SEISMIC RETROFIT OF TYPICAL IRANIAN STEEL BUILDINGS USING A NEW APPROACH FOR UPGRADING THE EXISTING CONNECTIONS

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INTRODUCTION

The construction of a wide range of Iranian steel buildings a large number of which were built before 1990 was based on no seismic code. These buildings can be seen from faraway rural areas to large cities of Iran, and are used widely as residential, commercial, and also administrative buildings. Based on the experiences of past earthquakes such as Manjil Earthquake (1990) and Bam Earthquake (2003), it has been confirmed that many of these steel buildings may suffer extensive damage while earthquakes. Considering that some of these buildings are critical facilities like hospitals and schools that must remain operational following earthquakes, serious concerns are raised about their performance in future earthquakes.

This category of Iranian steel buildings has obvious similarities in construction practices, and most of these common buildings suffer from the same deficiencies in their lateral load bearing systems. These buildings usually have the framing system in only one direction, and this framing system can just carry gravity loads. The beam-to-column connections of these frames often follow the practice of typical Iranian connection named as "Khorjini connection" which can be categorized as non-seismic semi-rigid connections. Because of non-rigidity of connections as well as non-existence of bracing systems in existing frames, typical Iranian steel buildings show limited strength against lateral loads, and they are not capable of resisting moderate or large earthquakes.

PROPOSED METOD FOR UPGRADING THE EXISTING CONNECTIONS

By the method proposed in the current research study, the Khorjini connection is upgraded in a manner that the load path changes from existing angle sections to new additional connection elements further to provide a rigid connection. Subsequently, the stress level in angle sections decreases significantly, and this results in preventing the brittle failure of the connection. In order to provide the expected seismic behavior, the connection is retrofitted by adding two vertical plates hereafter called R-plates perpendicular to the frame direction. These plates are placed between two beam profiles, and their edges are welded to beam and column flanges. Figure 1 shows the shape of an R-plate plus its installation on an upgraded Khorjini connection. Both horizontal and vertical loads as well as flexural moments are transferred from beams to columns through these added plates instead of existing angle sections. R-plates lock the rotation of connection, and satisfy required strength and stiffness by connecting to beams by fully penetration welds, and to columns by fillet welds.

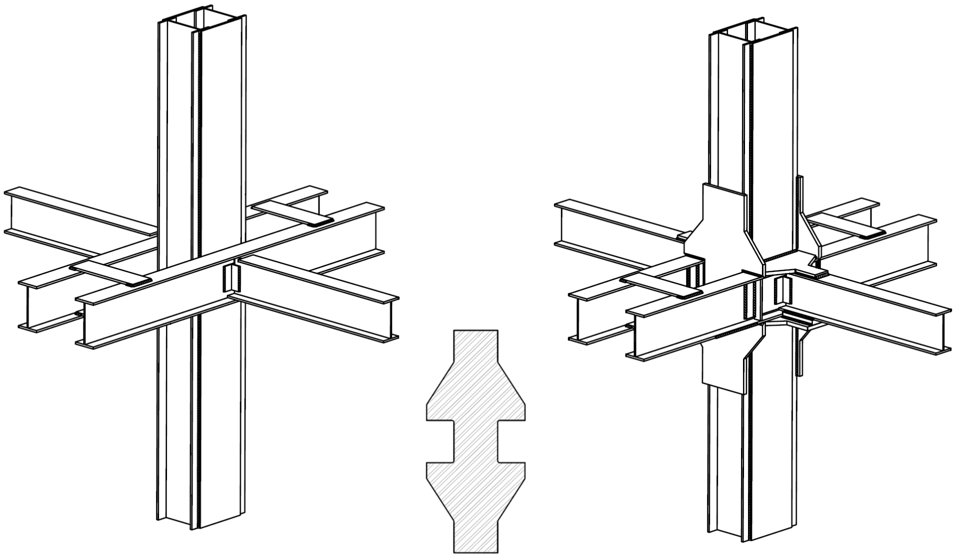

Figure 1: Typical existing Khorjini connection before upgrading (Left), proposed vertical plate (R-plate) which should be added to both sides of the connection (Middle), and the upgraded Khorjini connection (Right)

SEISMIC EVALUATION OF CASE STUDY BUILDINGS

For the purpose of seismic evaluation of typical Iranian steel buildings which have Khorjini connections, three categories of them have been studied before and after upgrading their connections. These buildings include 3-, 6-, and 9-Floor existing buildings that can be representative of low-, medium-, and high-rise buildings respectively. These selected buildings have been modeled and analyzed by static and dynamic methods comprehensively in order to understand their seismic performance. Each of aforementioned buildings has been studied in three different stages: At the first stage, the existing building with its typical Khorjini connections has been considered. Then at the second stage, connections of the study building have been upgraded to rigid connections using the proposed method. Finally at the third stage, the frame elements including beams and columns have been strengthened in addition to the upgraded connections. Comparison of these three stages can give a clear view toward the seismic behavior of study buildings.

CONCLUSIONS

Comparison of results obtained from both experimental and analytical studies confirms that the load bearing capacity of upgraded frames is increased significantly using proposed method. Frames with upgraded connections are capable of resisting moderate or high earthquakes by their ductile behavior in contrast to the existing Khorjini frames which can bear just limited lateral forces by their brittle behavior. Investigation of analytical results approves that the lateral displacements of frames with upgraded connections decrease considerably, and this strengthening scheme increases the stiffness of frames, and causes the less lateral displacements. Additionally, this pattern of strengthening prevents from undesirable weak column-strong beam mechanism by formation of plastic hinges in beams instead of columns. In short, it can be concluded that the proposed upgrading method is an applicable cost-saving method which considers all possible deficiencies, and improves the seismic behavior of typical Iranian steel buildings significantly.