DEVELOPMENT OF A NEW INNOVATIVE STEEL MOMENT CONNECTION

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Introduction

Steel moment frames are widely used in buildings subjected to lateral loads such as wind and earthquakes. This project aims to develop a new economical steel ductile moment connection for highly seismic areas. The highly ductile new connection is primarily utilizing ductility of the gusset plate to provide necessary rotational capacity while the entire beam and column, connected by this connection, remain essentially elastic. The proposed connection is well-suited to be used in steel and composite special ductile moment frames, special steel shear walls and dual systems of moment frames plus special concentrically braced frames, all currently used in seismic lateral force resistance in buildings. It can also be used for gravity load and wind application.

Objectives

The main objective is to develop a new economical type of steel moment connection that uses the highly ductile yielding of gusset plates as the primary source of rotational ductility for the connection. Such connection can be used not only in *ductile steel moment frames* but also in *ductile steel plate shear walls* as well as in *ductile "dual" systems* consisting of moment frames and concentrically braced frames.

Background

Design of steel moment connections has changed significantly since the 1994 Northridge earthquake with the outcomes of SAC Joint Venture Steel Project and other research efforts. Various modifications have been made and several new moment connections have been developed to increase ductility.

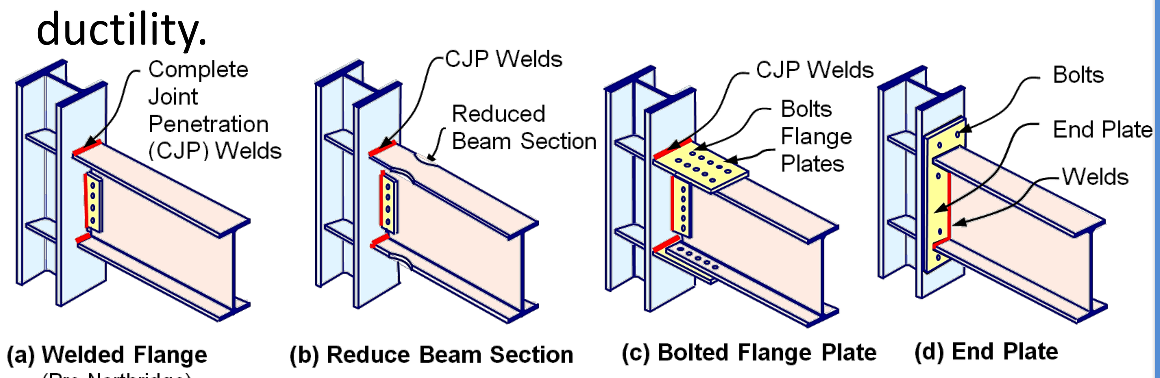

Fig.1 Example Existing Steel Moment Connection

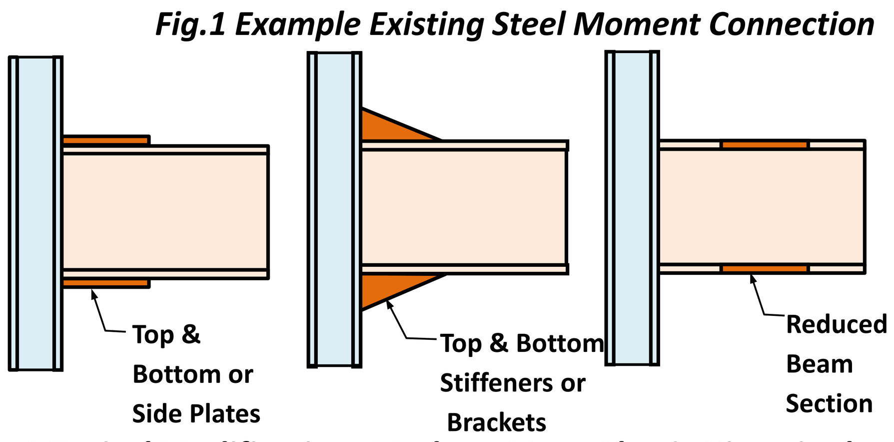

Fig.2 Typical Modifications Made to Move Plastic Hinge in the Girder Away from the Face of the Column

(1) Welded vs Bolted

- Welded option: stable and stocky hysteresis loops
- Bolted option: stable but pinched hysteresis loops
- Bolt slippage (pinching) may add to the ductility
- "Upset bolts" recommended where the diameter of the shank is less than the diameter of the threaded part to force yielding of the shank to occur prior to fracture of the threaded parts

