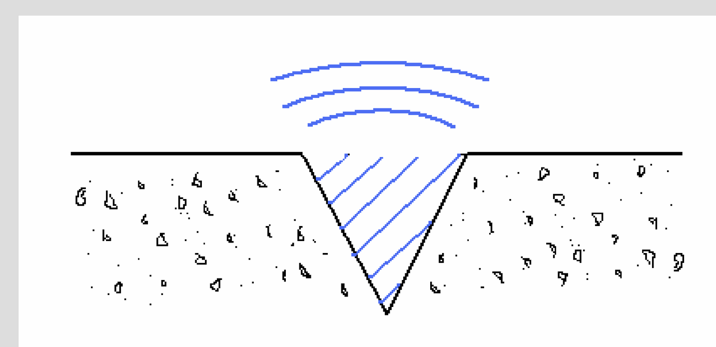
[1] *University of Edinburgh*

Introduction

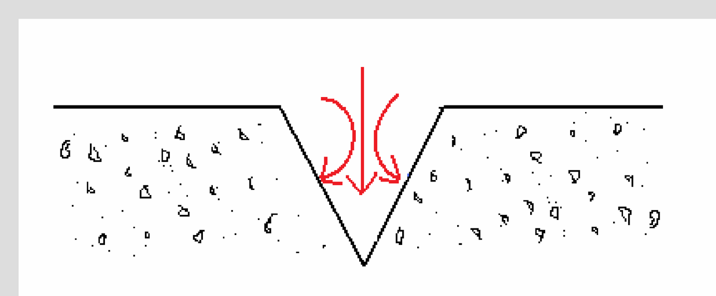
Reinforced concrete structures are widely considered to possess an inherent fire resistance due to the low conductivity and high heat capacity of the concrete. However, this fire resistance can be compromised during prior extreme events such as earthquakes, blasts and impacts. These extreme events can cause the structure to become damaged therefore a subsequent fire will be amplified and may lead to the collapse of the structure.

"Does Tensile Cracking affect the Fire Resistance of Reinforced Concrete?"

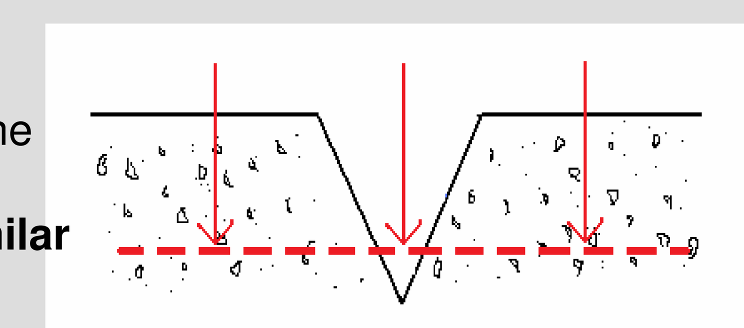
Hypothesis I
- The **air** within the crack **act as an insulator**
- **Thermal propagation decreases**
- Temperatures at the reinforcement level rises less quickly



Hypothesis II
- The tensile crack allows **radiation and buoyancy effects** to become **more dominant**
- **Thermal propagation increases**
- Temperatures at the reinforcement level rises more quickly



Hypothesis III
- The tensile cracks causes **no significant differences** to the thermal propagation through the structure
- Temperature of the **reinforcement level experiences similar temperatures**



