

Computational limit state analysis of reinforced concrete structures.

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Summary

Nonlinear static analysis is emerging as a paradigm for the evaluation of the seismic performances of structures. In the civil engineering literature it is probably better known as the pushover analysis method, introduced in the 1980s aiming to construct a viable alternative to nonlinear transient dynamic analysis, whose cost is in general prohibitive for large-scale engineering structures. In this context, the success of nonlinear static analysis procedures is probably due to the directness and flexibility of the method that, for a moderately wide class of structural systems, can predict the seismic force and deformation demands due to the redistribution of internal forces in the nonlinear regime at an affordable computational cost.

Nonlinear static computations produce less accurate results compared to a fully nonlinear dynamic analysis owing to the implicit assumptions made about the dominant deformation modes when selecting the load patterns to be used in the analysis. However, a nonlinear static analysis can provide valuable information on the structural response provided that the inelastic behavior of all the elements coexisting in the structural system is consistently described. This is particularly true for those systems containing shear walls that, if not properly modeled, may lead to unsafe estimations of limit loads and of failure mechanisms.

In this talk a simplified model is discussed for computing the response of reinforced concrete structural walls that is suitable to nonlinear static analysis. In particular, a shell element is implemented in which arbitrary distributions of steel re-bars and nonlinear material constitutions for both concrete and reinforcement are allowed. Nonlinearity due to the axial-flexural behavior of the wall is accounted for based on a closed-form stress integration procedure, thereby bypassing the inaccurate and computationally expensive subdivisions of the cross section into fibers.

The driving rationale of the present approach to the limit state analysis of reinforced structural walls is to develop a formulation that meets two basic requirements. The first one is to end up with a reinforced shell element whose kinematics is sufficiently rich to overcome known limitations of beam and layered elements. The second is a robustness requirement, whereby the present approach can be confidently used to analyze full-scale structures based on a minimal set of material parameters.

Numerical results will be presented that demonstrate the performances of the proposed approach in finite element computations.