Assessment of Risk to School Buildings Resulting from Distant Earthquakes

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INTRODUCTION

The effects of far distant earthquakes felt in regions with low and moderate seismicity have increased markedly over the last decade due to active faults that are even more than 300km away. These incidents have caused thousands of people in several cities in low and moderate seismicity regions to flee their houses and even hospitals because the majority of them felt insecure. In order to prepare for such natural disasters, fragility curves are used to predict the risk to the structures after an earthquake event. The fragility curves characterize the probability of reaching a damaged state at various levels of ground motion as in Eq. 1 (Singhal and Kiremidjian 1996). Henceforth, reliability decisions can be made from the curves immediately after an earthquake to indicate whether structures are safe to enter or not.

Please refer to the full text

where P_{ik} is probability of reaching a damage state d_i given that ground motion is y_k; D is a damage measure; and Y is ground motion. In this study, analyses of two and four storey RC school buildings on a particular soil condition were performed in DIANA by response spectrum analyses to estimate the response of structures subjected to earthquake excitations. The structural response of a multi-degree of freedom system is described as

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where is the ground acceleration, {V} is the displacement vector of the floor mass with respect to the base, {1} represents a unit vector and [M], [C] and [K] are the mass, dampers and stiffness matrices respectively. It is assumed that the ground motions are only applied in the direction of the most critical structural response, along the surface of the structures.

2. DAMAGE LIMIT STATES

Due to the wide range of structural capacity of different RC frames, (Reston and Virginia 2000) defined a common structural capacity for RC frames that is expressed in terms of three damage states, corresponding to immediate occupancy, life safety and collapse prevention.

The damage state of immediate occupancy is defined as retaining the pre-earthquake design strength and stiffness of the structure. Although the structures are generally safe to occupy, some minor cracks may appear. The life safety damage state includes damage to structural components, but with some margin against either partial or total structural collapse. Structures meeting the collapse prevention damage state are expected to have undergone significantly more damage, including significant degradation in the stiffness and strength of the lateral-force-resisting system and large permanent lateral deformation of the structure. Even though the structures continue to support their own member loads, nevertheless the structures are not safe to reoccupy because the structures may collapse due to aftershock.

The level of damage is quantified in terms of the inter-storey drift ratio. The drift limits for the three damage states are estimated corresponding to a comprehensive review of past studies on seismic structural performance as well as a number of experts' perceptions. It is certainly true that the drift limits are provided to illustrate the overall structural response associated with various structural performance levels, but the use of drift limits in fragility curve derivation has been presented by (Hueste and Bai 2007). The drift limits for the damage states defined in (Reston and Virginia 2000) are tabulated in Table 1. The fragility curves in this study were then developed accordingly.

3. GROUND MOTIONS

In order to represent the seismic characteristics in regions with low and moderate seismicity, the actual ground motions recorded from historical earthquake events covering an area from 85ºE to 150ºE longitude and 15ºS to 30ºN latitude for earthquakes of magnitude 5 and greater from the end of December 2004 to May 2008 were used for this study. However, 40 sec. was a considerable duration of an earthquake being felt as observed in the region. Such a duration was also applied by (Kircil and Polat 2006) to generate artificial ground motions that have a probability of over 10% within a 50 year period. The ground motions were integrated into 150 acceleration response spectrums and were scaled up to a PGA of 0.2g with an interval of 0.025g and were used directly without modification for bias effect (Song and Ellingwood 1999). The purpose of such an approach is due to the limited number of strong ground motion records. Fig. 1 shows an accelerogram ground motion record. The properties of the ground motions are tabulated in Table 2.

In terms of a probability of over 10% within a 50 year period, (Petersen et al. 2004) predicted that the ground motion is likely to reach 0.15g compared to 0.2g by (Adnan et al. 2005). However, (Petersen et al. 2007) revised the ground motion and expected it to reach 0.06g over the period. Accordingly, the earthquake catalogue covered an area from 90ºE to 120ºE longitude and 10ºS to 10ºN latitude and was compiled for earthquakes of magnitude 5 and greater from the beginning of 1988 to February 2008. The peak ground motions were predicted from the Sumatran fault and the slip rates along the fault varied from

50 to 60mm/year with the slip rate accelerating to the north. A ground motion of 0.06g was used in this study to identify the probability of damage states occurring over the return period.

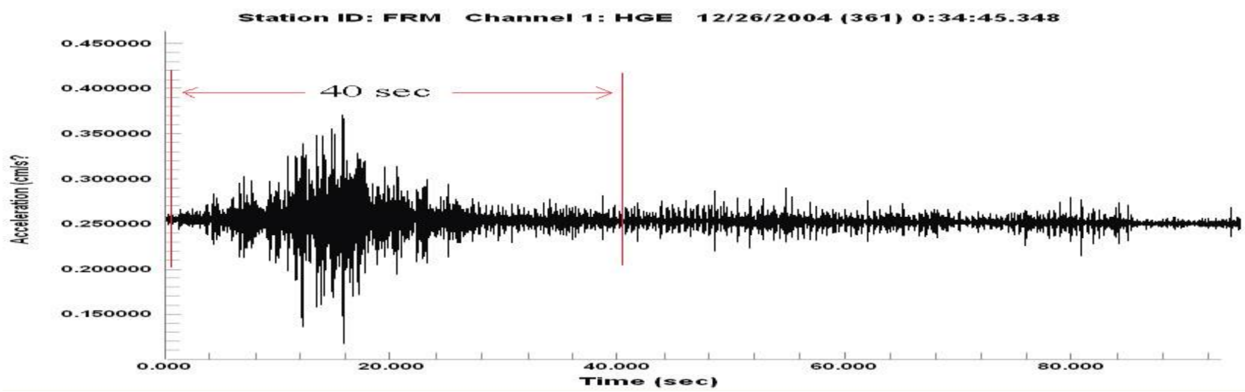

Figure 1: An accelerogram ground motion record

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