RAPID VISUAL SCREENING OF EXISTING BUILDINGS USING ANDROID APPLICATION

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India has experienced number of earthquakes around the country, mostly in North India and North East side of the country due to tectonic movements and faults. In last couple of decades, India has witnessed a huge number of damaging earthquakes. During last two decades, there are nine high intensity earthquakes which has affected the structure and account to large number of lost life. Before 2001 Bhuj earthquake, construction quality was poor in rural and sub urban areas and urban areas were supposed to have safe construction because of modern engineering techniques being used and good quality of materials being used. But after that 2001 Bhuj earthquake, there is a huge damage to the structures was observed and shattered the myth of urban seismic safety. Almost all building codes worldwide accept some amount of structural failure and damage during high intensity earthquakes but they don't allow structure to collapse.

In this paper I have mainly studied about the seismic vulnerability assessment of existing buildings. It is one of the important issues for many countries these days because earthquakes are very frequent in many countries which are damaging many important structures. Every country has developed their codal provision and regulation for RVS according to their conditions. In India, many works has been done but still there is not any standard procedure for RVS in India because of different materials used, different topography, various soil types etc. I have used android application for screening purpose and generating score for existing buildings on the basis of various parameters. This score may help in retrofitting or taking precautionary measures for the buildings which may lead to reduce the intensity of damage during earthquake.

Keywords: FEMA **(**Federal Emergency Management Agency**),** RVS (Rapid Visual Screening), Geo-Location, Band.

Introduction

Earthquake is one of the most devastating natural disasters. It has huge impact on human lives and property and causing several other losses like economical damage all over the world. India has experienced number of earthquakes around the country, mostly in North India and North East side of the country due to tectonic movements and faults. Before 2001 Bhuj earthquake, construction quality was poor in rural and sub urban areas and urban areas were supposed to have safe construction because of modern engineering techniques being used and good quality of materials being used. But after that 2001 Bhuj earthquake, there is a huge damage to the structures was observed and shattered the myth of urban seismic safety.

Existing Vulnerability Assessment Methods

There are various methods available for the Rapid Visual Screening of a building. I have referred some of them and the content what got from there are mentioned below in my literature review.

FEMA 154

Rapid Visual Screening (RVS) process is developed by FEMA (Federal Emergency Management Agency). It is an agency of United States homeland security and it is documented in FEMA 154 (2002) to find, inventory, and rank potentially seismically vulnerable buildings. It is very quick procedure where seismically vulnerable buildings are screened out without going for any detailed complex analysis. In this process building is reviewed by sidewalk around the building without entering inside of building and there is no need for refer structural drawings and structural calculations. If possible screener can enter inside the building so that reliability and confidence of the data will increase. Hence it is a scoring system that requires screener to (1) identify the primary structural lateral load resisting system, (2) identify building attributes that modify seismic performance expected of this lateral load system. Inspection, collection of data and decision making process will be done at the site and this all process will take an average time of 15 to 30 min per building (30 min to 1 hour if accessible to inside).

FEMA 310

FEMA 310 was developed in 1998 and it is a most advanced seismic evaluation process and evaluation is based on the rigorous approach to determine the structural performance or condition. It is based on the two levels of performances of structure defined as *Life Safety* and *Immediate Occupancy* during design earthquake.

Life Safety: building can receive significant damage to both non-structural and structural components with some limit against either partial or total structural collapse such that level of risk for life-threatening injury and getting trapped is low.

Immediate Occupancy: Marginal damage to both non-structural and structural components during design basis earthquake. The primary elements of lateral force resisting system retains nearly all of their original strength and stiffness, however there could be a minor injuries and damages which can be easily repairable while the building is occupied.

EURO CODE 8

The Euro Code 8 has approved by CEN in 2004. The main aim of this document is seismic evaluation of already existing structures. This document considers both seismic and non-seismic actions for an existing structure for the life time of structure. Modelling is carried out for each structure and modelling uncertainty factor is found. Evaluation process is mainly depends on analysis method, hence it is more complex to use. The main deficient of this process there are many parameters not having proper guidelines and it is left to the design professionals.

SWISS STANDARD (SIA)

It consists of three stages of seismic evaluation:

Stage 1: Visual Inspection and building plan, primary elements of the structure and seismic vulnerability is screened roughly.

Stage 2: Seismic vulnerability of selected elements is studied in more detail.

Stage 3: Remedial or strengthening measures are developed for limited number of vulnerable buildings.

RVS Methodology Proposed by Dr. Anand S Arya (2011)

In this method RVS procedure was designed for Indian context, it follows a grading system where screener has to i) determine primary structural lateral load resisting system and ii) determine parameters which may be modify seismic performance of structure including non-structural components. Zones are considered as per Indian conditions and importance factor is considered for important buildings. Also special hazards (liquefiable area, land slide prone

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area, plan irregularities and vertical irregularities) and falling hazards are taken into account. Finally a grading system was performed in the buildings.

