Characterization of Earthquake induced road damages in and around Indian subcontinent

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EXTENDED ABSTRACT

Almost every country across the world have suffered severe economic and social setbacks due to earthquakes. Roads play an important role not only as a mere path to transport but also as a means to reach and rescue the distressed people during emergencies like natural disasters. Numerous studies have been conducted regarding the damage assessment, damage quantification, vulnerability, and risk analysis of structures. But very limited studies are carried out in damage assessment and risk analysis of road or transport networks. Road system is a valuable asset of a city, and road network plays a vital role in emergency operations i.e., to evacuate dead and injured people. If an evacuation plan is well organized, the number of dead and distressed people can be significantly reduced. Hence, earthquake-induced road damage assessment and post-earthquake damage control studies are important for an effective disaster management plan. Anbazhagan et al., (2012) first proposed the classification system on road damages based on its characteristics such as depth, width of the crack and the extent of remediation needed to restore the road known as Road Damage Scale (RDS) with a minimum RDS of 1 representing minor cracks lesser than 20mm width to RDS of 5 representing complete damage of road.

There are large number of roads that have been damaged due to earthquakes; however, the information regarding the road damage (description and photo) due to earthquake is very limited. In the present work, 14 roads in India and its adjoining regions which had undergone various kinds of damages during different earthquakes including 2001 Bhuj as well as 2015 Nepal earthquake are considered. Collected data are corresponding to 6.9 to 8.7 magnitude earthquakes with hypocentral distance varying from 10km to 197km.

2001 Bhuj earthquake of magnitude 7.6 which took place at a focal depth of 25km shook the western part of India followed by large scale liquefaction in the epicentral region. It is this earthquake after which the work on liquefaction actually started in India. Building damages during this earthquake have been intensively discussed in the literature. Similar to above damages, road damages were also considerable during this earthquake. Fig 1 presents the kind of road damages in Bhuj area located about 20km northwest of the epicenter showing 15 to 20cm wide cracks during the earthquake. Although the width of crack is more than 100mm, but a RDS of 2 is assigned to this damage since the road condition can be restored with minor treatment. Further, road damage during 2001 Bhuj earthquake at Chopadva located around 200km from the epicenter is shown in Fig 2 showing an uplift of 80cm. This location is assigned RDS of 3 in accordance with Anbazhagan et al., (2012).

Fig 1. Road damage in Bhuj during 2001 Bhuj earthquake

During the year 2011, Sikkim was shaken by another earthquake having magnitude of 6.8 reported at a focal depth of 20km as per USGS. Intensive shaking during this earthquake triggered a large number of landslides and caused significant damage to infrastructure. As per the available data, 2011 Sikkim earthquake triggered 354 new landslides in addition to reactivation of 48 old landslides. As a result of falling of rubbles and their impact, roads were also undergone severe damages. One such damage was observed on Lachung located just 68km from the epicenter. As per Sharma et al., (2012) cracks having width of over 20cm were observed in Lachung as shown in Fig 3(a). For the present analysis, RDS of 2 was assigned to this damage. In addition, Fig 3(b) presents a collapsed portion of NH 55 between Siliguri and Darjeeling during 2011 Sikkim earthquake. This damage is assigned RDS 5 for the present analysis indicating worst kind of damage.

Fig. 2. Road damage at Chopadva during 2001 Bhuj earthquake

Fig. 3. (a) Ground rupture in Lachung as per Sharma et al., (2012); (b) collapsed portion of NH 55 between Siliguri and Darjeeling as per EERI (2012)

Fig. 4. Road cracks in Bhaktapur during 2015 Nepal earthquake as per Young (2015)

Central Himalayas have been showing a deadly seismic activity since prehistoric times. These include earthquakes in the year 1100, 1255, 1344, 1408, 1505, 1681, 1810, 1833, 1934 and the recent 25th April 2015 Nepal EQ. For prehistoric earthquakes almost no information about road damages are available. However, enough evidences are available which supports considerable road damage during 2015 Nepal earthquake. Bhaktapur, which is located in central Nepal about 100km from the epicenter experienced a modified Mercalli intensity (MMI) of VII as per USGS indicating moderate level of ground shaking. Similar kind of road damage was also observed at Bhaktapur as per Young (2015) shown in Fig 4. For the present analysis, RDS of 3 has been assigned to the road damage shown in Fig 4.

In addition to above discussed road damages, supplementary data is considered in this work which is not presents here due to limitation in the page length. Other earthquake and site characteristics such as magnitude (M) as well as hypocentral distance (HD) for each of the 14 road damages are collected and regression analysis is performed in this work. Based on step by step regression, it is found that entire data cannot be analysis in single stretch but to be divided into subdivision. Since lesser data are available for RDS greater than 3 and for HD greater than 100km, while proposing the final correlation such data are avoided and can be considered in future when large number of data are available in the above range. Similarly, for HD lesser than 50km, very less RDS data are available and thus are avoided while proposing final correlation. Fig 5 presents the final correlation between RDS, M and HD. Functional form of (M+HD) used in the present regression analysis are taken with reference to Anbazhagan et al., (2012). It can be observed from Fig 5 that the plot follows a clearly defined trend. Hazard analysis can help in determining maximum potential earthquake magnitude for each of the casaultive fault during future. Using proposed correlation, RDS or tentative level of road damage can be accessed in advance from the proposed correlation. This will help in planning and maintaining important roads in a location. With more data, the proposed correlation can be revised so that it can be applied to a larger range of HD as well as M in the future.

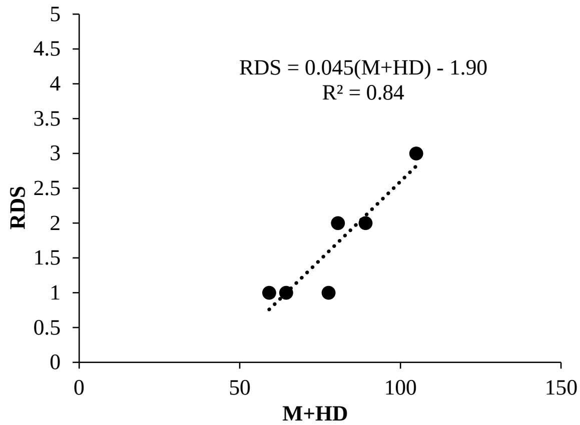

Fig. 5. Proposed functional form between RDS and M+HD

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