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Enhancing Seismic Resilience in Colombia's Informal Housing: A Low-cost Retrofit Strategy with Buckling-restrained Braces to Protect Vulnerable Communities in Earthquake-prone Regions

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Abstract : Colombia faces a critical challenge in seismic resilience due to the prevalence of informal housing, which constitutes approximately 70% of residential structures. More than 10 million Colombians (20% of the population), live in homes susceptible to collapse in the event of an earthquake. This, combined with the fact that 83% of the population is in intermediate and high seismic hazard areas, has brought serious consequences to the country. These consequences became evident during the 1999 Armenia earthquake, which affected nearly 100,000 properties and represented economic losses equivalent to 1.88% of that year's Gross Domestic Product (GDP). Despite previous efforts to reinforce informal housing through methods like externally reinforced masonry walls, alternatives related to seismic protection systems (SPDs), such as Buckling-Restrained Braces (BRB), have not yet been explored in the country. BRBs are reinforcement elements capable of withstanding both compression and tension, making them effective in enhancing the lateral stiffness of structures. In this study, the use of low-cost and easily installable BRBs for the retrofit of informal housing in Colombia was evaluated, considering the economic limitations of the communities. For this purpose, a case study was selected involving an informally constructed dwelling in the country, from which field information on its structural characteristics and construction materials was collected. Based on the gathered information, nonlinear models with and without BRBs were created, and their seismic performance was analyzed and compared through incremental static (pushover) and nonlinear dynamic analyses. In the first analysis, the capacity curve was identified, showcasing the sequence of failure events occurring from initial yielding to structural collapse. In the second case, the model underwent nonlinear dynamic analyses using a set of seismic records consistent with the country's seismic hazard. Based on the results, fragility curves were calculated to evaluate the probability of failure of the informal housings before and after the intervention with BRBs, providing essential information about their effectiveness in reducing seismic vulnerability. The results indicate that low-cost BRBs can significantly increase the capacity of informal housing to withstand earthquakes. The dynamic analysis revealed that retrofit structures experienced lower displacements and deformations, enhancing the safety of residents and the seismic performance of informally constructed houses. In other words, the use of low-cost BRBs in the retrofit of informal housing in Colombia is a promising strategy for improving structural safety in seismic-prone areas. This study emphasizes the importance of seeking affordable and practical solutions to address seismic risk in vulnerable communities in earthquake-prone regions in Colombia and serves as a model for addressing similar challenges of informal housing worldwide.

Keywords : buckling-restrained braces, fragility curves, informal housing, incremental dynamic analysis, seismic retrofit
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