Subject	Tensile membrane action
Clause N°/ Subclause N° / Annex	N/A

Reason for change

It is predicted to incorporate new design concept in EN 1994-1-2 based on the membrane action of composite slab for fire performance assessment of steel-concrete composite floors.

The method is derived originally from concrete slab and in consequence it is necessary to have this approach in compliance with certain specifications of EN 1992-1-2.

Original content

No clause about tensile membrane action

Change

(1) Membrane action is a load bearing mechanism that can develop during a fire in reinforced concrete slabs and composite floors with profiled steel sheets supported on all edges and reinforced in both directions. This mechanism may be considered in the calculation of the fire resistance of a floor according to the following rules.

(2) The fire resistance with respect to the function of thermal insulation « I » is calculated according to the rules defined under the relevant clauses of EN 1992-1-2 and EN 1994-1-2.

(3) The integrity function « E » needs to be addressed.

(4) The design methods shall take into account the changes of material properties and the effects of thermal elongation due to temperature elevation.

(5) The thermal and mechanical properties of the design methods shall be those recommended under the relevant clauses of EN 1992-1-2 and EN 1994-1-2.

(6) Failure by tension in the reinforcement and failure by compression in concrete shall be considered in the design methods.

(7) The variation of vertical reaction on the edges that occurs when the tensile membrane action develops shall be taken into account in the design of these supports and in shear resistance of the slabs.

(8) The contribution of any beam spanning between the edges may be taken into account.

(9) If a slab with trapezoidal profiles is analysed as a flat slab of equivalent thickness, the equivalent thickness shall be chosen to reflect the actual temperature of the reinforcement.

Background information

As stated in the specifications of this task, the new design concept based on membrane action should be incorporated in EN 1994-1-2 (and it has to be in compliance with certain specifications of EN 1992-1-2). The responsibility to develop this new concept is thus in the hand of the project team of EN 1994-1-2. The task of our HGF Project Team is to ensure that this new concept is consistent with the other parts of the fire Eurocodes.

As a consequence, the nine clauses above give features that HGF-PT considers as essential and that should be present, possibly in a different wording, in any recommendation written in the Eurocodes about Tensile Membrane Action in the fire situation. The ad-hoc committee may add additional considerations and precisions about the method provided that these don’t introduce inconsistencies with the different fire parts of the Eurocodes.

In clause (1), the important concepts are:

- in reinforced concrete slabs and composite floors with profiled steel sheets
- supported on all edges
- reinforced in both directions

Clause (2). As membrane action is a load bearing mechanism, the rules applicable for the function of thermal insulation (typically linked to the thickness of the slab) should be the same as when the slab works in bending.

Clause (3). The integrity function needs to be addressed because membrane action is typically accompanied by large displacements and through depth cracks have been observed in some experimental tests. This function may be addressed by rules or by detailing recommendations.

Clause (4). The first part of the clause is valid throughout the fire parts of the Eurocodes. The effects of thermal elongation are crucial because they are deeply involved in the large displacements that generate the membrane behaviour.

Clause (5) is to ensure consistency with the other parts of the Eurocodes. No new material model can be introduced in the new design concept.

Clause (6) mentions the two most common failure modes observed in experimental tests and both should be covered by the design method.

Clause (7) draws the attention to the fact that reactions at the edges that support the slab working in membrane action are modified compared to the room temperature situation when the slab was working essentially in bending and this must be taken into account.

Clause (8) relates to any kind of internal beam. It states a permission and not an obligation.

Clause (9) is to draw the attention to the fact that some rules based on the concept of equivalent slab thickness, e.g. Clause D.4 (3) in EN 1994-1-2, have been derived on the base of the thermal insulation function I, that means on the base of the temperature that develops on the upper side of the slab. If the concept of equivalent thickness is used to analysed the load bearing function R of a slab with a trapezoidal section working in membrane action, the equivalent thickness may be different in order to match in the slab of equivalent thickness the temperature in the real slab at the level of the reinforcement, as this temperature is particularly critical for the failure mode by excessive tension in the reinforcement.

Ease of use justification

N/A