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SEISMIC HAZARD VULNERABILITY MAP OF GANDHINAGAR REGION

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Abstract: The Gujarat region is one of the most seismic prone intra-continental regions of the world. All the four seismic zones V, IV, III and II defined in seismic zoning map of India falls in the Gujarat state and adjoining region (IS 1893:2002). This region has witnessed many destructive earthquakes in the past and in recent times. Gandhinagar city lies in zone 3 as represented on the Seismic Zoning Map of India (IS 1893:2002). In 2001 Bhuj Earthquake, a lot of damage occurred in nearby areas of Gandhinagar zone. The enhanced seismicity in the region warrants assessment of seismic hazard to aid engineers in urban development. Due to expansion and increase in the number of multi-storey buildings & important engineering structures, population is increasing day by day in the proposed cities of Gujarat state. A major earthquake close to any such major cities can actually cause not only a large number of causalities but also an economic collapse. Our results will be validated with the help of available bore-hole, geological and civil engineering data. So by developing seismic hazard vulnerability map of Gandhinagar city we can help minimize damage in structures of this area.

Keywords: Seismic Hazard, Region, Gandhinagar

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INTRODUCTION

An earthquake, in a way, does a good job of exposing most of the flaws in the previous design and construction practices in a particular region. It can also sometimes, help in recognizing the good features of the design and construction practices by studying the performance of an actual structure during the earthquake. In-depth pre-earthquake damage studies provides information on how an existing structure might perform in the case of an actual earthquake. It sometimes exposes the flaws in the design of the structure. Post-earthquake damage analysis helps in identifying vulnerable areas of the region based on the type and scale of damage that has been done due to the earthquake. These studies help in refining the building byelaws and codes of construction.

The January 26, 2001 Bhuj earthquake in the Kachchh district of Gujarat, India caused over 13,000 deaths and resulted in widespread destruction of housing stock throughout the epicentral region and the state. Over 1 million houses were either destroyed or required significant repair. Comprehensive, unprecedented and well-funded reconstruction and retrofitting programs soon followed. Earthquake-resistant features were required in the superstructure of new, permanent housing by the government and funding agencies.[1]

This paper sheds light on why we require to predict the damage that can happen prior to an earthquake after studying some past earthquakes in India and how can we efficiently predict future damage with the help of Rapid Visualization Survey (RVS).

II. EARTHQUAKES IN INDIA

Since the 1800s, six mega earthquakes of magnitude 8+ had occurred in India. They were the 1819 Kutch earthquake, 1897 Shillong earthquake, 1905 Kangra earthquake, 1934 Bihar-Nepal earthquake, 1941 Andaman earthquake and the 1950 Assam earthquake. Out of these, three earthquakes have occurred in Himalayanregionand it is considered prone to great earthquakes of magnitude 8 or more. The earthquakes which caused significant damage were Anjar(1956), Kapkote(1958), Badgam(1962), Koyna (1967), Baroach(1970), Kinnaur (1975), Pithoragarh(1980), Silchar (1984), Dharamshala(1986), Shillong(1986), N.E. India (Indo-Burma Border (1987), Indo-Bangladesh boundary (1988), N.E. India (1988), Bihar-Nepal(1988), Uttarkashi (1991), Latur (1993), Jabalpur(1998), Chamauli (1999), Bhuj(2001), Kashmir (2005), Sumatra & Andaman(2004); Sikkim(2006) and Sikkim Earthquake of September 18, 2011. Damage survey of the above damaging earthquakes has been reported in GSI Memoir and DEQ Reports wherein important lesson learnt have been reported. A very few R.C. buildings have been exposed to major earthquakes and none of the major cities have been subjected to major earthquakes in India. As a result, major cities of India are vulnerable to damage due to earthquakes. Hence there is a need for better understanding of the behaviour of buildings during earthquakes. The indirect damages to buildings during earthquakes are sometimes far greater than the damages due to earthquake itself, such as, outbreak of fire, landslide, avalanche and tsunamis. However, these damages are not due to inadequacies in the design and planning and therefore, not discussed here. But since the damage done during earthquakes is far too much to neglect, there arises a need to predict this damage, to the maximum extent possible, in order to help minimize it. [2]

