PROGRESSIVE COLLAPSE OF A BUILDING WITH POST-TENSIONED CONNECTION

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A post-tensioned (PT) steel moment resisting frame is a self-centering earthquake resistant steel frame having post-tensioned strands to compress the beam flanges against the column flanges at the connections, as shown in Figure 1. The post-tensioned strands contribute to the moment capacity of the connections and provide an elastic restoring force to return the frame to its pre-earthquake position (Garlock Maria et al., 2007). Most important advantages of the PT connection are that the beams and columns remain essentially elastic while inelastic deformation (and damage) in the connection provides energy dissipation. Significant damage to the connection occurs just in the angles of the connection which can be easily replaced (Ricles et al., 2002).

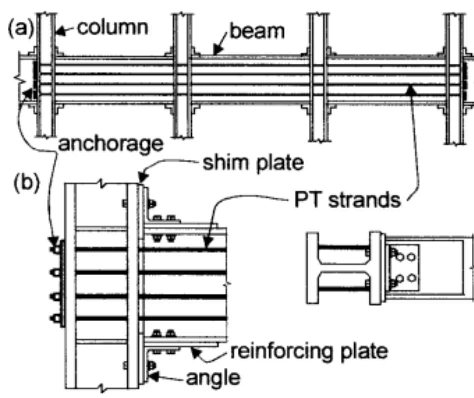

Figure 1. (a) Schematic elevation of one floor of a PT frame; (b) connection details (Garlock et al., 2007)

During a progressive collapse scenario, when a single column (or a wall) is removed, beams act together to develop catenary action. This catenary action prevented progressive collapse by redistributing gravity load through reliable load paths (Cheol-Ho et al., 2009). If a structure has good alternative loading path, the initial failure will not expand to the other parts of the structure and the local damage will be restricted. Based on the accomplished researches one of the methods to increase catenary action in the structure may be applying post-tensioned connections that is discussed in this paper. In this regard, two six-story, four- bay steel frames are designed, one having post tensioned and the other with rigid connections, and modeled in Opensees program. Then progressive collpse possibility of each of these structure are studied and compared.

For the structure with PT connections, five different details are considered for the connections. This helps to study the influence of the design parameter (α) on the progressive collapse. Five frames with different α (α =0.95, 1.1, 1.25, 1.4 and 1.55) are designed, where:

$$\alpha = \frac{M_a}{M_{des}} \tag{1}$$

in which M_a is connection moment initiating angle yielding and M_{des} is the design moment in the beam at the column face.

A sensitivity analysis is also carried out on the influence of the PT connection details on the potential of the progressive collapse: for this different strands initial posttensioning forces and flexural capacities of PT connection at yield of angle state (M_a) are considered. The obtained results show that the former is more efficient than the latter in reduction of the progressive collapse potential of the structure.

To study the possibility of progressive collapse in the structure of this study, the gravity loads are firstly applied to the structure and then progressive collapse analysis is performed dynamically by removing the middle column of the first floor. Deflections of the critical points (top of the removed column) for these frames are compared. Time histories for top of the removed column for the studied cases is shown in Figure 2, in comparison with the one having rigid connections. As shown, PT connection is more efficient in decreasing progressive collapse possibility than rigid connection if α>1.4, otherwise rigid connections are preferred.

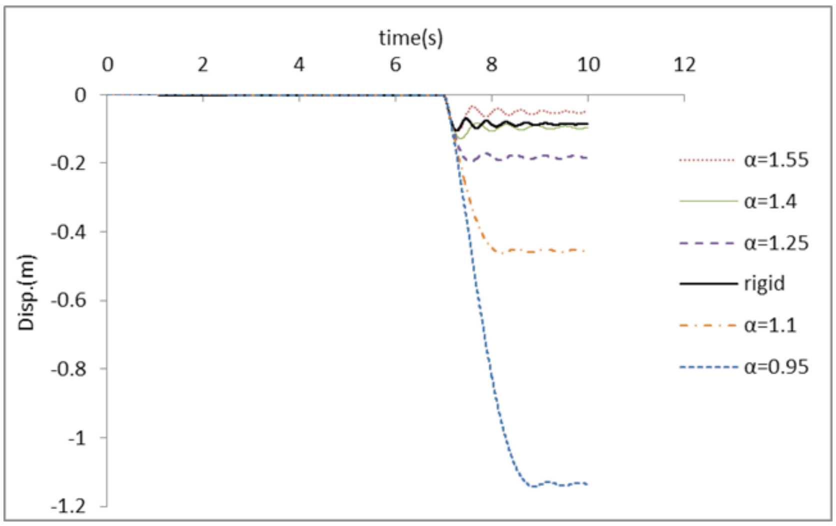

Figure 2. Time history of removal column vertical displacement in frames with variable α and rigid frame

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