Aleksandra Radlinska

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Room: G212

Major Professor: Jason Weiss

Title: Reliability-based analysis of early-age cracking in concrete

Abstract:
With recent concern regarding the environmental impact of the construction and urban development, there has been an increased emphasis placed on understanding how the concrete industry can become more sustainable. Sustainability relates to the application of energy efficient materials with low impact on environment and ensured durability. By improving the long-term durability of concrete elements, the life of the infrastructure can be extended, saving resources and environment. One problem that leads to premature deterioration in concrete structures is the development of cracks. As a result, there is an interest in developing procedures to produce crack free concrete elements. This research describes how experiments and computer simulations can be used to relate fundamental material properties and variability to the cracking performance of cement and concrete materials.

When thermal, hygral or chemical volume changes in concrete are restrained, residual stresses arise. If the residual stresses exceed the tensile strength of concrete, cracking occurs. Previous research has focused on the development of test methods and computer models to predict cracking in concrete. While these models are a great step forward, they are generally deterministic and do not consider inherent variability in material properties, construction processes, and environmental conditions. As a result, these models do not accurately capture the true risk of cracking in concrete elements.

In this research, Monte Carlo method and Load and Resistance Factor Design (LRFD) approach have been applied to incorporate different sources of variability in investigating the probability of cracking in restrained concrete members. Simulations are performed to determine the extent of free shrinkage reduction that is required to minimize the probability of cracking to an acceptable level. An approach is presented that allows engineers to select and incorporate the probability of cracking during the material design process. With this information, concrete can be designed using new materials, like shrinkage reducing admixtures (SRA) or by internal curing using lightweight aggregates (LWA), to meet the specified shrinkage performance.