RVS Procedure developed bySudhir K Jain

This method is also based on Indian conditions whereas checklist is prepared for screened building. It is the first method in India which is based on the scoring pattern, here performance score is calculated based on the zone, architectural considerations, structural parameters, geotechnical characteristics and etc. this method was practically used many parts of India first it was used in Gujarat after Bhuj earthquake.

Methodology and Data Collection

There are various parameters which we are going to consider for the performance score calculation. Some have greater impact and some data are having less impact.

(a) General information of building
(b) Geotechnical Characteristics
(c) Seismic Safety Features

Table 1: General Information of Building

General Information	
Sl. No	**Parameters**
1.1	Seismic Zone
1.2	Building Name
1.3	Address and Pin
1.4	Year of Built
1.5	No of Stories
1.6	Total area covered all floors (Sq.m)
1.7	Ground coverage (Sq.m)
1.8	Geo-Location
1.8.1	Latitude
1.8.2	Longitude

Table 2: Typology of Various Masonry Buildings

Sl. No	Parameters	Sl. No	Parameters
2.1	**Foundation Type**	**2.4**	**Roof Material**
2.1.1	Strip footing	2.4.1	Reinforced Brick Concrete
2.1.2	Isolated pier footing	2.4.2	Reinforced Concrete

2.1.3	Any other (describe)	2.4.3	CGI (corrugated galvanised iron sheets)
2.2	**Wall type /Material**	2.4.4	AC (asbestos cement sheets)
2.2.1	Earth/Adobe	2.4.5	Fibre sheets
2.2.2	Mud/rammed	2.4.6	Stone slates
2.2.3	Grass/thatch	2.4.7	Any other (describe)
2.2.4	GI sheet	2.5	Roof Under structure
2.2.5	Bamboo	2.5.1	Bamboo truss/Rafter/purlin
2.2.6	Wooden	2.5.2	Wooden truss/Rafter/purlin
2.2.7	Burnt/Unburnt Brick	2.5.3	Steel truss/Purlin
2.2.8	Dressed/Undressed Stone	2.5.4	Any other (describe)
2.2.9	Cement Concrete Blocks	2.6	Floor Material
2.2.10	Thickness of Wall	2.6.1	Mud
2.2.11	Any other (describe)	2.6.2	Cement Concrete
2.3	Roof Type	2.6.3	Wooden
2.3.1	Flat	2.6.4	Bamboo
2.3.2	Slope	2.7	Type of Mortar
2.3.2.1	Gable roof	2.7.1	Mud
2.3.2.2	Hip roof	2.7.2	Lime
2.3.2.3	Shed roof	2.7.3	Cement

Table 3: Geotechnical Characteristics of Buildings

3.1	**Site Morphology**	**Description**
3.1.1	Flat topography	0 to 5 degrees
3.1.2	Crest	Peak point of hill
3.1.3	Downward slope	slope of hill/mountain
3.1.4	Trough	depression between two downward sloping hills
3.2	Depth of water table	
3.3	Liquefaction Potential	water table >3m for sandy soils
3.4	Type of Soil	ref IS 1893: 2002
3.4.1	Hard	

3.4.2	Medium	
3.4.3	Soft	
3.5	Expansive or Non Expansive soil	Black cotton soil
3.6	Land slide prone area	

Table 4: Seismic Safety Features for Masonry Buildings

Sl.No	Parameters	Reference
4.1	Horizontal Plan Irregularity	Geometry shape (L,H,U,T,+ and etc.,) IS:1893
4.2	Vertical Irregularity	ref IS:1893
4.2.1	Set-back	
4.2.2	Step-back	
4.3	Horizontal Bands	ref IS:1893
4.3.1	Plinth Band	
4.3.2	Lintel Band	
4.3.3	Sill Band	
4.3.4	Ceiling Band	
4.3.5	Gable Band	
4.3.6	Eaves level of pitched roof	
4.3.7	Top of ridge wall	
4.4	Vertical reinforcement at corner of the walls	ref IS:1893
4.4.1	At corner of rooms	
4.4.2	At T junction of walls	
4.4.3	At Jambs of doors & windows	
4.5	Diaphragm Opening	ref IS:1893
4.6	Distance between openings	ref IS:4326(1993)
4.6.1	Distance between two successive openings	
4.6.2	Distance of opening from the corner of wall	
4.7	Percentage of openings	ref IS:4326(1993)
4.7.1	First floor	
4.7.2	Second floor	
4.7.3	Third floor	
4.8	Length between two cross walls	ref IS:13935 (2009)

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4.9	Height to width ratio	ref IS:13935 (2009)

