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SEISMIC VULNERABILITY ASSESSMENT OF BUILDINGS IN HYDERABAD CITY

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ABSTRACT

India has a range of the world's greatest earthquakes in the last century. Assuredly, quite one-half space within the country is considered at risk of damaging earthquakes. The northeastern region of the country as well as the entire Himalayan belt is liable to great earthquakes of magnitude over 8.0. the objective of this study is to determine the seismic vulnerability of R.C.C. structures of the Hyderabad City by R.V.S (Rapid Visual Screening) technique and also the Turkish method. Investigations of past and recent earthquake damage have depicted that the building structures are at risk of severe damage and/or collapse during moderate to sturdy ground motion. an earthquake with a moderate magnitude is capable of inflicting severe damage of designed buildings, bridges, industrial and port facilities additionally as giving rise to huge economic losses.

The areas covered under the survey are Adarsh Nagar residential area, jubilee Hills and Tolichowki. The survey was primarily focused on earthquake problems like identifying building type, plot size and shape, clear distances from close structures, road width and basic data of the building: type of foundation, slab type, year of construction, no. of storeys, no. of inhabitants etc. The detail analysis (or the level-2 analysis) coated the determination of support space (length x width), column size and direction, lift core size, cantilever length of the building etc. Digital images of every building from a minimum of two directions were taken. The developers' names concerned with every building are recorded throughout the survey.

The survey process was conducted between 17-01-14 to 12-10-15. A database was compiled in MS Access. It was found that almost all of the buildings are RCC structures. The Ground floors of soft storeyed buildings are mostly being used as parking lot. it had been additionally found that almost all of the buildings of the target areas were constructed without the development of correct disaster resistant system against any potential earthquakes. The use of rapid Visual Screening (RVS) on the study area enables to divide screened buildings into two categories such as those that are expected to possess acceptable seismic performance and those that may be seismically risky and should be further studied. For additional analysis of the buildings the assistance of methodology proposed by the Turkish method and STAAD software would be taken.

KEYWORDS: earthquakes of magnitude, severe damage, moderate magnitude, buildings are RCC structures.

INTRODUCTION

Amongst the natural hazards, earthquakes have the potential for causing the greatest damages to engineered structures. They can cause large scale loss of life and property and disrupts essential services such as water supply, sewerage systems, communication and power, transport etc. They not only destroy villages, towns and cities but the aftermath leads to destabilize the economic and social structure of the nation. Since earthquake forces are random in nature & unpredictable, the engineering tools needs to be whetted for analyzing structures under the action of these forces. No part of the Earth's surface is safe from earthquakes. But some areas experience them more frequently than others. Earthquakes are most common at plate boundaries, where different tectonic plates meet. The largest events usually happen where two plates are colliding - this is where large amounts of stress can build up rapidly. India has a number of world's greatest earthquakes in the last century. In fact, more than fifty percent area in the country is considered prone to damaging earthquakes. The northeastern region of the country as well as the entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. Investigations of past and recent earthquake damage have depicted that the building structures are vulnerable to severe damage and/or collapse during moderate to strong ground motion. An earthquake with a moderate magnitude is capable of causing severe damages of engineered buildings, bridges, industrial and port facilities as well as giving rise to great economic losses.

EARTHQUAKE HAZARD

An earthquake is a sudden and violent shaking of the earth when large elastic strain energy released spreads out through seismic waves that travel through the body and along the surface of the earth (Murty, 2005). For example, the energy released during the 2001 Bhuj (India) earthquake is about 400 times that released by the 1945 Atom Bomb dropped on Hiroshima.The earth crust consists of portions called plates. When these plates collide with each other, stresses arise in the crust. The areas of stresses on the plate boundaries that release accumulated energy by slipping and rupturing are known as faults. A rupture occurs along a fault when accumulated stresses overpass the supporting capacity of the rock mass and the rock rebounds under its own elastic stress until the stress is relieved. The point of rupture is called the focus or hypocenter and may be located near thesurfaceordeepbelowit.

