TIMBER-FIBRE CONCRETE STRUCTURES IN FIRE

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The use of timber-concrete structures has considerably increased especially in case of reconstructions and constructions of residential houses. The benefits are an obvious increase of the load bearing capacity, a reduction of the deflection, better vibration behaviour of the ceiling and an improvement of building physical properties like sound insulation and fire resistance. The reinforcement of the concrete slab is necessary, but leads to a large slab thickness in connection with the necessity of a sufficient concrete cover and to disadvantages during the execution of construction work. Therefore it is reasonable to replace the conventional reinforcement by steel fibres. Experimental and theoretical studies shows that the compressive strength at elevated temperatures of fibre-reinforced concrete is higher than that of plain concrete. The presence of steel fibres increases the ultimate strain and improves the ductility of fibre-reinforced concrete elements.

The design of timber-concrete floor slabs for fire resistance is usually based on prescriptive generic ratings that specify the minimum slab thicknesses. These generic ratings have generally been based on standard fire resistance tests using furnaces which are not representative of real construction because they do not account for two-way action or the effects of axial restraint at the slab supports. Once large deflections occur, tensile membrane action can significantly increase the fire resistance of reinforced concrete slabs, especially two-way slabs. For ambient conditions developed a theory to determine the load carrying capacity of reinforced concrete slabs at large deflections by considering the tensile membrane action. Both theoretical and experimental research into membrane action of concrete slabs at large displacements has previously been limited due to the difficulty in identifying any practical application. During a fire, large displacements of the structure are acceptable provided overall structural collapse is prevented. With the identification of the practical use of membrane action at large displacements previous work, findings on slabs tested at ambient temperature, has been re-visited and the need to understand the mechanics of membrane action in slabs when subjected to a fire has been stimulated amongst researchers and practitioners. Significant analytical work on the steel to concrete composite slab has been conducted, based on the fire test results from the Cardington building. The modellers, however, have found difficulties in modelling the cracking behaviour of the concrete slab together with an accurate prediction of the fracture of the reinforcement, with the conclusion that more fundamental research is required.

The fire resistance of timber-fibre concrete floors is important especially when used in multi-storey building. The fire safety of a building with these wooden elements can match or even succeed that of other structural materials. For this reason it is necessary to gain a deeper knowledge of the behaviour of timber-fibre concrete structures in fire, to remove all unknown and to ensure safe use for the intended purpose. The fire resistance of timber-fibre concrete composite construction was studied at few laboratories only. The study of the fire resistance of the timber-fibre concrete structure was not published yet.

The main objective of the proposed project is the preparation of the analytical prediction model for the fire resistance of the fibre concrete and timber concrete slab with dispersed reinforcement. The model will utilize the current knowledge of the design of the timber concrete and steel concrete composite slabs at ambient and elevated temperatures. Based on the prepared bibliographic search the experiments at ambient and elevated temperatures will be prepared. After its evaluation and FE sensitivity study the analytical model will be prepared. The model will describe the initial behaviour, the ultimate resistance as well as ductility demands. The current generation of the materials will be taken into account: the fibre concrete and the glue laminated beams. The proposed model will describe the development of membrane behaviour, its progress and the achievement of the ultimate limit state including the boundary conditions. The model will facilitate the increase of the fire resistance of the multi-storey building by the optimal structural solution of its floor slabs for reconstructions and new structures.

Furnace test of timber-fibre concrete structure was performed on one full-size floor specimen at the Fire testing laboratory PAVUS. Floor specimen was 4,5 m long and 3 m wide, consisting of 60 mm fibre concrete topping on plywood formwork, connected to GL floor joists. It was subjected the standard fire for over 150 min. The membrane effect of the floor was progressively activated due to burning of the timber internal beams. The full collapse of the test was reached at 154 mins due to damage of the fire protection of edge beams.