A07

Damage Progress and Collapse of High-Rise Steel Frame Buildings with Various Beam-Column Strength Deterioration Factors

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1. Introduction

Existing high-rise steel buildings in Japan face severe safety risks in the background of 2011 Tohoku Earthquake and future extreme earthquakes. Various deterioration effects are incorporated to reveal the damage progress and collapse mechanism of existing high-rise steel buildings in Japan.

2. Modeling of deterioration effects

In the fiber element analysis program, accurate stress-strain (S-S) model for steel elements determines the seismic behavior of the buildings. Associated with the strength and stiffness deterioration effects, a calibrated S-S model is utilized for collapse simulation of a realistic high-rise steel building model, which is 40-story, four spans as shown in Fig. 1. This model is taken to have a large beam-to-column strength deterioration factor as the compact sections.

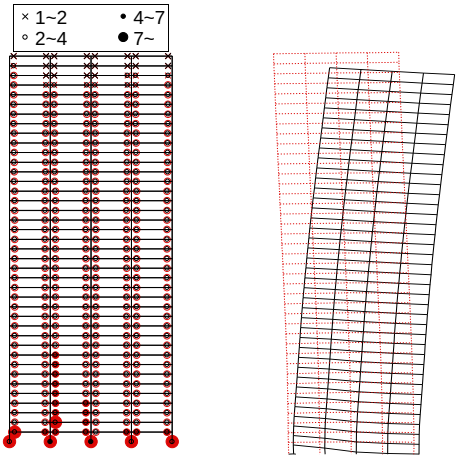

Fig. 1 Damages and collapse of high-rise buildings: (a) plastic deformation ratios; (b) collapse mechanism

3. Damage progress

Conventionally, plastic damage determined by the plastic hinge rotations is used to measure the seismic damage. However, even after the occurring of plastic hinges, the bending capacity of steel components are capable to increase from M_y to M_p. At this stage, local buckling induces sudden strength degradation, the bending capacity starts to deteriorate until complete loss. This consequence has significant influences on the seismic damage especially on collapse resistance. Fig. 1 (a) illustrates the plastic deformation ratios, and it is notable that the deterioration effect (red solid cycles) lead the bottom story to damage concentration which triggers the onset of story collapse mechanism as shown in Fig. 1 (b).

4. Seismic collapse

Collapse of high-rise steel frame buildings should be regarded as a progress where gravity capacity (N) of columns deteriorates and completely loses associated with the reduction of their overturning moments (M). Fig. 2 shows the incremental process of the bottom-story columns that gradually lose their axial loading resistance. According to the M-N interaction relationship, the case with FB columns demonstrates premature collapse compared with the case with FA columns.

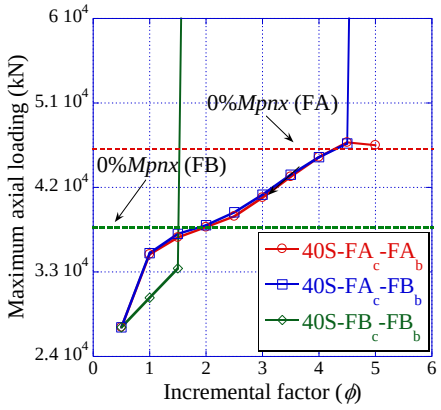

Fig. 2 Collapse process of building column