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Seismic Retrofit of Existing Substandard Reinforced Concrete Beam-Column Joints with Hybrid NSM Steel Bars and EB GFRP Wrap Technique

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Extended Abstract

Earthquakes are one of the most costly and deadly natural hazards that societies face. Historically, countless earthquakes have been responsible for the death and injury of thousands of people and the collapse of numerous buildings around the world [1]. Whereas events like the 2011 Christchurch and Tohoku earthquakes have shown that modern seismic design does offer good protection from these events there are many existing reinforced concrete (RC) buildings (in both developed and developing countries) that have not been built to the latest code. In fact, in developing countries, a considerable proportion of the building inventory has major structural deficiencies such as poor quality of concrete, insufficient flexural strength, and improper reinforcement detailing that these structures are still susceptible to failures during earthquakes [2], [3], and [4].

Post-earthquake surveys show that most of the catastrophic failures leading to building collapse and the deaths of occupants occur due to insufficient capacity of the beam-column connections [5] and [6]. Therefore, in such buildings constructed to conform to old building codes, beam-column connections generally do not have sufficient transverse steel reinforcement in the junction area, beam reinforcement has inadequate anchorage, and/or the strong column-weak beam criterion has not been implemented. In these cases, these joints are vulnerable to brittle failure during an earthquake due to the earthquake producing large shear stresses in the column-beam junction [7]. These are prone to fracture during seismic action and may lead to major structural issues and collapse [8].

The seismic behaviour of full-scale exterior reinforced concrete (RC) beam-column joints retrofitted with Externally Bonded (EB) Glass Fiber Polymers (GFRP) and Near-Surface Mounted (NSM)-steel are examined in this project. Casting and testing of four similar reinforced concrete beam-column joints in the absence of transverse reinforcement at the joints took place under reverse cyclic loading with regulated displacement to examine their fundamental seismic performance. All test specimens were designed by following TS 1998 [9]. The first joint was examined as the control specimen and the second specimen was strengthened with u-shaped steel bars using the NSM method, and the third specimen was retrofitted with GFRP sheets, and then the fourth specimen which is called the hybrid method was strengthened using both methods.

It is demonstrated in the experimental findings that the retrofitted beam-column joint shows significantly greater strength, loading capacity, and ductility in comparison to the control specimen. According to the experimental results, the specimen strengthened with the NSM method provided a 12.86% capacity increase for maximum push and a 15.33% capacity increase for maximum pull. The specimen retrofitted with the EB method achieved a 26.41% capacity increase for maximum push and a 21.82% capacity increase for maximum pull. The hybrid-enhanced specimen achieved a 20.07% increase in capacity for maximum push and a 36.99% increase in capacity for maximum pull compared to the control sample. There was a shift in the failure from the joint region to the beam ends in the retrofitted specimens, especially for EB and Hybrid methods, which would help prevent the structure from disintegrating progressively.

Keywords: seismic design, beam-column joint, GFRP sheets, NSM, cyclic loading, reinforced concrete

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