III. NEED FOR PREDICTING EARTHQUAKE DAMAGE

Scientists and Researchers are working on devicing new ways in order to accurately predict future earthquakes. Earthquake data from the past is generally used to predict future earthquakes. Sometimes they succeed but mostly they have failed in doing the same up to the level of accuracy required in the same as it involves various risks. But even if we succeed in determining the exact time, location and magnitude of the earthquake there is very little we can do reduce the devastation. Lives of people can be saved but what about the lives of the Structures? What about the Money & Time invested in building them? So there is a need along with predicting the earthquake its effects i.e. the damage it can cause to the structures in any defined area. If we can get to know the vulnerability of the existing structures in an area through a quick survey of each structure prior to occurrence of any earthquake in the defined area, we can repair them or improve them based on the data obtained from the survey in a manner such that they will at least withstand a certain magnitude of earthquake if it arrives in the future. This needs to be done in order to not only save lives of the people but also the structures they live in, their time and money as well as minimizing their losses.

IV. RVS

The RVS uses a methodology based on a “sidewalk survey” of a building and a Data Collection Form, which the person conducting the survey completes, based on visual observation of the building from the exterior, and if possible, the interior. The Data Collection Form includes space for documenting building identification information, including its use and size, a photograph of the building, sketches, and documentation of pertinent data related to seismic performance, including the development of a numeric seismic hazard score. [3]

V. HISTORY OF RVS

During the decade following publication of the first edition of the FEMA 154 Handbook, the rapid visual screening procedure was used by private sector organizations and government agencies to evaluate more than 70,000 buildings nationwide (ATC, 2002). As reported at the FEMA 154 Users Workshop in San Francisco in September 2000 these applications included surveys of (1) commercial buildings in Beverly Hills, California, (2) National Park Service facilities, (3) public buildings and designated shelters in southern Illinois; (4) U. S. Army facilities, (5) facilities of the U. S. Department of the Interior and (6) buildings in other local communities and for other government agencies. The results from some of these efforts are described below. In its screening of 11,500 buildings using the FEMA 154 RVS procedure, the U. S. Army Corps of Engineers Civil Engineering Research Laboratory (CERL) used a cut-off score of 2.5, rather than 2.0 (S. Sweeney, oral communication, September 2000), with the specific intent of using a more conservative approach. As a result of the FEMA 154 screening, approximately 5,000 buildings had final S scores less than 2.5. These buildings, along with a subset of buildings that had FEMA 154 scores higher than 2.5, but were of concern for other reasons, were further evaluated in detail using the FEMA 178 NEHRP Handbook for the Seismic Evaluation of Existing Buildings [BSSC, 1992]). Results from the subsequent FEMA 178 evaluations indicated that some buildings that failed the FEMA 154 RVS procedure (that is, had scores less than 2.5) did not fail the FEMA 178 evaluations and that some that passed the FEMA 154 RVS procedure (with scores higher than 2.5) did not pass the FEMA 178 evaluation (that is, were found to have inadequate concern identified at the beginning of this chapter that the use of FEMA 154 may not identify potentially earthquake hazardous buildings as such, and that buildings identified as potentially hazardous may prove to be adequate seismic resistance). This finding emphasizes the concern that the use of FEMA 154 may not identify potentially earthquake hazardous buildings as such, and that buildings identified as potentially hazardous may prove to be adequate.[3]

