



Numerical evaluation of the seismic behavior of façades of Mexican colonial churches



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ABSTRACT

The seismic assessment of façades of churches built during the colonial era in Mexico is presented. This study takes into account two typologies of churches of the center of Mexico, which are far away of the epicenters of the subduction zone, but they both are subjected to frequent earthquakes. The first one corresponds to churches built near to local faults. The second typology corresponds to churches built far away of the local faults. The façades of the first typology are low-rise and have thick walls and some buttresses. The façades of the second typology are taller and slender. Both typologies have only one bell tower attached to the façade. The seismic behavior was studied by means of non-linear dynamic analyses, by using several real earthquake records. These seismic records were registered by stations located near and far of the epicenter zone. According to the numerical results, the façades of the churches built near the local faults can support high accelerations with moderate damage. While the façades of the churches built far away from the local faults present considerable damage for medium accelerations. For both typologies, the belfries are the most vulnerable elements. Besides, the main damage mechanism is a vertical crack on the joint of the tower and the wall of the façade; since the body of the tower tends to separate of the façade wall.

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1. Introduction

The earthquakes have been one of the main causes of destruction of the architectural heritage buildings, especially those which are placed in the regions of high seismic risk. The careful seismic assessment of the architectural heritage affected by severe earthquakes is one of the most effective ways to understand the structural weaknesses of those constructions. It is also necessary for assess the interventions made in the past, in order to establish which have had successful behavior and must continue to be used and which not.

Thousands of churches were built in Mexico from 16th to 18th century, and persist to date in rather good conditions. They vary in size and architectural sophistication, but follow some basic typologies. The simplest among them are rather small parochial churches which are found in every town and village of Mexico. One important factor that has influenced the evolution of their architectural features has been the experience of ancient builders about the damages suffered from earthquake activity [1]. Generally in the Pacific coast, where the recurrent destruction of the first constructions caused an evolution of the churches towards edifications of not much height, with big buttresses and not much outer ornamentation. In other regions where the seismic activity is smaller, the churches remained higher and slender (Fig. 1).

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Fig. 1. Typical colonial churches built in: a) low seismic risk zone (central Mexico), b) high seismic risk zone (Pacific coast).

The seismic activity of Mexico can be divided in four big zones: A, B, C and D (Fig. 2; [2]). These zones are delimited with base in the frequency of occurrence of the earthquakes in the different regions and the expected maximum ground acceleration in a century. The zone A is a zone where earthquakes have not been reported in the last 80 years and ground accelerations bigger than 10% of the gravity acceleration is not expected. The zone D identifies the places where earthquake occurrence is very frequent and the ground accelerations can be higher than 70% of the gravity acceleration. It is here where the historical big earthquakes were registered. The B and C zones are intermediate regions where earthquakes are not registered frequently and the ground accelerations recorded are not greater than the 70% of the gravity.

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