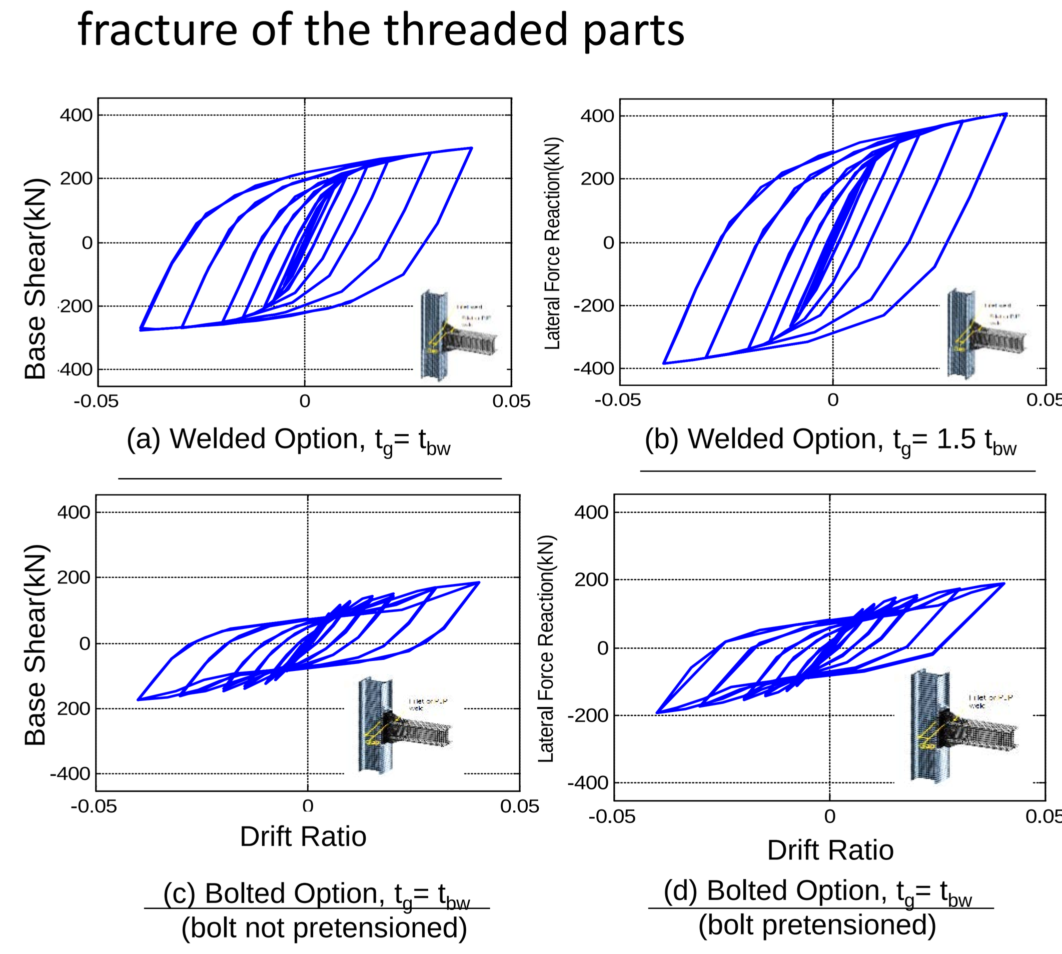

Fig.5 Hysteresis Loops of Gusset Beam-to-Column Connection Sub-assembly

Proposed Gusset Plate Moment Connection

- Connection Geometry: Shown below
- Plastic Hinge: Forms in the gusset plate as a ductile fuse
- Beams: Remain essentially elastic during seismic event
- Columns: Remain essentially elastic during seismic event with some or no yielding in the panel zone
- Continuity Plates: No or minimum continuity plate required
- Welds: Use of CJP for thick gussets and fillet weld for thin gusset plates (thinner than ½ inch.)
- Applications: Fit to be used in Special Moment Frames, Steel Shear walls and Dual systems.

