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Evaluation of Steel Moment-Resisting Connection with Nonlinear Replaceable Link

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Abstract

Moment resisting frames were believed to be ductile systems. This belief was put into question during the 1994 Northridge earthquake. Brittle fractures developed near the connection welds in many cases. As a result different schemes were developed to improve the connection performance. The improvements on connection configuration are mainly based on the connection reinforcement or the weakening of the beam section. These methods are intended to force the plastic hinge to form away from the column face and consequently increasing the connection ductility. In this study these goals are achieved by using replaceable link. To investigate the behaviour of connection with replaceable link nonlinear finite element models were developed for the beam-to-column using the commercial software ANSYS. Analytical results from the current study indicate that the replaceable link provide sufficient strength and ductility. It seems that repair of the beam in replaceable links is easier than other methods.

Keywords: Replaceable link, Post-Northridge connection, Ductility, Strength, Finite element model.

1. INTRODUCTION

In a steel Special moment-resisting frame (SMRF), plastic hinges develop near the beam-to-column connections during large seismic events. Plastic hinges act as ductile fuses, dissipating energy through stable hysteretic behavior while limiting forces transmitted to other components of the structure. To ensure this ductile behavior and to maintain the integrity of the structure, the beam-to-column connections must be able to sustain large inelastic deformations without brittle fractures or significant loss of strength, while the other structural members should remain essentially elastic. SMRFs with traditional welded flange and bolted web connections were believed to be very ductile systems and were extensively used between the 1960s and the early 1990s. This belief was put into question during the Northridge, California earthquake on January 17, 1994. Brittle fractures developed near the post-Northridge connection (Fig. 1) welds in over 150 buildings, in many cases without any signs of plastic deformation in the beam. To investigate these damages and to develop solutions, the SAC Joint Venture was formed and was responsible for administering a research program initiated by the U.S. Federal Emergency Management Agency (FEMA). Finally numerous potential causes for the numerous brittle fractures (Fig. 2) were identified [1, 2] including inadequate workmanship and inspection quality, poor filler material and welding procedure, over-strength of the beam material, stress concentration caused by the backing bar, and tri-axial forces at the column face. Improved welding practices were also recommended. Such practices include using removing backing bars, and using weld access holes to facilitate welding of the bottom flange.

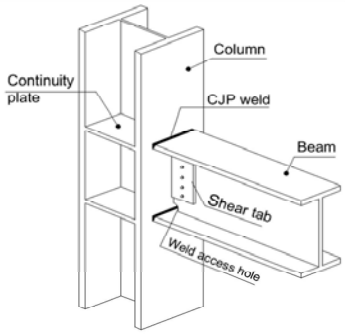

Figure 1. Typical pre-Northridge connection

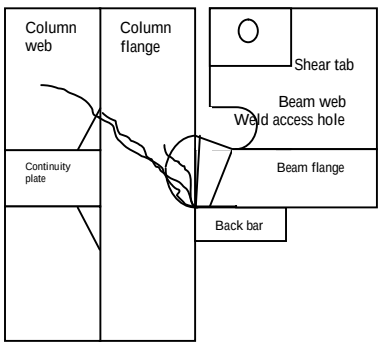

Figure 2. Type of fractures in connection