VI. USES & APPLICATIONS/ IMPORTANCE OF RVS

In addition to identifying potentially seismically hazardous buildings needing further evaluation, results from RVS surveys can also be used for other purposes, including: (1) designing seismic hazard mitigation programs for a community (or agency); (2) ranking a community's (or agency's) seismic rehabilitation needs; (3) developing inventories of buildings for use in regional earthquake damage and loss impact assessments; (4) developing inventories of buildings for use in planning post-earthquake building safety evaluation efforts; and (5) developing building-specific seismic vulnerability information for purposes such as insurance rating,decision making during building ownership transfers, and possible triggering of remodeling requirements during the permitting process.[3]

VII. CASE STUDY: CONSTRUCTION PRACTICES PRIOR TO 2001BHUJ EARTHQUAKE& IMPROVEMENTS DONE

Following observations were made during the field visits and discussions with engineers from government and private sectors:

1. Post-earthquake construction practices have been improved significantly. Such practices are listed below:

i. Post earthquake constructions have no floating columns. This practice was abandoned after seeing the poor performance of such columns. Practice of staggered level footings and long columns also has been abandoned after earthquake.

ii. Bands are now common in load bearing masonry buildings. Pre-earthquake construction used to have plinth band to avoid damping, but now lintel and roof bands are also used.

iii. Many large projects are using ready mixed concrete (RMC).

iv. Now a days minimum concrete grade is M20 for columns.

v. Raft footing and plinth beam are more popular after earthquake.

vi. Basement shear walls are usually 230 mm thick.

vii. Water tank on staircase column was a common practice prior to earthquake, which caused serious damage in many buildings during 2001 earthquake. This practice is still not totally abandoned. But now such columns are designed appropriately and usually their dimension and reinforcement is kept same throughout the height.

viii. Ductile detailing (full or partial) is more common in concrete construction.

2. Ahmedabad Municipal Corporation (AMC) and Ahmedabad Urban Development Authority (AUDA) are the authorities to give construction permission. There have been significant changes in their working after Bhuj earthquake.

i. After 2001 Bhuj earthquake building by-laws were changed in entire Gujarat. Current construction practices are much better in entire state.

ii. AMC/AUDA demands for soil testing report before approval of construction. Soil testing is necessary for any plot size more than 500 m2 or low rise/high rise buildings.

iii. AMC/AUDA do not check structural design calculations from design engineers. They demand a safety certificate and a set of drawing, showing all beam/column/foundation steel/concrete details. Format of stability certificate has been significantly improved after earthquake.

iv. Design engineer and AMC engineers perform on site check minimum three times: foundation/plinth level concreting, first floor concreting and top floor concreting. In high rise buildings, an intermediate story inspection is also performed.

v. For the existing buildings if there is a structural complaint from residents and/or neighbors, AMC ward engineer inspects the buildings.

3. Many areas in and around Ahmedabad have filled up soil. So foundation needs to be designed properly and placed at greater depths.

4. Curing practice is not up to the mark and needs to be addressed.

5. In the recent times fly ash bricks and concrete blocks are also being used, but mostly they are for partition and not for load bearing construction.

6. Most of the individual houses are load bearing masonry with RCC slab. Most of post earthquake constructions have beams below RCC slab.

7. Recycled steel is rarely used now. TMT bars and Fe415 grade are very common nowadays.

8. After the earthquake all the government buildings were surveyed and retrofitted if required.

9. According to design engineers from PWD, all the government buildings have been following codes since before the earthquake.

10. In the informal talk government engineers revealed that private design practitioners' attitude is again becoming lax towards seismic design. Lack of third party check is also a reason for this degradation.

11. Practice of providing different concrete grade for column and beam/slab has been observed.

12. Concrete is produced by volume batch mixing, not by mix design. But mixing is done with mixers. Hand mixing is rarely seen.

13. Concrete mix design is done for high rise buildings, where concrete grade of more than M25 is required. Usually M20 is used up to 5 story building. [4]

VIII. CONCLUDING REMARKS

Because due to expansion and planning of multi story buildings, Information Technology hubs, new structures, industries, new shopping malls etc, the population is increasing day by day around the Ahmedabad city. Therefore this study will be very important to evolve a plan for disaster mitigation.

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