SEISMIC ASSESSMENT OF SELF-CENTERING CONCENTRICALLY BRACED STEEL FRAMES

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Nowadays constructions are designed to achieve a controlled response against earthquake shakings and the design goal is just not to threat human life and structures stability. Kinds of different structures are designed in this way by having inelastic and ductile performance caused by yielding at predetermined elements which are accurately studied. Nevertheless, these systems are expected to have residual displacements and drifts because of their hysteresis behaviour in extreme events. These residual deformations can cause extreme repair costs or cause the structure not to be reparable at all.

As the usage of post tensioning was developed in concrete structures, engineers start studying posttensioning concept to use with precast shear wall system. For employing this concept, rigid rotational fixity of wall is released and instead, posttensioned cables or bars are used to resist against rotation. Posttensioned system must remain elastic in all performance states of the structure so no residual deformation will occur. To reduce effective forces of an earthquake, dissipating fuses will be used to dissipate energy of earthquake. As we use this concept in suitable form, we can have a flag shape hysteresis behavior for the system. It means no residual deformations but well energy dissipation in system through every event. Concentrically braced frames can be used in this concept. By releasing vertical fixity in column-base connection, the braced frame can rock relative to the base. It means that the frame can rotate while the deformations of its member are negligible relative the rotation. Posttensioned cables are used to resist overturning moments. Special fuses will be used to dissipate energy. Although the fuses will help the cables in resisting overturning moments through their elastic response but when the frame drift increases, it resists frame self-centering after its yielding. Self-centering means no residual displacement in the frame. Hysteresis curve in Figure 1 shows the behaviour of a self-centering post-tensioned concentrically braced frame.

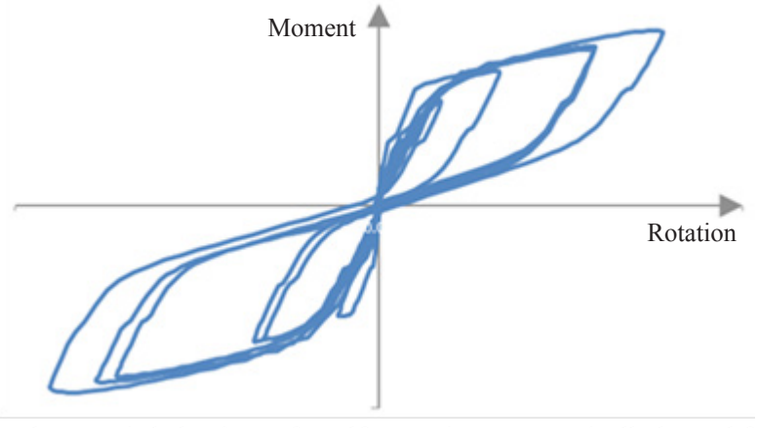

Figure 1. Flag shape hysteresis behaviour of a self-centering concentrically braced frame (Attari, 2014)

For this dissertation we studied self-centering concentrically braced steel frames with special kind of fuses called butterfly fuses. The posttensioned cables are connected to the middle of roof beam of the frame at the top and to the base at the bottom. The fuse is placed at the base level and connects the frame by means of a vertical strut connected to the middle of first story beam. Three story frame configuration studied in this dissertation is shown in the Figure 2a and the used shear fuse is shown in Figure 2b.

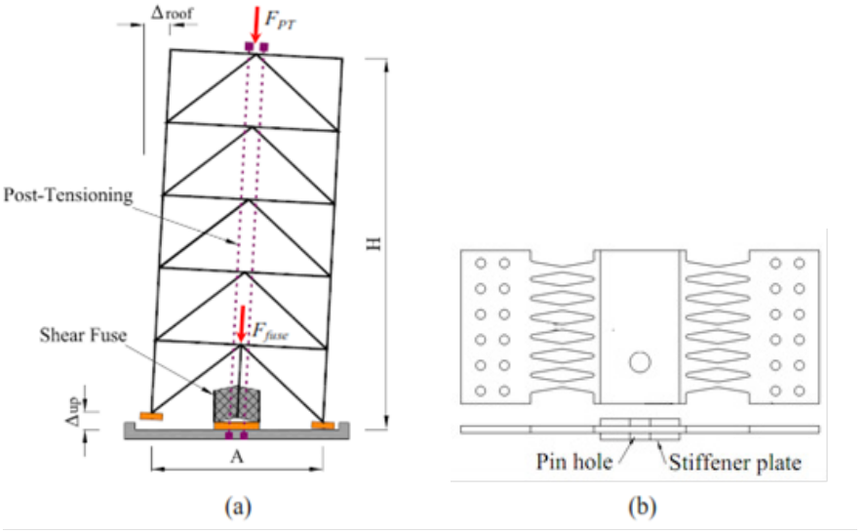

Figure 2. Frame and its shear fuse configuration (Ma, 2010)

For this dissertation design method introduced by "Xiang Ma" is used to design eleven frames include 3, 5, 7 or 9 stories. These frames are modeled in OPENSEES with a verified method. Static nonlinear and Incremental Dynamic Analysis are conducted for the models. FEMAP695 instructions are applied for the models to verify the design parameters and then by usage of hazard curves for the determined site (near Los Angeles 34N, 117.5W, site class D) annual rate of collapse is calculated. It is observed that the value of annual rate of collapse for these cases is in the range of 0.0002 to 0.0009 and its average is 0.00046 which corresponds an average collapse return period of about 2180 year with a range of 1110 to 5000 years. Table 1 shows the results for all eleven cases.

Table 1. Annual rate of collapse and collapse return period for studied cases

case num	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
num. stories	3	3	3	3	5	5	7	7	9	9	9
num. frames	2	2	2	4	4	4	4	4	4	4	4
Height/Bay	2.4	1.6	2	2.4	4	2.7	3.7	2.8	3.6	3.2	4
annual rate of collapse	0.0002	0.00027	0.00035	0.00066	0.00044	0.00091	0.00048	0.00056	0.00039	0.00037	0.00042
collapse return period	5000	3703.7	2857	1515.15	2273	1098.9	2083	1785.71	2564	2702.7	2381

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