# Structural Safety of Reinforced Concrete Structures Designed Following the ACI 318 Code

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## Summary

Reinforced concrete buildings around the world are often designed following the ACI 318 code. Among the recent changes in the code is the acceptance of the ASCE7 load factors, together with new resistance factors. In this study, the safety of reinforced concrete members designed following the 2008 edition of ACI 318 code is investigated using the reliability index. Probabilistic load and resistance models are obtained from the available literature. The flexure and shear limit states at ultimate are considered. A wide range of longitudinal and transverse reinforcement ratios are investigated. Reliability indices of typical reinforced concrete members are computed for a range of live-to-dead load ratios, with and without wind. The results of the study showed that the reliability index for reinforced concrete members designed following the ACI 318 code is non-uniform, especially when the live-to-dead load ratio is low. It ranges between 3.5 and 4.5 for the case of flexure, and between 4.0 and 5.5 for the case of shear.

**Keywords:** Codes; limit states; load factors; probability of failure; reliability index; resistance factors; specifications; structural safety.

## 1. Introduction

Structural design codes and specifications for building structures have evolved ever since their introduction a century ago. Such standards will continue to develop as engineers and contractors learn more about structural behaviour, material strength properties, construction, and loading. Over the years, design codes around the world have changed from an allowable stress format to a strength design philosophy. In the United States, this trend was lead by the American Concrete Institute's ACI 318 code [1], and was followed later by many other design standards for structural steel, masonry and timber [2-4].

In general, the main objectives of the new generation of LRFD-based structural design codes are to provide uniform reliability wherein all members of a structure have approximately the same margin of safety against failure, simplify and the design procedures, consider serviceability requirements, address ductility and redundancy following a rational approach, and improve the overall economy.

Although the strength design approach first appeared in the ACI 318 code in 1956, it took the code about 15 years to fully embrace it. In the strength design method, loads are amplified by load factors, whereas the nominal resistance is reduced by a strength reduction factor. Load factors compensate for variations in loads and consider the fact that it is unlikely for all loads to attain their maximum values at the same time. Reduction factors, on the other hand, allow for the probability of under-strength, cover approximations in the design equations, address ductility demand, and consider the importance of the member within the structure.

Among the recent changes in the ACI 318 code is the acceptance of the ASCE7 load factors [5], together with new set of resistance factors, in 2002. These changes paved the way toward the adoption of a single set of load factors that are useful in the design of "mixed" structures containing

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