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Microstructural analysis of high performance concrete under fire. Improving resistance through the use of fibres

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ABSTRACT

Fire is considered one of the most serious potential risk in concrete structures, in fact disasters occurred in the lasts years in Europe due to the action of fire, even with lost of human lives (in tunnels as, Channel, Mont Blanc, Tauern, Kaprun, Gotthard, and as the Windsor Tower are some examples) have put in evidence the need to design and use of materials for concrete structures showing more resistance to fire.

The wide diffusion and new technologies on the use of concrete as structural material has moved to the need to know more in detail the effect of fire. Ultra high performance concretes, UHPC, have been developed in last years due to the demand increased for durability of structures. These concretes usually have steel fibres additions in order to improve their mechanical properties. UHPC are very dense materials with a number of excellent properties as, for instance, the compression resistance above 100 Mpa, however, the low porosity of these materials may induce potential problems with regard to fire resistance. In occasions polypropylene fibres are also added to improve fire resistance [1,2].

Although many researches have dealt with the strength resistance of traditional concrete, the knowledge with HPC and UHPC is still limited, because these materials are new and their service performance has not been sufficiently evaluated in order to better identify the risk of explosion, [3,4,5].

Present paper deals with microstructural performance of high and ultra high strength concretes exposed to high temperatures. The contribution of the use of metallic and polypropylene fibres has been analysed. The concretes were exposed up to 700ºC and the changes occurring inside the material during heating have being determined. Analysis of physic-chemical and microstructural changes induced by the temperature in the different components of the concrete is evaluated.

The results indicate that changes occurring in HPC seem not to follow the same trend than UHPC. The evolution of vapour losses with temperature are smaller in UHPC and do not result on a proportional increase in porosity, however microcracks have been heavily developed. Furthermore, the fine pore structure of UHPC delays the exit of the vapour, which in contact with the high content of anhydrous in UHPC favours the evolution of hydration of anhydrous material. The use of polypropylene fibres has increased the fire response of UHPC. These fibres melt at 160ºC with the aim to create open paths for vapour release, but their melting is not transformed in an immediate increase in porosity that occurs at

higher temperatures, above 300ºC, when the fibres and the cement has been completely dehydrated. The use of steel fibres contribute to increase the fire resistance of UHPC concretes, these fibres remain unaltered up to 500ºC. They contribute to maintain the cohesion of the dehydrated cement, but at temperatures above 500ºC the steel fibres are oxidised, become brittle and contribute to the developing of cracks.

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