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Role of the Floor System in the Cyclic Response of Steel Gravity Framing

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Abstract

In typical U.S. design practice for steel buildings, lateral loads are assumed to be resisted by a small number of lateral-force-resisting frames, while the rest of the structure consists of gravity framing, typically assumed to have no flexural resistance. It has long been recognized that the simple shear connections used in gravity framing do possess some flexural strength. However, there is little experimental data on the cyclic loading response of these connections. This paper details ongoing experimental research into the response of such connections. Full scale cruciform composite beam-column subassemblies were tested under large cyclic inter-story drifts. These tests have shown that simple shear connections can develop significant moments under large drifts, largely due to the formation of large tensile forces in the floor system. Given the large number of shear connections in most structures, this capacity could significantly enhance the seismic resistance of a structure.

Keywords: seismic behaviour; composite connections; steel buildings; cyclic loads;

1 Introduction

Seismic resistance is typically provided in steel structures by a small number of moment frames, braced frames, or shear walls. The remainder of the structure is composed of gravity framing (beams framing into columns with “simple shear” connections, topped by a composite slab). These simple shear connections are typically designed as perfect pins, assumed for design purposes to have no flexural strength or stiffness. This assumption implies that these connections cannot contribute to the seismic resistance of a structure. In reality, these connections do possess flexural strength, particularly when they act compositely with the floor slab. While this strength may be small, the large number of gravity frames present in a typical steel structure means their overall contribution can be significant.

After the Northridge earthquake in 1994, it was observed that many of the structures experienced significant fractures in the moment connections of their lateral frames, yet none of those structures exhibited full collapse [1]. During the investigations that followed that event, analytical studies suggested that the gravity framing can play a key role in the survival of steel buildings in earthquakes, in some cases being the difference between survival and collapse [2,3].

Though these studies suggest that gravity framing can play a significant role in the response of steel buildings to seismic events, their behaviour is not yet fully understood. Current models of shear connection behaviour are based on a limited number of experimental studies, primarily those of Liu and Astaneh [4], but also Leon [5], Azizinamini [6] and others. While those studies have shown that simple shear connections can exhibit significant flexural capacity, especially in the presence of a composite floor slab, the strength, stiffness and ductility of those connections can vary significantly depending on connection and floor system details. Given the large number of different configurations seen in gravity connections, questions still remain as to the behaviour of such systems. This paper details research intended to improve our understanding of the behaviour of

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