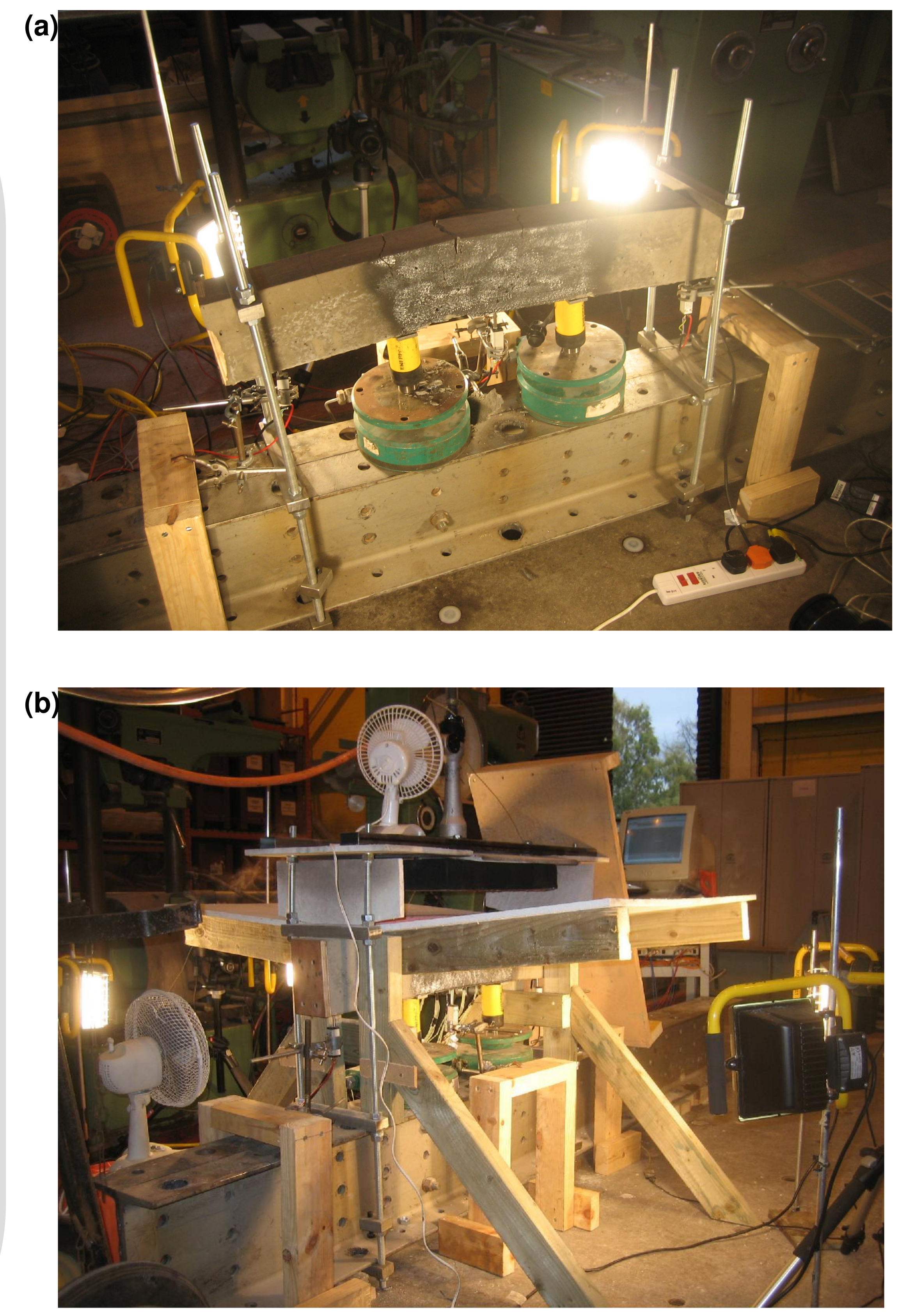


Figure 1 – (a) Mechanical control showing crack pattern of beam at ultimate load. (b) Thermal testing of tensile cracked section in progress

Experimental Program

Eight concrete beams were loaded in **four point bending** and **heated via radiant heat panel**. The **thermal profiles recorded** by **embedded thermocouples** (Fig.1) (Fig. 2)

Defection control was used to cause **damage** in the form of **tensile cracking** of **various degrees of severity** on their tensile faces (Fig. 3)

Comparison of the **thermal profiles** of **damage** and **intact beams** was carried out (Fig. 4)

