Design of a High-Rise Steel Building to Resist Disproportionate Collapse

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Summary

This paper will present information on practical design methods and verification procedures which can be used for design against disproportionate collapse, as relevant to high-rise buildings. The case study of a 30 story high-rise commercial office building will be given. The ease of which resistance to disproportionate collapse can be implemented as part of an overall multi-hazard design process is discussed. As is typical for slender high-rise buildings, the structural efficiency of the system increases as the participation of the gravity system in the lateral load resisting system is increased. By conceptualizing the frame from the outset to also be available to provide alternative load paths, an efficient structure can be provided with minimal penalty for resistance to disproportionate collapse. Design methods include the utilization of alternate load paths in the building framing. Verification procedures presented include simplified nonlinear static analysis.

Keywords: high-rise buildings, steel, disproportionate collapse, robustness, multi-hazard, nonlinear.

1. Owner's Vision and Consequent Building Structure

Fig. 1: Building Perspective

The subject building is a 30 story high-rise commercial office building in midtown Manhattan in New York City. Design began in 2006 and construction was completed in 2009. It has a total floor area of approximately 30,000 square meters, and tower floor plates typically 18 meters wide by 40 meters long. See Figure 1 for a perspective view.

The owner's, and architect's vision was to produce a building with superlative attention to the satisfaction and comfort of the tenants. This combined with the prime Manhattan location would eventually lead to some of the highest rents charged for office space in New York. The details of their vision included having "column–free" floors, as well as having high ceilings, unobstructed views to the outside, and in general a structure which went unnoticed. To achieve these goals, the various structural subassemblies of the building were conceived from the outset to recede from view while meeting the structural requirements for strength, deflection, velocity and acceleration, against vertical and lateral loading. As a directly related bonus to this concept, the structural system was developed to exhibit substantial robustness against disproportionate collapse.

The floor framing assemblies generally consist of relatively shallow long span steel framing composite with the floor slabs. These provided increased ceiling heights and eliminated the need for interior columns in the tower, allowing columns to remain at the exterior and a slender core to be offset to the rear of the building.

The perimeter columns are assembled into moment frames at the north and south facades, providing lateral strength in the long direction of the

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