8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

COLUMN BASE CONNECTIONS SEISMIC SUSTAINABILITY

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Keywords: Low damage, Column base, Self-centering, Seismic performance, Dissipator

Modern codes for seismic-resistant structures adopt the philosophy that strong earthquakes must be resisted by dissipative members while the rest non-dissipative members remain elastic and free of damage. Typical dissipative members are the beams in moment resisting frames (MRFs) and the diagonal braces in the concentrically braced frames (CBFs) while the columns can be considered as non-dissipative members. The damage of structural components as well as the residual drifts can be significant and may lead to high repair costs and disruption of building use or occupation. To address these socio-economic risks, significant research has been given in the development of low damage structures which can reduce both repair costs and downtime. Examples of such structures include steel frames with self-centering beam-column connections, self-centering braces, viscous damping devices and others. These earthquake-resilient steel frame typologies have been extensively studied during the last decade but little attention has been paid to the behavior of their column bases. Conventional steel column bases typically consist of an exposed steel base plate supported on grout and tied to the concrete foundation using steel anchor rods.

Column bases can be either full strength or partial strength. In the first case a plastic hinge is expected to be developed at the bottom end of the first story columns. The specific damage in the columns is non-reparable and contributes to the overall residual drifts which is not desirable. In the case of a partial-strength column base, as field observations have shown after strong earthquakes, a number of difficult-to-repair damages in the column bases can be appeared such as concrete crushing, weld fracture, anchor rod fracture and base plate yielding. Moreover, in this case the knowledge of the plastic rotation capacity of the column base would be needed which is difficult to predict. Also, recent investigations have shown the complex hysteretic behavior of such column bases under cyclic loading.

In current practice, conventional column bases can be designed as rigid or pinned. These two assumptions could be invalid since “pinned” column bases may possess significant stiffness while the “rigid” ones may be flexible under bending. Under seismic loading, modelling the column bases of a steel MRF as rigid leads to unconservative results in terms of the first story drift and collapse resistance. Therefore, the current design assumption of perfectly rigid or pinned column bases may produce erroneous results and jeopardize economy, serviceability and safety. In addition, the design of semi-rigid column bases is not straightforward, as previous studies show that their rotational stiffness is strongly affected by the base plate flexibility and the magnitude and proportionality of the axial force. A number of alternative column bases has been proposed recently with the goal of overcoming the shortcomings of conventional column bases. Some of them used steel bars as re-centering devices, while others used replaceable bolts in an effort to direct all the damage in these elements under an earthquake event. In this paper, qualitatively evaluation and comparison of different current details of base connections are presented (Table 1) and they are evaluated from seismic performance (energy dissipation and damageability), self-centering and replacement. Low damage column base connections and dissipation by friction and other external dissipators are the most promising.

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Table 1. Different current details of base connections.

No.	Type of Structure	Authors et al.	Type of Study	Description of Fuse (s)	Replaceable	Self-Centering System
1	Structures with Self-Centering Systems	Garlock et al. Chou and Chen Ricles	Analytical	PC bar, Steel damper, PT bars Anchor bolts	-	Yes
2	Structures with Rocking and Energy-Dissipating Fuses	Midorikawa et al. Pollino, Vetr et al. Borzouie et al. Hosseini and Ebrahimi	Analytical Experimental	Fluid dampers, Yielding base plates, Friction connection, Central fuse, DADAS	-	No
3	Structures with Self-Centering and Energy-Dissipating Fuses.	Sawada Liu	Analytical Experimental	Gap, opening and closing through the spring loaded wedge, Buckling restrained steel plates, PT bars	Yes	Yes
4	Structures with Rocking, Self-Centering and Energy-Dissipating Fuses	Bruneau, et al. Azuhata, Freddi et al. Kamperidis et al.	Analytical Experimental	Yielding base plates, Unbonded pre-stressing tendons, Butterfly fuse, BRB, Friction dampers, PT bars, Anchor plate, Web hourglass pins	Yes	Yes