EARTHQUAKE MAGNITUDE

The magnitude of an earthquake is a quantitative measure of the amount of energy released at the source, the focal area. It is estimated from instrumental observations. The oldest and most popular measurement of an earthquake is the Richter scale, defined in 1936. Since this scale is logarithmic, an increase in one magnitude signifies a 10-fold increase in ground motion or roughly an increase of 30 times the energy release. Thus, an earthquake with a magnitude of 7.5 releases 30 times more energy than one with a 6.5 magnitude. Reinforced Cement Concrete (R.C.C) frame buildings are becoming increasingly prevailing in urban Hyderabad city. Many such buildings constructed in recent times have a special feature – the ground storey is left open for the purpose of parking, i.e. the columns in the ground floor do not have any partition walls between them. Such buildings are often termed as 'Soft Storey' buildings. Open ground storey buildings have consistently shown poor performance during past earthquakes across the world (for example during 1999 Turkey, 1999 Taiwan, 2003 Algeria earthquake, 2001 Bhuj Earthquake and 2005 Kashmir Earthquake), a significant number of them being collapsed. A large number of buildings with open ground storey have been built in Hyderabad in recent times. The objective of this study is to compile a database of R.C.C. (With & without Soft Storey) and U.R.M buildings within a specified area of Hyderabad City and also to make a vulnerability analysis of those structures. The objective of this study is to assess the seismic vulnerability of R.C.C. structures of the selected area by R.V.S (Rapid Visual Screening) method and The Turkish Method. These kinds of assessments were previously made in BUET (Bangladesh University of Engineering and Technology) campus and also in Dhaka University Campus. (Reference: Rajon, 2006 and Wahid, 2005) In order to design simple structures like low rise buildings, engineers idealize earthquake ground acceleration as horizontal forces applied at the elevated floor and roof levels. These horizontal forces are then transmitted to the foundations by specially designed walls called Shear walls. The seismic forces are carried by the floors and roof to the Shear walls. Floor and roof framing specially designed to carry seismic loads to the walls are known as diaphragm to structural engineers. The diaphragm and Shear walls work together to carry the seismic force to the foundation. The particular type of system carries lateralloadsinthe same way a box resists collapse.For the past 10 years Hyderabad has had a boom in Real Estate sector. The prime locations have been Adarsh Nagar area with further extension in Jubilee Hills and Tolichowki areas. Worrying fact is that most of the buildings do not have masonry walls in the ground floor which is generally used for parking, making it a soft storey. The focus of this study has largely been on such apartments. The provision of earthquake resistance and to know how the structures would react was the goal of the study.

SELECTING THE AREA TO BE SCREENED

The initial step was to select a community or group of Buildings. These apartments tend to have a weaker ground storey as most of the structures have provisions for parking there. That means less brick walls in the Ground floor. These types of apartment were defined as "Soft Storey" Buildings.

The selected area is basically a residential one. But it has turned into a semi commercial area in the recent past. There has been a growth of Supermarkets, Schools, Universities and commercial structures in an unplanned way. No steps or studies have been taken for earthquake provisions in this populated busy area. This study would help to assess the implications of an earthquake on this area.

METHODOLOGY

To assess the buildings of the surveyed area two methodologies were mainly used named R.V.S (Rapid Visual Screening) suggested by FEMA (Federal Emergency Management Agency) and Turkish Method.3.1 RVS (Rapid

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Visual Screening)Rapid visual screening (RVS) of buildings for potential seismic hazards, originated in 1988 with the publication of the FEMA 154 Report, Rapid Visual Screening of Buildings for Potential Seismic Hazards a Handbook. RVS provides a procedure to identify record and rank buildings that are potentially seismically hazardous (FEMA 154, 2002). This screening methodology is encapsulated in a one-page form, which combines a description of a building, its layout and occupancy, and a rapid structural evaluation related to its seismic hazard. Although RVS is applicable to tall buildings, its principal purpose is to identify (1) older buildings designed and constructed before the adoption of adequate seismic design and detailing requirements (2) buildings on soft or poor soils, or (3) buildings having performance characteristics that negatively influence their seismic response. Once identified as potentially hazardous, such buildings should be further evaluated by a design professional experienced in seismic design to determine if, in fact, they are seismically hazardous.

