Abstract

Most codes of practice adopt a semi-probabilistic design approach for the dimensioning and assessment of structures. Accordingly, structural safety is ensured by performing limit state verifications using design values determined with adequately calibrated Partial Safety Factors. Depending on the type of structure, the analysis performed and the code of practice used, structural verifications can be performed by comparing actions effects to sectional resistances or by comparing the load bearing capacity directly to the actions. Both verification methods lead to the same result for statically determinate structures, but the results can be different for statically indeterminate structures. While extensive studies have been performed to quantify the model uncertainty on the resistance side, the model uncertainties related to the calculation of actions effects and load bearing capacity in statically indeterminate structures have not been properly investigated yet. Thus, the first contribution of this thesis is to quantify this uncertainty for reinforced concrete structures by considering various mechanical models and failure modes. As there is little experimental data available on statically indeterminate systems, to perform statistical analyses, the experimental response of statically indeterminate systems is obtained by using a simple and effective technique. Practical implications are finally discussed on the basis of parametric analyses and case studies.

The second contribution of this thesis is to clarify the influence of high-level sustained loading on the resistance and deformation capacity of reinforced concrete members in compression. While the detrimental effect of high-level sustained loading on the concrete compressive strength is already acknowledged in current codes of practice, its influence in terms of deformation capacity is generally neglected. Besides the uncertainty in calculating the member compressive strength due to a larger activation of the reinforcement, the deformation capacity influences also the calculation of the action effects, which is caused by forces redistribution between elements of the same structural system. On this basis, the effects of high-level sustained loading and its practical consequences are addressed in this thesis on the basis of an experimental programme which consists of 14 prismatic specimens tested under various uniaxial stress rates and a theoretical investigation using a mechanical model. The results allow clarifying the materials responses and validating the mechanical model. Practical implications are discussed based on parametric analyses performed for different concrete ages, reinforcement ratios and materials properties.

The last part of the thesis focuses on updating the partial safety factors for permanent loads in road bridges by means of updated statistical distributions. To accurately estimate the sensitivity factors, in addition to permanent loads, the variability of the resistance calculation, materials strength and traffic loads is investigated. Finally, parametric analyses are performed to calibrate the partial safety factors for permanent loads. Two different partial factors are proposed for structural and non-structural self-weight and, by means of case studies, it is demonstrated that a sufficient level of safety is ensured, both in absolute terms and when compared to the current partial factors.

Keywords: reinforced concrete, structural reliability, model uncertainty, failure modes, action effects, statically indeterminate, sustained loading, permanent loads, partial factors, materials strength, traffic variability, road bridges