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Influence of Deficient Materials on the Reliability of Reinforced Concrete Members

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Abstract : The strength of reinforced concrete depends on the member dimensions and material properties. The properties of concrete and steel materials are not constant but random variables. The variability of concrete strength is due to batching errors, variations in mixing, cement quality uncertainties, differences in the degree of compaction and disparity in curing. Similarly, the variability of steel strength is attributed to the manufacturing process, rolling conditions, characteristics of base material, uncertainties in chemical composition, and the microstructure-property relationships. To account for such uncertainties, codes of practice for reinforced concrete design impose resistance factors to ensure structural reliability over the useful life of the structure. In this investigation, the effects of reductions in concrete and reinforcing steel strengths from the nominal values, beyond those accounted for in the structural design codes, on the structural reliability are assessed. The considered limit states are flexure, shear and axial compression based on the ACI 318-11 structural concrete building code. Structural safety is measured in terms of a reliability index. Probabilistic resistance and load models are compiled from the available literature. The study showed that there is a wide variation in the reliability index for reinforced concrete members designed for flexure, shear or axial compression, especially when the live-to-dead load ratio is low. Furthermore, variations in concrete strength have minor effect on the reliability of beams in flexure, moderate effect on the reliability of beams in shear, and sever effect on the reliability of columns in axial compression. On the other hand, changes in steel yield strength have great effect on the reliability of beams in flexure, moderate effect on the reliability of beams in shear, and mild effect on the reliability of columns in axial compression. Based on the outcome, it can be concluded that the reliability of beams is sensitive to changes in the yield strength of the steel reinforcement, whereas the reliability of columns is sensitive to variations in the concrete strength. Since the embedded target reliability in structural design codes results in lower structural safety in beams than in columns, large reductions in material strengths compromise the structural safety of beams much more than they affect columns.

Keywords : code, flexure, limit states, random variables, reinforced concrete, reliability, reliability index, shear, structural safety
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