CIVIL ENGINEERING

COMPUTATIONAL FRAMEWORK FOR DURABILITY ASSESSMENT OF REINFORCED CONCRETE STRUCTURES UNDER COUPLED DETERIORATION PROCESSES

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A reinforced concrete structure may degrade through a combination of coupled physical, chemical and mechanical deterioration processes. This study develops an integrated finite element-based computational framework to quantitatively evaluate the resultant mechanical responses of reinforced concrete structures exposed to multiple coupled environmental loadings. Heat transfer and associated thermal expansion/contraction process, moisture transport and associated wetting expansion/drying shrinkage process, carbon dioxide transport and associated carbonation process, chloride penetration process, reinforcement corrosion and rust expansion process due to chloride contamination, as well as the subsequent crack initiation and propagation are taken into account. Interaction effects among multiple coupled processes are considered by adjusting the transport properties of concrete through multifactor equations. The crack propagation analysis is implemented using a smeared cracking approach, and the crack-induced accelerated deterioration process is modeled using relative crack density concepts. The developed computational framework is general and flexible, which

makes it possible to include additional deterioration processes.

Due to a large amount of random variability and uncertainty existing in the material properties of concrete, various environmental loadings and the developed computational framework, an appropriate approach for assessing the structural durability is to combine the deterministic computational framework with advanced stochastic modeling. The most influential random variables in the computational framework are identified, and a nonlinear response surface is established through combining experimental design with multilevel regression. Monte Carlo simulation is then performed with the response surface to predict the statistics of service life and assess the associated time-dependent failure probability of reinforced concrete structures. Sensitivity analysis is implemented to quantify the influence of each random variable on the estimation of service life.

Approved_________________________________ Date_____________________