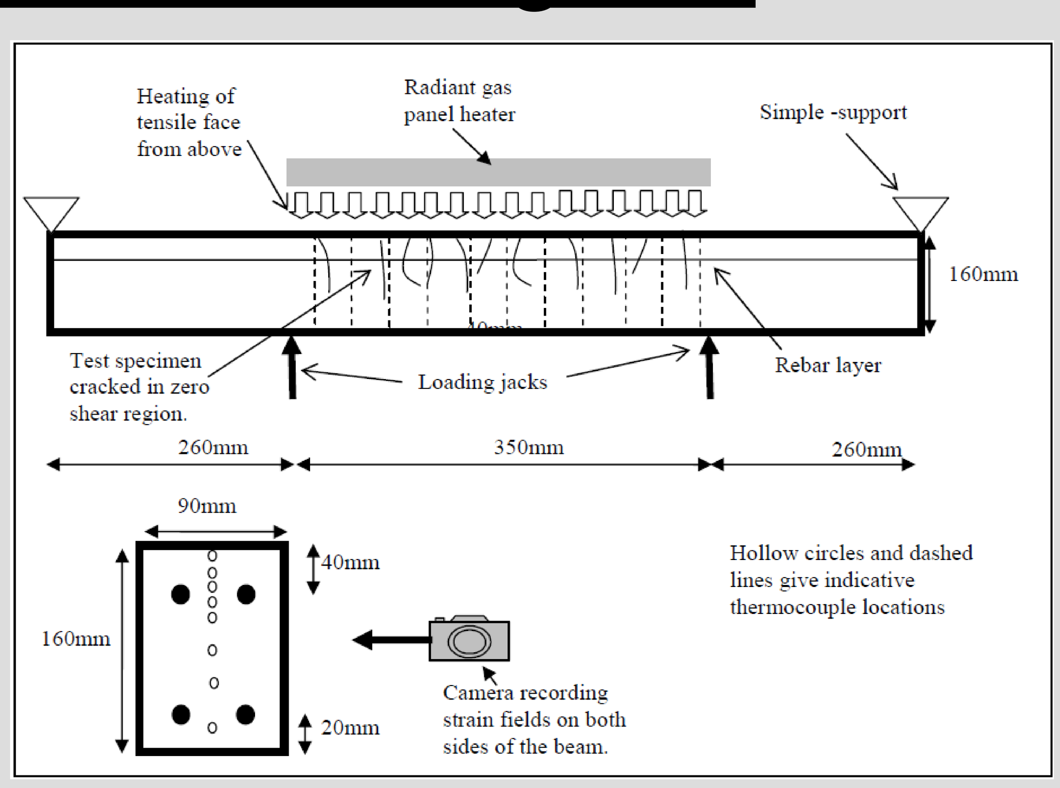


Figure 2 – Experimental setup showing side view of loaded beam and typical cross-section

