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Application of seismic fragility functions for a post-earthquake bridge inspection protocol in Costa Rica

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Costa Rica is located at the southern end of the subduction zone between the Cocos and Caribbean plates (subducting rate of ∼83 mm-yr). The majority of earthquakes in Costa Rica are associated with the subduction process, the Panama Fracture Zone (PFZ), the North Panama Deformed Belt (NPDB) and crustal faults located in the interior of the country. The latter are historically the ones responsible for destructive events e.g. Limón 1991 (7.7 Mw) and Cinchona 2009 (6.2 Mw). The impact of earthquakes led to the establishment of building seismic codes (from 1974) and the bridge seismic design guidelines (2013). Before 2013, bridges were design largely following the AASTHO normative.

The national road network of Costa Rica has a total of 1395 bridges; more than 50% were designed before AASTHO 1977 which meant that several structures could present significant seismic weaknesses. Vulnerability of bridge structures was evident after the Limón earthquake with devastating impact manifested in the collapse and severe damage of several bridges. The effect was major since the roads affected are the main access to the country's most important port on the Caribbean and the northern border with Panama. Recently, the Samara 2012 (7.6 Mw) earthquake damaged 54 bridges, including the total collapse of two structures; one located about 200 km away from the epicenter.

Post-earthquake bridge inspection and safety assurance is one of the first activities to be done after major earthquakes. The actual procedure consists of managing reports of community emergency committees, general public and the public road administrator. There is no formal inspection plan, and assessment of bridges by qualified inspectors is not common; most efforts are usually focused on collapsed structures. In addition, reports are difficult to be verified and damage condition to be understood in order to take proper actions. Due to these issues, a new protocol proposal for bridge inspection is currently being developed at LANAMME-UCR. This protocol includes importance classification, seismic fragility functions, and real-time seismic intensity (data by LIS-INII) to prioritize post-earthquake bridge inspections.

Nowadays, the LIS-INII accelerograph network covers the national territory with more than 100 strong-motion stations. Thanks to this, adequate estimations of acceleration motions can be interpolated at each bridge site. With use of spectral accelerations, the most probable condition for each bridge can be computed and reported to the local and national authorities as a startup for emergency inspections. By this, the effectiveness of inspection can be improved by the examination first of vulnerable and strategic important bridges which leads to faster assessment of relevant damage and to enhance emergency response.

This protocol project involves several tasks including the generation of a geo-referenced national scaled inventory, classification of bridges into one of the twelve predefine fragility groups, evaluation of the method results for the Samara earthquake, implementation of expected bridge damage calculation into the LIS-INII earthquake triggered activities, development of App-tools for fast inspections and data gathering (include three bridge safety inspection levels) and finally the training of local and national emergency authorities and inspection teams.