The rapid visual screening method is designed to be implemented without performing any structural calculations. The procedure utilizes a scoring system that requires the evaluator to (1) identify the primary structural lateral load-resisting system, and (2) identify building attributes that modify the seismic performance expected for this lateral load-resisting system. The inspection, data collection and decision-making process typically occurs at the building site, and is expected to take around 30 minutes for each building. The screening is based on numerical seismic hazard and vulnerability score. Basic Structural hazard scores for various building types are provided on the RVS form. The screener modifies the basic structural hazard score by identifying and circling score modifiers which are then added (or subtracted) to the basic structural hazard score to arrive at a final structural score, S. The basic structural hazard score, score modifiers, the final structural score S, all relate to the probability of building collapse. The result of the screening procedure is a final score that may range above 10 or below 0, with a high score indicating good expected seismic performance and a low score indicating a potentially hazardous structure. While the score is related to the estimated probability of major damage, it is not intended to be a final engineering judgment of the building, but merely to identify buildings that may be hazardous and require detailed seismic evaluation. If the score is 2 or less, a detailed evaluation is recommended. On the basis of detailed evaluation, engineering analysis and other detailed procedures, a final determination of seismic adequacy and need foe rehabilitations can be made.

Turkish Method

In recent times, after the 1999 earthquake in the cities of Kocaeli and Duzce, Government of Turkey and Japan International Cooperation Agency (JICA) came forward for implementing a regional seismic assessment and rehabilitation program. Researchers from various universities were involved in this program supported by the Government of Turkey and JICA. A simple Two-level Seismic Assessment Procedure for a building stock was proposed (Sucuoglu and Yazgan; 2003). In this most vulnerable buildings that may undergo severe damage in a future earthquake are identified. A survey of 477 damaged buildings (1-7 storey) affected by Duzce earthquake (November 1999) was carried out. This was then complied to form a database of damaged buildings to be used for future research work. This database was employed for developing the performance score (PS) equation to determine the vulnerability of a reinforced concrete building.

Level-1 Survey

The trained observers collect data through walk-down visits. The parameters that are selected in Level-1 survey for representing building vulnerability are the following:

a. The number of stories above ground
b. Presence of a Soft Storey (Yes or No)
c. Presence of heavy overhangs, such as balconies with concrete parapets (Yes or No)
d. Apparent building quality (Good, Moderate or Poor)
e. Pounding between adjacent buildings (Yes or No)
f. Local soil conditions (Stiff or Soft)
g. Topographic effects (Yes or No)

All of the above parameters are found to have a negative feature on the building system under earthquake excitations on a variable scale.

Once the vulnerability parameters of a building are obtained from two-level surveys and its location is determined, the seismic performance scores for survey levels 1 and 2 are calculated by using Tables 2 and 3, respectively. In these Tables, an initial score is given first with respect to the number of stories and intensity zone. Then the initial score is

reduced for every vulnerability parameter that is observed or calculated. A general equation for calculating performance score (PS) can be formulated as follows:
PS = (Initial Score – Σ (Vulnerability parameter) X (Vulnerability Score)
PS<50 → Vulnerable Structure

Level 2 Survey
Level 2 Survey is done for the buildings of a stock when those are found to be failing into the moderate and high risk levels using level 1 risk assessment. The trained observer teams enter into the basements and ground stories of these buildings for collecting more data for Level 2 risk assessment. Their first task is to confirm or modify the previous grading on soft stories, short columns and building quality, through closer observations. The second and more elaborate task is to prepare a sketch of the ground floor plan and measure the dimensions of columns, concrete and masonry walls. This data is then employed for calculating the following parameters.

COLLECTION OF DATA AND THE DATABASE

The whole area was divided into four suitable areas for convenience. The data were collected in a customized form. The data were basically such that it could be collected from visual inspection. Detailed

data were collected for 20% of buildings for level-2 analysis (Turkish Method) which included column and lift core dimensions.

The data was then compiled in an MS-ACCESS Database. With the help of the database we were able to analyze the structures.