Table 5: Building Distress and Non Structural Falling Hazards

Building Distress and other important features		Non-Structural Falling Hazards	
Sl. No.	**Parameters**	**Sl. No**	**Parameters**
5.1	Cracks in Building	6.1	Divisions/Partition
5.1.1	Wall	6.2	Façade elements
5.1.2	Beam	6.3	False ceiling
5.1.3	Column	6.4	Brick Parapets/pillars/planters
5.1.4	Window	6.5	Roof Chimneys
5.1.5	Door	6.6	RC/Masonry water tank on Roof
5.2	Bulging in column or wall	6.7	Signs/Display boards
5.3	Water seepage		
5.4	Quality of construction		
5.4.1	Good		
5.4.2	Moderate		
5.4.3	Bad		

Analysis and Development of Android Application

Performance Score of Building

India is divided into four seismic zones (IS 1893: 2002) i.e. Zone II, III, IV and V and these zones are divided on the basis of expected intensity of earthquake ground motion in various places of the country and past experiences. Hence it does not accounts seismic vulnerability in terms of peak ground accelerations. Scoring pattern in USA developed by FEMA has its own advantages and disadvantages, and this scoring pattern is very much suitable for their regions.

The relationship of performance score is given as

$$\mathbf{PS = (BS) + \sum [(VSM) \times (VS)]}$$

Here, PS = Performance Score

BS = Base Score

VSM = Vulnerability Score Modifiers

VS = Vulnerability Score

A building with more number of floors and highest seismic zone will get low score; hence the building is more vulnerable.

The whole SVA process is divided into five stages:

