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Tools for Earthquake Vulnerability Assessment of Buildings in Chukhuwala (Ward No. 13), Dehradun (Uttarakhand), India

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***Abstract*:-** In the present study to get the structure type of buildings, ground survey and rapid visual screening technique has been used. By using this technique, 1832 buildings have been covered. GIS and Remote Sensing data has used to analyze the spatial information of the satellite image. The aim of this study is evaluation of differential seismic vulnerability of the building stock in Chukhuwla (ward no 13) of Dehradun city.
Arc GIS 9.2 software has been used for digitizing, analysis and preparing thematic maps. According to seismic zonation map of India (IS-1893-2002) Dehradun lies in seismic zone IV, Injury Severity Level 4 formula has used to know the Indoor causalities for complete structural damage of Chukhuwala, Dehradun.

Key words: Rapid Visual Screening, GIS and RS, Vulnerability of building, Arc GIS, Thematic Map, Seismic Zonation map of India, Injury Severity Level 4, Chukhuwala ward (ward no 13), Dehradun.

I. INTRODUCTION

Natural Disaster in the form of Earthquake, Flood, Drought, Landslide etc. causes enormous loss of life and property in our country. The recent experience of Natural Disasters in Uttarakhand, Orissa and Gujarat etc. exposed various shortcomings in the existing disaster management system prevalent in the country. Experiences in many disaster-affected areas in the past clearly indicate that Disaster Management system prevailing in the country has many shortcomings and various important aspects in this field are still untouched and unexplored. From the past experience it is clear that existing disaster management policies and practices are more concerned about the immediate relief and rescue operations and other crucial aspects i.e. preparedness, mitigation and rehabilitation are either ignored or given negligible importance. The study has been done to evaluate seismic vulnerability of different types of buildings, ascertaining the population group prone to high seismic in the study area, risk assessment and Outline for the preparation of mitigation policies.

II. AREA OF FOCUS

This study focuses on Dehradun city, the capital of Uttarakhand. Chukhuwala has been focused mainly because this area is more congested than other area so the possibility of buildings damage is more. Bindal River is located to the northwest of Chukhuwala. We have found that there is preponderance of slums and squatters. The residential population of the area is 12,000. Dehradun lies according to seismic zonation map of India under seismic zone IV. The district is situated in the north-west corner of the state. It is bounded on the north and to some distance in the north-west by the district of Uttarkashi. In the east by the district Tehri Garhwal and Pauri-Garhwal, Saharanpur district (Uttar Pradesh) in the south and its southern tip touching the boundary of Haridwar district. It lies between 29 degrees 58' and 31 degrees 2' 30" north latitudes and 77 degrees 34' 45" and 78 degrees 18' 30" east longitudes; altitude is 640 meters (2100 ft) above mean sea level.

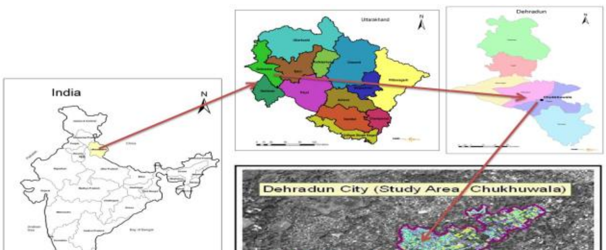

FIG.1: Location Map of Study Area Chukhuwala, Dehradun

IKONOS PAN Satellite image with spatial resolution of 1 meter were used for the study. For identification of the main features of the area Survey of India toposheet No 53 J/3 (1:50,000) were used and the Ward boundaries were delineated using the maps of the Dehradun Nagar Nigam. Satellite data was utilized for integrating the various parameters of the structures under GIS environment.

III. METHODOLOGY

The follow diagram is showing the methodology we have taken for seismic vulnerability assessment.

