Improvement of Design Codes to Account for Accidental Thermal Effects on Seismic Performance

PI: Prof. Amit H. Varma, Purdue Univ.

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Collaborators: Prof. Andrew Whittaker, University at Buffalo
Dr. Sanjeev Malushte, Bechtel Power
Mr. Derek Winkler, URS Corp.
Mr. Tod Baker, Westinghouse Electric Corp.

ABSTRACT:

The Fukushima nuclear accident of 2011 has highlighted the importance of designing safety-related nuclear facilities for accident thermal scenarios combined with design basis and beyond design basis shaking. While the probability of both events occurring simultaneously is low, severe environmental conditions may trigger accident thermal loading, and subsequent aftershocks, potentially as intense as the main shock, may occur during the accident thermal event. Current design codes and standards in the United States and abroad provide little-to-no guidance for including the effects of accident thermal loading on seismic behavior (stiffness, strength, ductility or reserve margin) of structures.

Prior research has focused on seismic behavior or accident thermal loading but not both in combination. The combination of accident thermal loading and earthquake shaking will present a significant design challenge for SMRs and ALWRs because postulated accident scenarios may cause higher elevated temperatures for longer durations. For approval, the regulator will require extensive technical information and clear evidence of safety, the lack of which may substantially compromise the licensing schedule.

The overall goal of this research project is to develop knowledge-based design guidelines for safety-related nuclear facilities subjected to combined accident thermal conditions and seismic loading. This goal will be achieved by conducting a logical set of tasks. The project team consisting of researchers and engineering leaders from two universities and three industry partners will conduct these tasks collaboratively. The tasks include: (i) identification of parameters influencing behavior and finalization of accident thermal conditions, (ii) experimental evaluation of the effects of accident thermal conditions on the seismic (in-plane shear) behavior of SC and RC walls, (iii) development and benchmarking of numerical models for predicting experimental results and observed behavior, (iv) comprehensive analytical parametric studies to evaluate the influence of various parameters and ranges, and (v) development of design guidelines and analysis recommendations for design basis and beyond-design-basis events involving combinations of accident thermal conditions and seismic loading.

The project outcomes will include fundamental knowledge in terms of experimental results, benchmarked numerical models, and analytical results regarding the influence of accident thermal conditions and various parameters on the seismic behavior (stiffness, strength, and ductility) of SMRs and ALWRs. This knowledge will enable future regulation through validated recommendations for analysis and design, suitable for consideration by committees of ACI 349 and AISC N690 (design and detailing) and ASCE Standards 4 and 43 (analysis and design). The knowledge could also be applied to existing nuclear power plants and structures in the DOE complex.