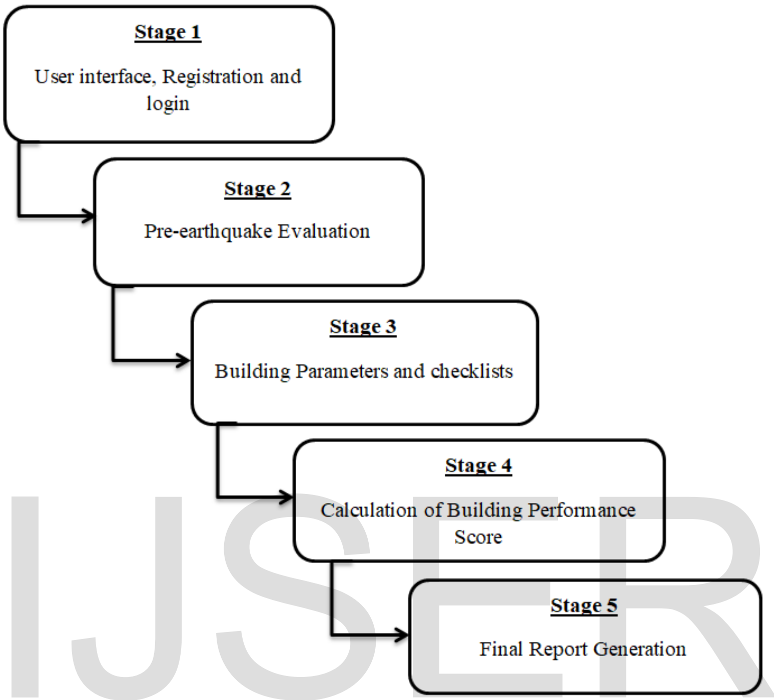

Figure 1: Stages of RVS application

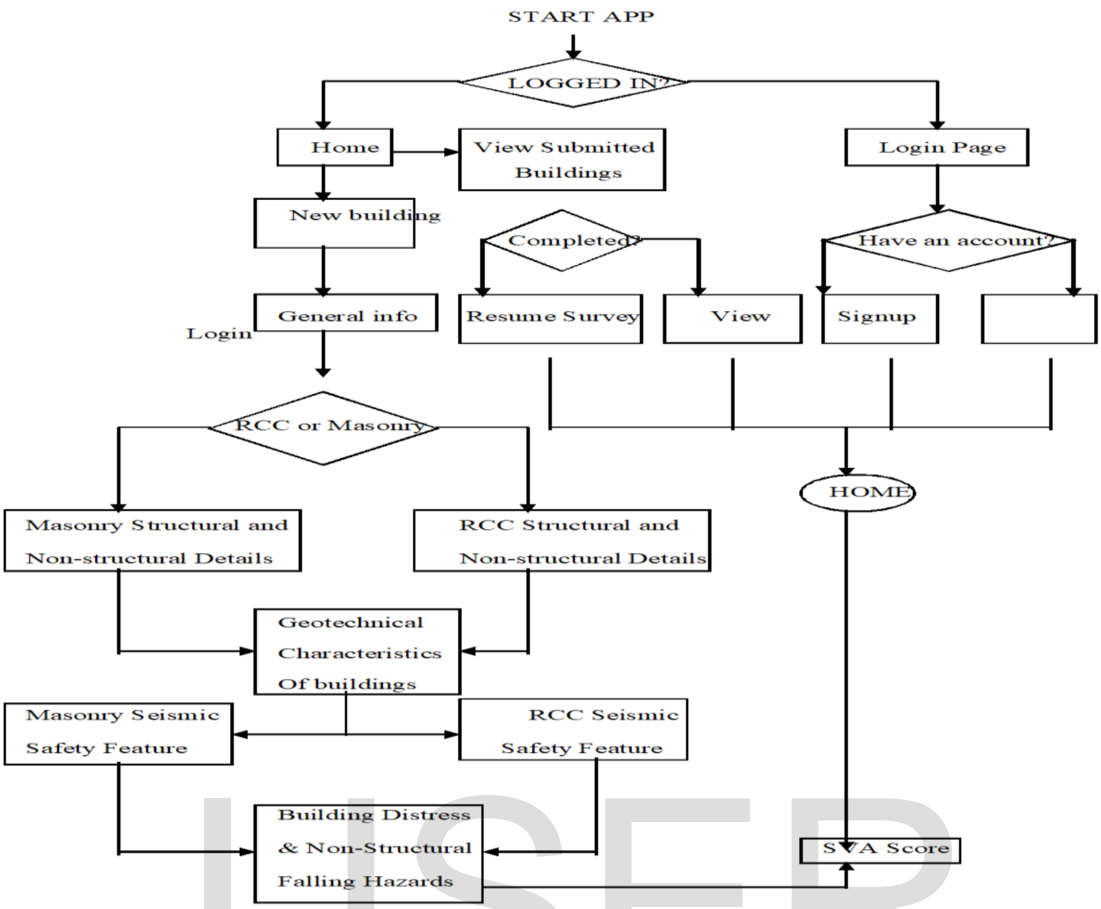

Figure 2: Flow Chart of Android Application

Results and Discussion

With the help of android application, data has been collected and compared with various aspects for the wide acceptance of this application. The comparison of data filledby different users irrespective of their technical background is summarised for wide use at ground level (Table 6). After collection of data, a score is generated and on the basis of score obtained the required measures to be taken for the structure is suggested.

Table 6: Comparison of data provided by SVA users

Building Name(Year of Build)	ASHUTOSH SADAN
Address and PIN	Rajendranagar Patna
Use of Building	Residential
Construction Type	RCC
No. of stories	2
ZONE	IV

Table 7:Data filled by different users

Engineering Attributes	User 1	User 2	User 3
Total area covered all floors (m^2)	510	500	600
Ground coverage area (m^2)	255	250	300
Foundation Type	Individual Footing	Not Sure	Not Sure
Wall Material	Burnt Bricks	Burnt Bricks	Burnt Bricks
Roof Type	RC Slab or T-Beam	RC Slab or T-Beam	RC Slab or T-Beam
Overall depth of floor	125	150	150
Type of mortar	Cement	Cement	Cement
Type of soil	Medium	Medium	Hard
Horizontal Plan Irregularities	Yes	No	No
Vertical Irregularities	No	No	No
Soft Story	No	No	No
Percentage Opening	11.6	0	0
Pounding	Doesn't exist	Doesn't exist	Doesn't exist
Frame Action	Yes	Not Sure	Not Sure
Cracks in buildings	No	No	Yes (Walls)
Water Seepage	No	No	No
Damage from past earthquake	No	No	No
Apparent quality	Moderate	Good	Good
Basement	No	No	No
Facade element	No	No	No
Bricks parapet	Yes	Yes	No
Performance Score	130	130	140

User 1: Pranav Kumar, Structural engineer with good technical knowledge and trained with RVS process.

User 2: Vikalp Patel (Civil Engineer), Person with technical knowledge.

User 3: Vikash Singh (School Teacher), Resident of the building with no technical knowledge regarding RVS.

Conclusion

For the development of any effective disaster mitigation programme, it is necessary to identify the seismically deficient structures. Hence, many countries have their own methodologies to handle seismic assessment of buildings, but they are according to their local conditions like there soil condition, depth of water table, material of construction used, type of construction, topography of area and various other factors and hence not suitable for Indian conditions. There are no any mobile applications developed for seismic assessment in India. Therefore there is a urgent need of such type of technology to catch up with this lightening fast moving world for Indian conditions. Hence this android based application for vulnerability assessment is very effective in data collection, synchronization, analysis and disaster mitigation plans.

With the help of mobile based android application, we can fill the data and simultaneously a score is generated considering the present health of structure. Where buildings having more number of stories or which are located in higher seismic zones will get less performance score as compared to the buildings having less number of stories and are in low seismic zone.

In this android application, data can be stored safely and can be updated in future if any change is need to be done.

The data uploaded includes photograph of building which increases reliability of data given by the surveyor and confirms building details with its latitude and longitude.

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