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Strategies for Enhancing Resiliency of Modern Concrete Structures under Fire Hazard

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Abstract

In recent years, the construction industry has shown significant interest in the use of high performance concretes (HPC) in building applications due to the improvements in structural performance, such as high strength and durability, and sustainable solutions that HPC provide as compared to conventional normal-strength concrete (NSC). These high performance concretes, which include concrete types such high strength concrete (HSC), fiber reinforced concrete (FRC), self-consolidated concrete (SCC), and ultra HPC (UHPC), are typically characterized by higher strength, higher sustainability, lower permeability and thus enhanced durability properties. The use of HPC, together with innovative cross-sectional configurations (such as hollow-core slabs, double T beams and deck slabs), and advanced analysis techniques, often lead to slender members in modern structures, especially concrete buildings.

Conventional concretes possess good fire resistance properties and hence concrete structures made of NSC exhibit good fire resistance and resiliency properties. However, number of studies have clearly shown that HPC exhibit poor fire resistance properties, as compared to NSC. Specifically, certain HPC types undergo rapid degradation of strength at elevated temperatures and are also susceptible to explosive spalling under severe fire conditions. These poor fire resistance properties of HPC, together with reduced cross sectional sizes of HSC structural members, can lead to lower fire resistance and lower resiliency in HPC structural systems.

In the presentation, severe conditions such as high fire intensity, weaker structural configuration, and poorer material characteristics that can be present in modern buildings, with respect to fire performance will be highlighted. The performance problems associated with high performance concretes under fire conditions will be discussed. Examples of innovative strategies for enhancing fire performance and resiliency of HPC structural systems will be presented. Specific guidelines to enhance fire resistance of HPC members, such as the use of bent ties in columns and addition of fibres to HPC to mitigate fire induced spalling, will be discussed. Through case studies it will be demonstrated that by adopting proper strategies, both at material and structural levels, fire resistance and resiliency of HPC structures can be enhanced.