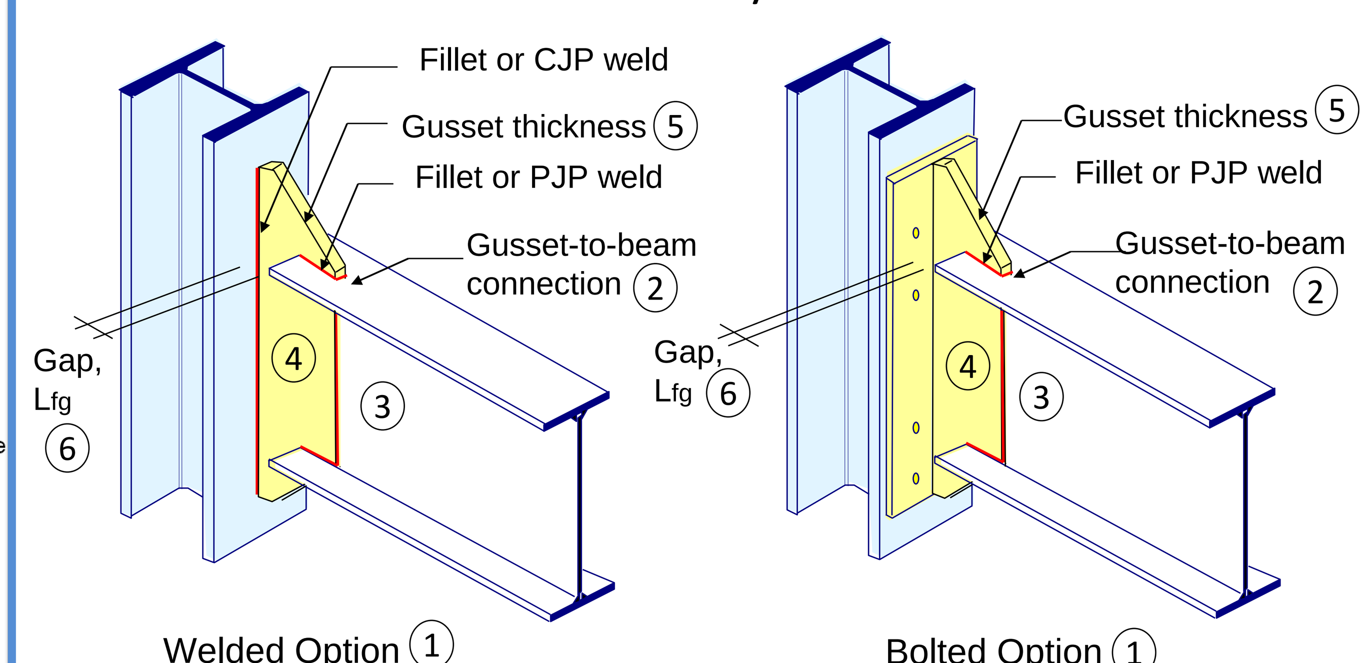

Fig.3 Illustration of the Proposed Innovative Gusset Plate Moment Connection

(2) Examples of Gusset-to-Beam Connection

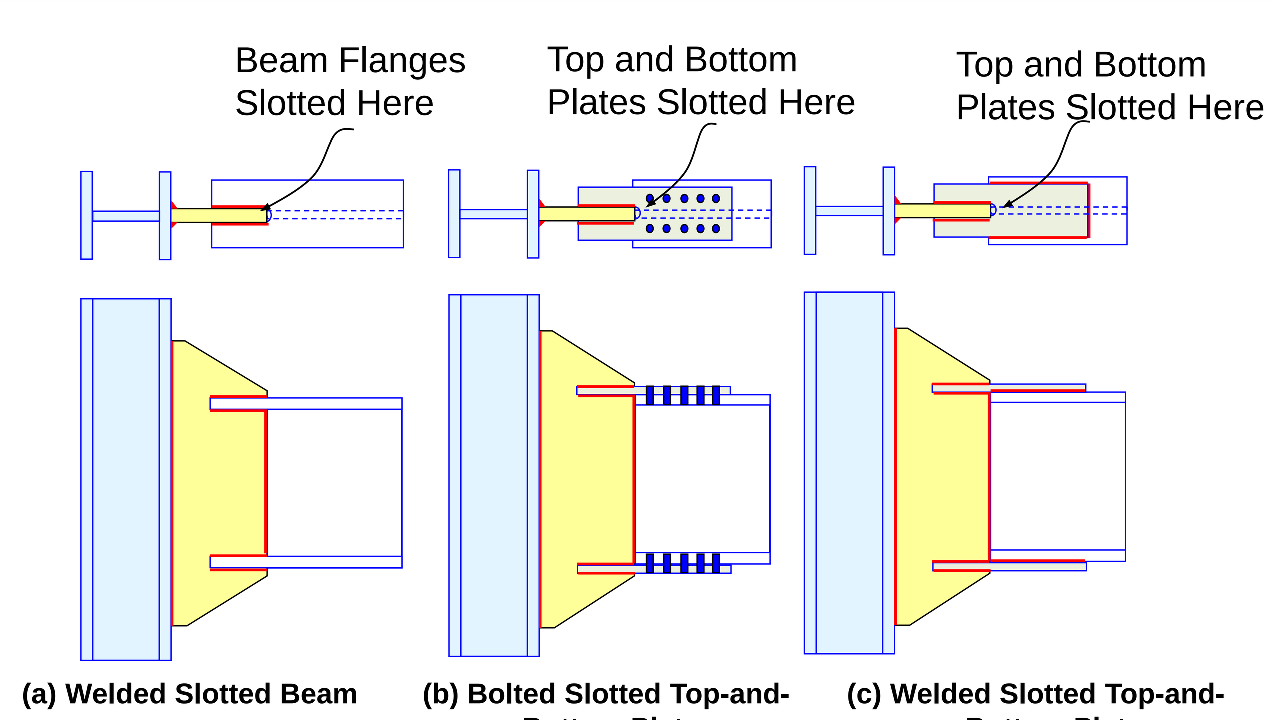

Fig.4 Other Feasible Details for the Proposed Gusset Plate Moment Connection

(3) Gusset-to-Beam Moment Capacity Ratio

- No significant effect on the overall moment-rotation relation
- $M_{pc}/M_{pb}<1$: all inelastic deformation is concentrated in the gusset plate