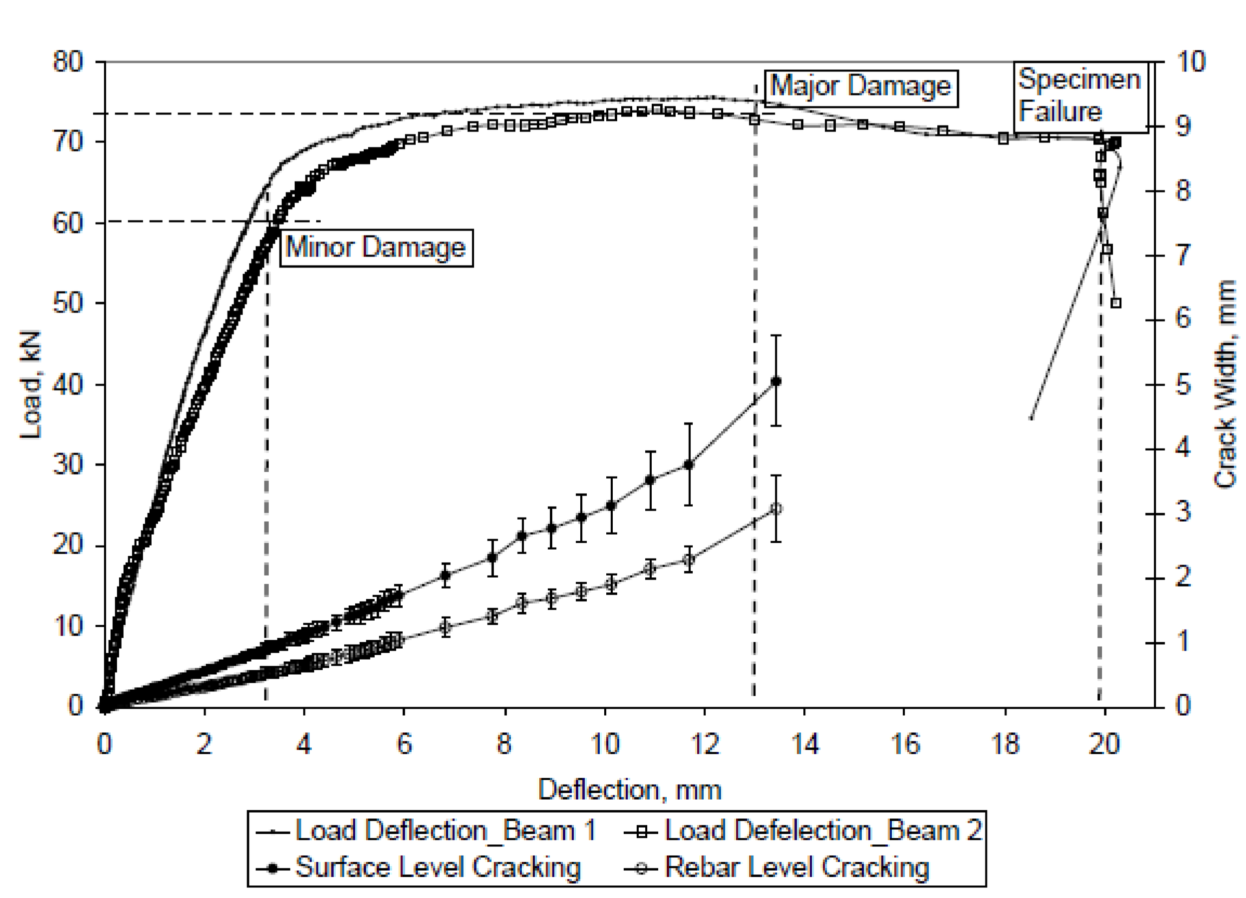


Figure 3 – Load Deflection relationship including associated crack widths

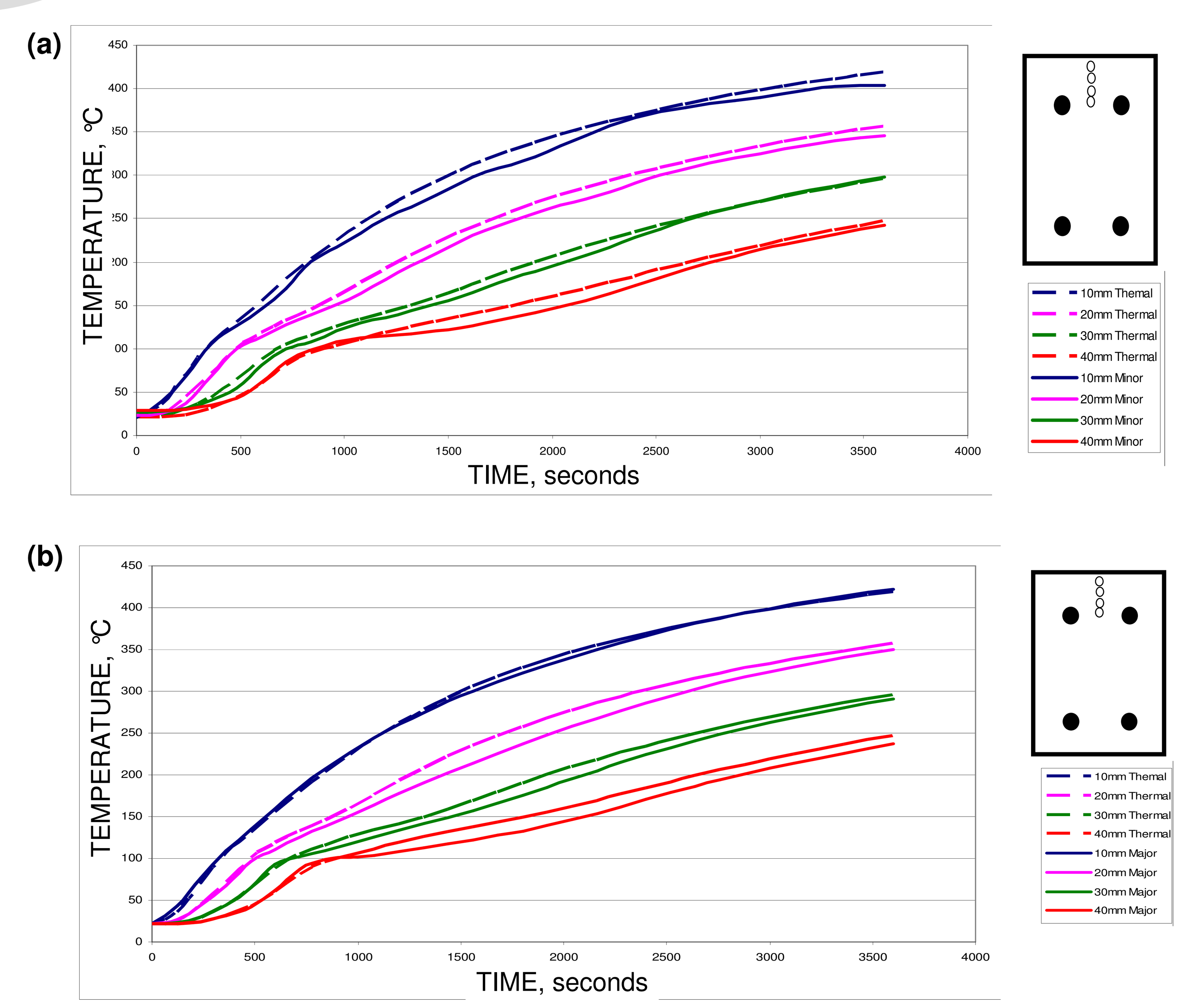


Figure 4 – Thermal profile from the surface through the concrete cover to the reinforcement for (a) minor damage and (b) major damage

Conclusions

➢Comparison of thermal profiles of an intact specimen and that of a specimen that has undergone tensile damage of the order of 10-1mm (at the surface) has shown that there is **no significant change in the thermal profiles**.

➢Therefore **hypothesis III** is generally **accepted**

➢**Computational modelling of damaged reinforced concrete structures in fire does not have to include thermal effects brought about by "tensile cracking"**

"Tensile Cracking does not significantly affect the Fire Resistance of Reinforced Concrete"

The authors acknowledge the financial support of EPSRC and the BRE Trust