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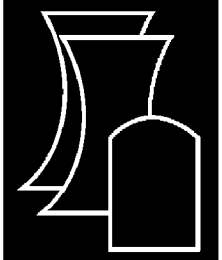

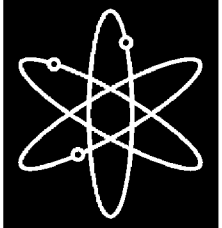

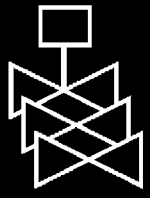

The Effect of Elevated Temperature on Concrete Materials and Structures - A Literature Review

Oak Ridge National Laboratory

U.S. Nuclear Regulatory Commission
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The Effect of Elevated Temperature on Concrete Materials and Structures - A Literature Review

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ABSTRACT

The objective of this limited study was to provide an overview of the effects of elevated temperature on the behavior of concrete materials and structures. In meeting this objective the effects of elevated temperatures on the properties of ordinary Portland cement concrete constituent materials and concretes are summarized. The effects of elevated temperature on high-strength concrete materials are noted and their performance compared to normal strength concretes. A review of concrete materials for elevated-temperature service is presented. Nuclear power plant and general civil engineering design codes are described. Design considerations and analytical techniques for evaluating the response of reinforced concrete structures to elevated-temperature conditions are presented. Pertinent studies in which reinforced concrete structural elements were subjected to elevated temperatures are described.

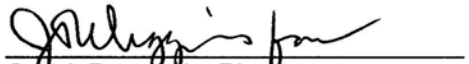
FOREWORD

Under normal conditions, most concrete structures in nuclear power plants are subjected to a range of temperatures that are no more severe than those imposed by ambient environmental conditions. However, there are situations in which such structures may be exposed to much higher temperatures (e.g., building fires and chemical and metallurgical applications in which the concrete is in close proximity to furnaces). Also, some new-generation reactor designs indicate that concrete may be exposed to long-term, steady-state temperatures in excess of the present limit of 65°C (149°F) set forth in the Boiler and Pressure Vessel Code promulgated by the American Society of Mechanical Engineers (ASME). In such situations, the effect of elevated temperature on certain mechanical and physical properties may determine whether the concrete will maintain its structural integrity.

The purpose of this research was to provide an overview of the effects of elevated temperature on the behavior of concrete materials. In particular, this report summarizes the effects of elevated temperatures on the properties of ordinary Portland cement concretes and constituent materials. This report also notes the effects of elevated temperature on high-strength concrete materials, and compares its performance to that of normal-strength concretes. In addition, this report presents design considerations and analytical techniques for evaluating the response of reinforced concrete structures to elevated temperature conditions.

The major findings contained in this report are that (1) many of the elevated temperature tests on concrete did not test either representative materials or representative nuclear power plant environmental conditions; (2) in general, the behavior of concrete specimens at elevated temperatures indicated that concrete loses more strength if moisture is not permitted to escape during heating; and (3) the decrease in concrete's modulus of elasticity caused by exposure to elevated temperatures is more pronounced than the decrease in concrete compressive strength. Also, several research projects have been conducted to investigate the behavior of reinforced concrete structures at elevated temperature; however, the overall level of effort has not been sufficient to establish widely accepted elevated temperature concrete design or analysis procedures.

On the basis of these findings, if a reinforced concrete structure in a proposed advanced reactor is required to maintain its functional and performance specifications at temperatures in excess of ASME Code limits for extended periods of time, techniques for optimizing the design of structural elements to resist these exposures should be investigated.



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