- $M_{pc}/M_{pb}>1$: beam yielding observed

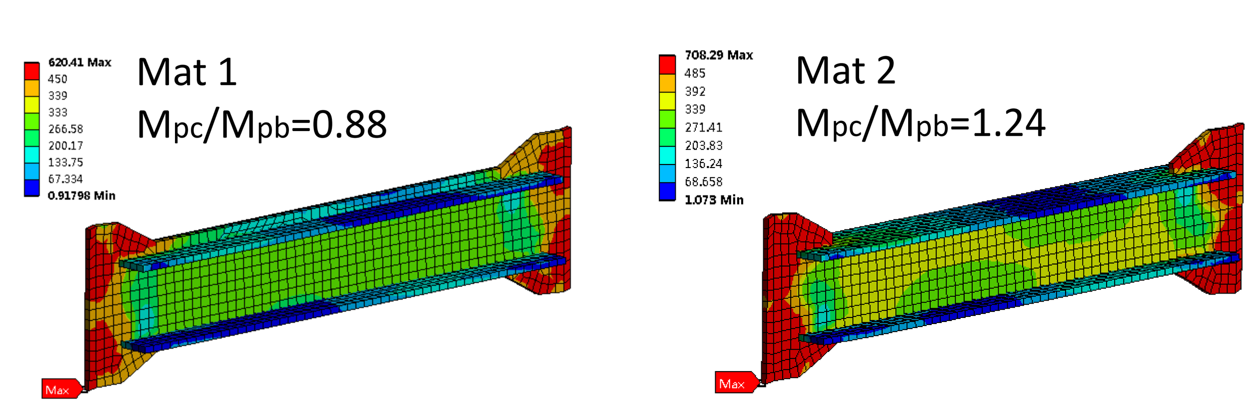

Fig.6 Illustration of Yielding Region for $M_{pc}/M_{pb} < 1$ and $M_{pc}/M_{pb} > 1$

(4) Effect of Shape of Gusset Plate

- Larger gussets result in larger capacity but cause more yielding in the column web
- Geometry of the gusset plate shape affects the location of maximum equivalent plastic strain - Shape Trap 2 most desirable

