Optimization of R/C Frames

Using Reliability Concepts

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A general formulation of a structural optimization algorithm capable of handling standard structural elements along with different types of constraints was researched. It has the particular feature of having the global displacements as decision variables. This implies the addition of the equilibrium equations to the set of behavioral constraints. The result is that analysis and design are considered simultaneously.

The optimization algorithm was applied to planar reinforced concrete frames with nonlinear material behavior submitted to static loading. The flexural performance of the elements was evaluated as a function of the actual stress-strain curve of concrete and the elasto-plastic behavior of the reinforcing steel. Formation of rotational hinges with strain hardening were allowed and the equilibrium constraints were updated accordingly.

The inelastic behavior of the structure due to the material nonlinearities imposes a change of the global stiffness terms independently of those dictated by the alterations of the dimensions during the optimization search. For that reason the reinforced concrete element was modeled as a linear elastic beam with nonlinear rotational springs at each end.

The system reliability was evaluated using the Beta-unzipping method. Considering the linear combination of pairs of elementary mechanisms, the corresponding reliabilities could be calculated. Those close to the minimum value were considered for future linear combinations. Repeating the process an adequate number of times one would consider only those in an interval close to that with the minimum reliability. The frame reliability was then obtained considering the fundamental collapse mechanisms as a series system using the Ditlevsen bounds method.

The adequacy of the frames was guaranteed by imposing as constraints on the required reliability indices for the members and maximum global displacements for the structure. The system probability of failure was evaluated at the mechanism level at the end of the optimization procedure. If the value obtained was not acceptable, the process was repeated with updated values of the members with higher probability of failure.

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