Performance-based Analysis of Steel Structures with Semi-rigid Connections

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Summary

The behaviour of steel frames is highly influenced by the way in which the beam-to-column connection is accomplished. For quite some time now, traditional design has regarded such connections as being either perfectly rigid or perfectly flexible (hinges), thus the calculation being developed starting from this assumption.

The paper aims to develop the theoretical concepts that are needed to include the characteristics of semi-rigid connections in the geometrical nonlinear approach. The analysis uses the finite element method and fundamental relationships are inferred by the separate and independent introduction of static, kinematic and constitutive conditions to be met.

Relevant numerical examples are given and discussed. Conclusions regarding the effect of semi-rigid connections upon the performance of steel frames are formulated in the final part of the article.

Keywords: Performance-based design; steel frames; connections; structural mechanics.

1. Introduction

In recent years, the civil engineers are faced to a challenging situation: constructions become more and more ambitious and their structures more complex at the same time with the raise in the demand for increased safety measures. This led the structural engineers to face a contradictory situation: the increase in the load bearing capacity is usually associated with the decrease in ductility, the structures becoming sensitive to the seismic action.

The advent of performance-based engineering has placed an emphasis on simulating the nonlinear response of a structural system either to ordinary or seismic action. Accurate and computationally efficient models that represent the nonlinear behaviour in beam-to-column connections are thus required to evaluate the performance of the structures.

2. Performance Criteria for Steel Structures

The analysis of the damage produced by strong earthquakes has shown that the hypothesis of rigid nodes is not correct and that an accurate analysis must take into account the real mechanical properties of the beam-to-column connections.

A study on the effects that the Northridge 1994 earthquake had on steel frame-type buildings evidenced the failure of welded beam-to-column connections. Although no collapses of steel structures with welded joints occurred, a large number of cracks in the welding seams of the beam-column connection areas were found, which evidenced the unexpectedly brittle nature of welded connections. The cracks in the welding seams covered a wide spectrum of locations and disclosures. The lesson taught by the Northridge, as well as other strong earthquakes (Kobe, Chi-Chi Taiwan) is

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