ABSTRACT

Many reinforced concrete (RC) frame structures with non-seismically designed (NSD) beam-column joints, typical of pre-1970s construction, are still in service. These structures may possess weak beam-column connections due to the absence of transverse reinforcement in the joint core. Such deficiencies make these joints highly vulnerable to shear failure, which can ultimately lead to catastrophic structural collapse. Hence, retrofitting these joints is critically important.

To date, much of the research, both experimental and numerical, has focused on exterior beam-column joints. However, accurate assessment of the global behavior of NSD structures require a thorough understanding of all joint configurations in a structure. Interior joints pose additional challenge, particularly related to bond performance, due to the push-pull effect on longitudinal beam bars running through the joint core.

This work presents a numerical parametric investigation of non-seismically designed 2D and 3D interior beam-column joints using the finite element (FE) method. FE investigations are used to evaluate the behavior and effectiveness of the Fully Fastened Haunch Retrofit Solution (FFHRS) in interior joint configurations. In this technique, diagonal steel haunches are connected to columns and beam with post-installed anchors. The objective of FFHRS is to relocate the plastic hinge away from the joint to the beams through a redirection of forces.

The FE model philosophy is validated against experimental results on as-built and retrofitted interior beam-column joint subassemblies in the literature. Subsequently, a parametric study was carried out on three as-built models with different geometric joint configurations and their respective retrofitted versions. Finite element analysis revealed the beneficial role of transverse beams and slabs framing into the joint region, both in as-built and retrofitted models, in enhancing strength, stiffness, and energy dissipation capacity. However, improvements in ductility were not observed in models with slab.

The analysis confirmed the effectiveness of the FFHRS in improving joint performance by shifting the plastic hinge away from the joint core and into the adjacent beam, thereby promoting a more desirable beam flexural failure mode. The failure mechanisms of the retrofitted structures were critically examined, and finally supplementary measures to enhance the shear capacity of the column section for the model with slab are provided to guide the application of FFHRS in non-seismically designed interior beam-column joints.