FIRE RESISTANCE OF CONCRETE SLABS REINFORCED WITH FRP BARS

Experimental investigations and numerical simulation on the thermal field and the mechanical behaviour

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Use of fiber reinforced polymer (FRP) bars or grids instead of traditional steel reinforcements is an interesting application, especially to improve structural durability and extend the actual service life. Several building codes are now available for the design of concrete structures reinforced with FRP even if no calculation model taking account of fire conditions has been suggested. Intuitively, the fire endurance of concrete members reinforced with fiber reinforced polymer (FRP) bars is related to the decrease in the mechanical properties of the materials concerned, especially resin. Large-scale fire tests recently performed on nine concrete slabs reinforced with glass FRP bars, characterized by different values of concrete cover and anchorage length, demonstrated the importance of bond between FRP and concrete for performance under fire situations. The experimental results showed that (1) the length of the FRP bars in the zone of slabs not directly exposed to fire (namely, anchoring length in fire situations) can be much more relevant to fire endurance than the concrete cover in the zone directly exposed to fire; and (2) the shape of the bar, for instance bent at the end, allows a reduction in anchoring length. From a design point of view, evaluating the necessary anchoring length through a bond model seems to be a key aspect.

The experimental programme is extensively reported, giving detailed information on tests to highlight the practical significance of the experimental research. The results of investigations are discussed with particular reference to the structural behavior. A detailed discussion of the experimental thermal readings is reported to give as a support to the remarks on mechanical response. In particular the influence of concrete cover on temperature in exposed area and the temperatures in the area not exposed are examined to investigate the effectiveness of the anchor. The influence on the temperature in the bars of different concrete thermal properties is investigated. Furthermore, the influence of the thermal properties of the bars on the temperature field is evaluated.

Test results, were used to investigate the bond behavior of FRP bars embedded in concrete at high temperature and to assess a procedure to predict bond stress, slip, and load transfer at elevated temperature, based on both the results of numerical thermal analysis and the predictions of a bond theoretical model adjusted for fire situations. The design procedure outlined for calculating the minimal required anchoring length proves a valuable approach for the practicing engineer and stands together with the experimental results presented earlier. Finally strains and displacements recorded during the tests by means of strain gauges and displacement transducers applied on concrete and FRP bars are compared with the results of numerical simulations.

Results are shown with the aim of providing ideas for experimental tests, benchmark for numerical simulation, suggestions for updating design codes, proposals for further development.