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ABSTRACT

Properties of Reinforced Concrete for Use in Fire-Design of Concrete Structures

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This paper describes the development of a comprehensive database on the properties of reinforced concrete for use in fire-design of concrete structures. Over the past 50 years, much research has been conducted on the behavior of concrete and reinforcing steel at elevated temperatures. At the same time, research on advanced construction technologies has led to a significant expansion of different types of concrete utilizing different additives and aggregates (e.g., high-strength concrete, fiber-reinforced concrete, etc.), potentially resulting in different material properties under fire. The synthesis of the underlying coupled phenomena and material properties from the available test data is further complicated due to differences in the test specimen shape and size, and differences in testing conditions, pre-loads, and heating rates. Thus, while a significant amount of test results exists on the properties of reinforced concrete under fire temperatures, a comprehensive evaluation of this data is not straightforward and has been limited to date.

The primary goal of the database presented in this paper is to collect and synthesize the existing data, and to determine design relationships for the mechanical, physical, and thermal properties of reinforced concrete when subjected to fire. Reinforced and un-reinforced concrete focusing on North American sources are studied as well as the effects of fire on reinforcing steel. Through the use of statistical analysis such as multiple linear regression, design models are presented for the temperature-dependent material properties (e.g., concrete compressive strength). Recommendations are presented for concrete properties that show a strong dependence on temperature and for areas where future research should be directed to gain a better understanding of the behavior of reinforced concrete at fire temperatures. Recommendations are also made for a unified method of conducting fire tests and a unified method for presenting the results so that future researchers can most effectively utilize this data.

Current U.S. fire design specifications prescribe the relative fire resistance of building components and assemblies using the concept of "fire endurance," without much consideration of structural performance. The need for developing rational methods to improve the design and retrofit of civil structures for fire was recognized by NIST as a part of the Federal Building and Fire Safety Investigation of the World Trade Center Disaster (NIST 2005). The database presented in this paper, which was developed with funding from the Portland Cement Association, forms a fundamental step towards achieving this goal.

NIST, "Final Report on the Collapse of the World Trade Center Towers," National Institute of Standards and Technology, September 2005.

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