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STRENGENING JOINTS OF RC FRAMES WITH STIFFENED STEEL PLATES

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In many instances, the earthquake damage to RC buildings is more profound at the beam–column joints (Torabi & Maheri, 2017). It has also been noted that because of discontinuity of structural geometry and substandard confinement conditions, external beam–column joints are more susceptible to seismic loading than internal beam–column joints. These joints have a significant role in the lateral stability of the structure, since a brittle failure of the joint may result in progressive collapse of the building. As a result, retrofitting RC beam-column joints has received notable attention and several techniques have been proposed. Some of these methods include: steel jacketing, shotcrete jacketing, cast-in-place concrete/RC jacketing, using Fiber Reinforced Polymer (FRP) overlays or bars and using steel stiffeners (Torabi & Maheri, 2017).

Strengthening RC joints by steel plates goes back to the works carried out by Maheri and his colleagues (Maheri & Sahebi, 1997; Maheri & Ghaffarzadeh, 2008; Maheri & Yazdani, 2016) to retrofit RC frames by internal steel bracing system. In their works, they used steel plate connectors and gusset plates for connecting steel bracing to RC joints. Experimental and numerical works conducted by them showed that the steel retrofitting of the RC joint increased the strength of the joint by relocating the plastic hinge region into the beam or in-effect by shortening the effective length of the beam. Other studies concentrated on repairing damaged beam-column joints by attaching steel plates to beams and columns at the joint location.

Although in recent years many great works have been conducted on retrofitting of RC beam-column joints. In these studies, the retrofitting scheme was mainly suitable for 2D planar frames without due consideration for the presence of cross beams and the slab. In the proposed paper, a practical repair and strengthening scheme for damaged 3D RC beam-column joints utilizing stiffened steel plates is proposed and tested. The objective of the proposed scheme is to enhance damaged joint seismic performance by means of enlarging the joint area and relocating the plastic hinge away from the damaged region. The repair and retrofitting scheme is a unique stiffened steel jacketing technique. In this scheme, the joint is strengthened by installing stiffened steel plates at the corners of the beam–column joint, both above and below the beam. The stiffened plates are attached to each other (in internal joints) and to a supporting steel plate at the back of the column (in external joints) by means of high tensile strength steel bars passing adjacent to RC member faces (see Figure 1). This retrofitting scheme is relatively simple to implement and unlike many other proposed retrofitting techniques does not need cutting through the slab except for some small holes to pass the connecting bars through. It should be noted that, similar to any other joint retrofitting scheme which is based on joint enlargement, the column and beams of the retrofitted joint will experience higher levels of shear forces due to the increased stiffness as a result of member length shortening. Therefore, necessary provisions should be implemented to avoid member shear failure.

A full-scale external beam-column joint is designed and constructed as an ordinary moment resisting frame based on ACI 318M-11 provisions. The structure is then subjected to progressive quasi-static cyclic loading to failure. The damaged joint is then repaired to its former configuration using pressurized epoxy resin and retrofitted by stiffened steel plates. The repaired and retrofitted joint is then subjected to the same cyclic loading protocol to failure (Figure 2). Seismic performance parameters such as strength, stiffness, ductility and energy dissipation capacity of the original joint and the repaired and retrofitted joint are then extracted from their capacity backbone curves and compared. Results show that the proposed repair and retrofit technique not only regenerated the original capacity but also increased capacity and improved the joint performance by relocating the plastic hinge beyond the repaired region.

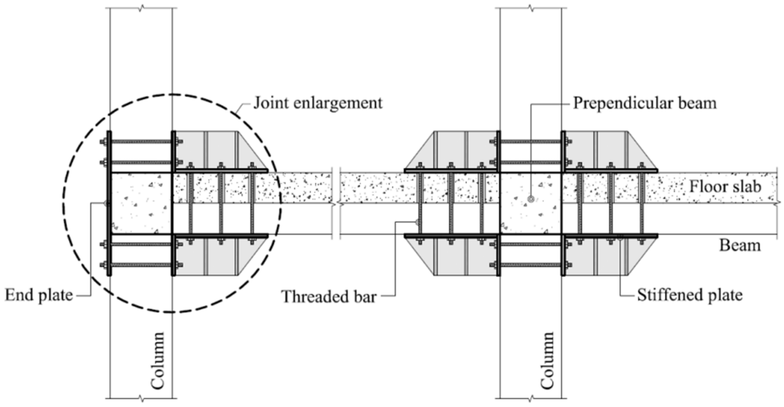
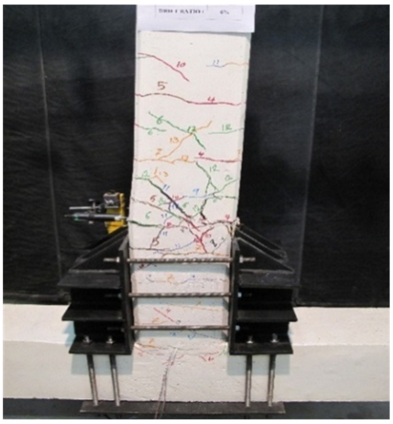


Figure 1. Stiffened steel plates retrofit scheme for RC beam-column joints.



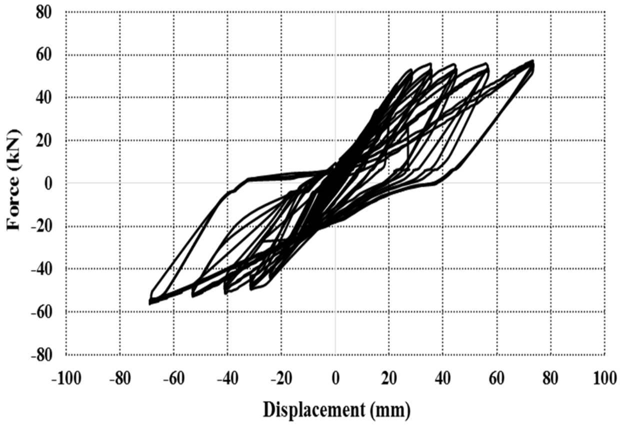


Figure 2. Cyclic loading test on RC joint retrofitted with stiffened steel plates.

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