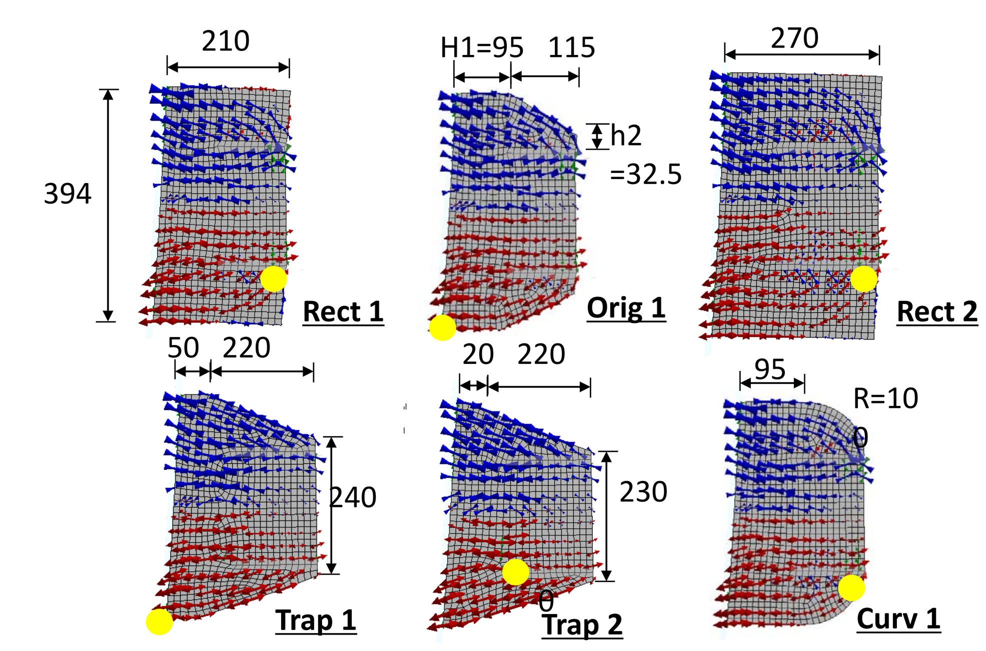

Fig.7 Comparison of Dimensions and of Maximum Equivalent Plastic Strain Regions for Different Gusset Plate Shapes

(5) Effect of Gusset Thickness

- Thick gusset – larger capacity but impose larger yielding in column web & beam
- Thin gusset – less capacity and less yielding in column web & beam, but may suffer large out-of-plane deformation
- Preferred t_g=1.25t_{bw}

(6) Effect of Free Gusset Length

- Small L_{fg} gusset plates behave similar to directly welded beam-to-column connections with triangular stiffening plates; have relatively large capacity and cause larger yielding in column web
- Larger L_{fg} gusset plates have less capacity and impose less demand on the column web; may suffer from gusset out-of-plane deformation, even yielding in the beam web and have un-symmetric hysteresis loops.
- Preferred free length of gusset: $L_{fg} = 4t_g \sim 6t_g$.

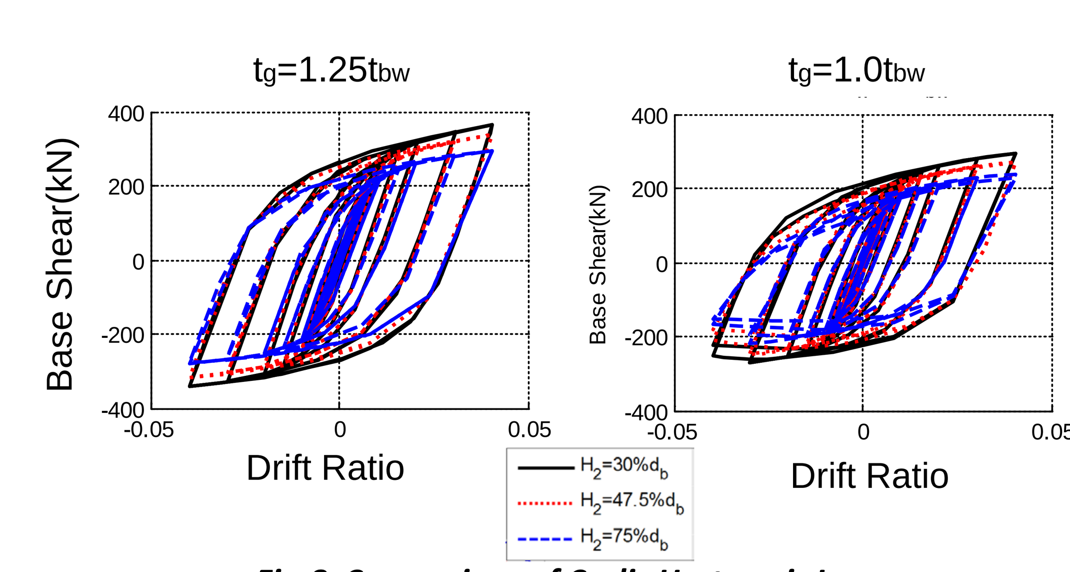

Fig.8 Comparison of Cyclic Hysteresis Loops

Acknowledgement

These studies were done at the Department of Civil and Structural Engineering at the University of California at Berkeley, which were made possible with the support from *the Professor T.Y. Lin Fellowship in Structural Engineering* to Xin Qian.

Conclusions & Future Works

A new economical type of highly ductile steel moment connection called " Gusset Plate Moment Connection" is developed and proposed for seismic and non-seismic applications. The effectiveness of the innovative connection concept has been validated in this R&D project and the effects of key parameters on the performance of the connection under seismic loads (cyclic loading) have been established. We are writing a PEER Research proposal to NSF to conduct verification cyclic tests of the proposed innovative connection as well as to develop seismic design procedures for our proposed connection. A plan for patenting the connection is under consideration.