RESULTS AND DISCUSSION

Results based on vulnerability assessment against earthquake forces:

Typical case 1: Residential buildings of G+3 floors

Spans	:	3.05 x 3.05 m
Size of columns	:	230 x 300 mm
Reinforcement	:	6 Nos, 12 mm bars; Ties: 8 mm @ 190 mm
Size of beams	:	230 x 300 mm
Reinforcement	:	3 Nos 12 mm at bottom 2 Nos 12 mm at top with 1 No 12 mm extra over supports
Stirrups	:	2L – 8 mm @ 150 mm c/c
Concrete Mix	:	M20

S.No.	Age of Building	Result
1.	Upto 15 years	Safe
2.	> 15 years upto 25 years	About 10% lower columns fail
3.	> 25 years upto 50 years	About 15% columns fail

Typical case (ii): Residential buildings for commercial purpose of G+5 floors.

Span	:	3.5 x 5 m
Size of columns	:	230 x 380 mm
Reinforcement	:	6 Nos, 16 mm bars; Ties: 8 mm @ 190 c/c
Size of beams	:	230 x 400 mm (for 5 m span)

		230 x 300 mm (for 3.5 m span)
Reinforcement	:	<u>For long beams:</u> 3 Nos 16 mm at bottom 2 Nos 12 mm + 2 Nos 16 mm at top over supports Stirrups: 2L – 8 mm @ 125 mm c/c <u>For short beams:</u> 3 Nos 12 mm at bottom 2 Nos 12 mm + 1 No 12 mm at top over supports Stirrups: 2L – 8 mm @ 150 mm c/c
Concrete Mix	:	M20

S.No.	Age of Building	Result
1.	Upto 10 years	Safe
2.	> 10 years upto 20 years	About 10% columns are unsafe
3.	> 20 years	About 15% columns are unsafe

The areas covered under the survey are Adarsh Nagar residential area, Jubilee Hills and Tolichowki areas. The survey was mainly focused on earthquake issues such as identifying building type, plot size and shape, clear distances from surrounding structures, road width and basic information of the building: type of foundation, slab type, year of construction, no. of storey, no. of inhabitants etc. The detail analysis (or the level-2 analysis) covered the determination of plinth area (length x width), column size and direction, lift core size, cantilever length of the building etc. Digital photographs of each building from at least two directions were taken. The developers' names concerned with each building are also recorded during the survey. A database of 50 structures was compiled in MS Access. It was found that approximately 50% are R.C.C structures. About 30% of them are soft storied. The rest buildings are un-reinforced masonry (URM).

CONCLUSIONS

1. Although past earthquakes have scored "direct hits" on cities of less than 100,000 people within the Indian sub-continent (Kathmandu, 1934, Quetta 1935, Muzafferabad 2006 etc) there's no historical example of a significant earthquake close to or near amegatown withapopulation surpassing five million.
2. Earthquakes that have occurred close to urbanagglomerationsconsistingof preponderantly weakmulti-storey concrete frame buildings in India, Pakistan, Turkey and China, have resulted in the death of 10-30% ofthe native population. An unprecedented 1.0-3.0 million death toll may occur were an earthquakeoccurs closeto amega town of ten million people like Hyderabad city.
3. With some exceptions, existing earthquake resistant building codes don't seem to be applied uniformly to new construction. Unsafebuildingpractices are favored, particularly in the private sector because they may scale back building prices by 10-20%. Theycan occur because of indifference or corruption in public offices, or just as a result of an insufficient number of building inspectors are outthere toenforce asecure construction code.
4. Contractors and employees within the construction trade (as opposed to the earthquake engineering community) are oftentimes uneducated in usually quite simple strategies which will help ensure the integrity of concrete frame constructions.
5. From the year 1995 and ahead, a time during which a building boom was fueled by urban population doubling and redoubling, there have been no huge earthquakes.
   This lulled the building trade into a state of ignorance and apathy regarding the fact of earthquakes within the Himalaya and elsewhere.
6. Most of the buildings (almost 100%) don't have any provision of safety route (such as emergency exit). People have very few information on the way to react once earthquake happens.
7. About 50% of the building surveyed had elevate core within the plan that makes them stronger against earthquake.
8. From the study applied it's discovered that the majority of the buildings higher than twenty five years old need retrofitting in columns to make them safe against earthquakes in Hyderabad city and around 100% of the buildings between fifteen and twenty five years old need retrofitting in few columns.

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