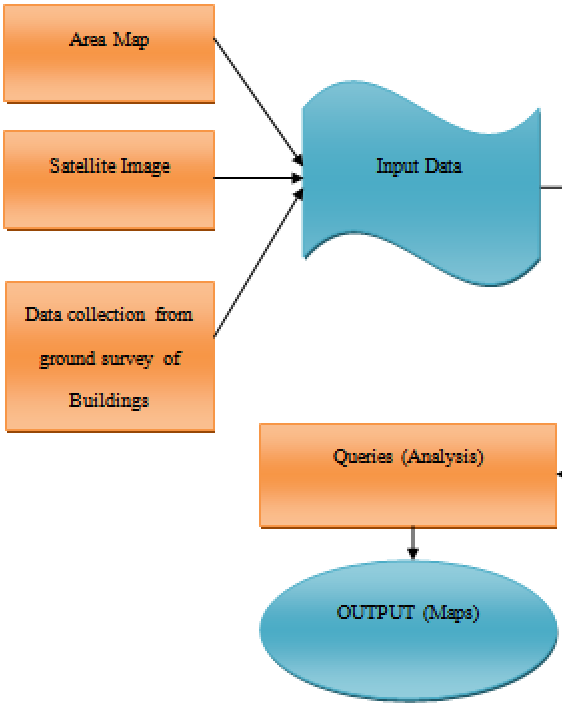

FIG.2: Flow Chart showing steps followed while performing Methodology

Rapid Visual Screening

For the actual data collection a modified version of the FEMA-154/ATC-21 based data collection form for Rapid Visual Screening (RVS) for potential seismic vulnerability is used. As Dehradun is located in Zone IV of Seismic Risk Zonation Map of India, the standard form for seismic zone IV is taken. The form is then modified to match the conditions in Dehradun. The ground data has collected in the ground survey for individual houses. In the survey each building is identified and marked with a particular ID over the map. The same ID is marked on the data collection from to relate the attribute data to the spatial information.

TABLE-1: Buildings Wall Structure Type with Codes

Buildings Wall Structure Type	Codes
Earthen Building	1
Randam Rubble in Lime Surkhi	2
Ashlar Stone in Lime Surkhi	3
Burnt Brick in Lime Surkhi	4
RC Frame Building	5
Randam Rubble in Mud Mortar	6
Randam Rubble in Cement Mortar	7
Ashlar Stone in Cement Mortar	8
Burnt Brick in Cement Mortar	9
RC Frame-Shear Wall Building	10

QUERIES AND STATICS

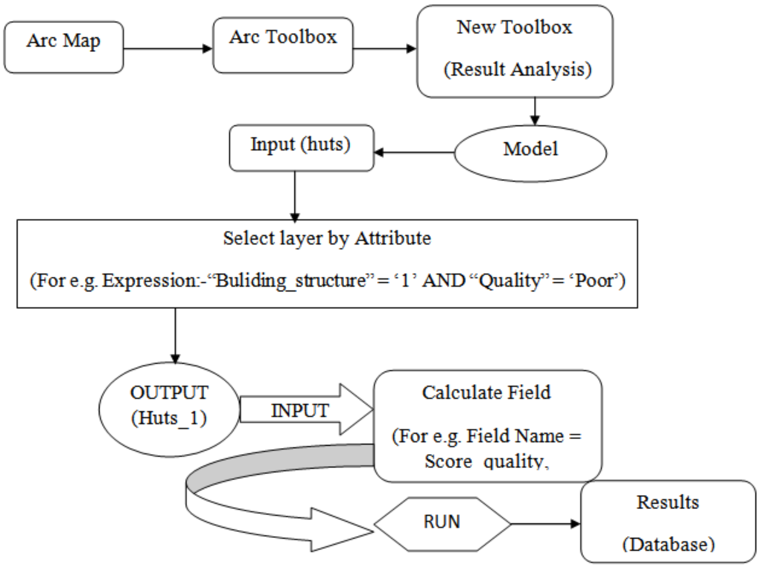

FIG.3: Flow diagram showing steps followed in performing queries and generating statistics

Vulnerability of Buildings

Vulnerability can be briefly defined as "being prone to or susceptible to damage or injury" (Blaikie 1994). To determine vulnerability a long chain of causes or factors can be analyzed including natural, technological, social and political factors. The assessment of vulnerability to seismic risk requires particular information on each one of the factors and elements at risk. All items, like geologic evolution, urban development, strength of structures, and possible collateral effects, have to be considered carefully to assess the seismic vulnerability as accurately as possible. Vulnerability of buildings in the ward is derived on the multi criteria analysis which is based on the building type (Structure). Depending upon the various parameters scores are assigned to each individual building, i.e., each type has a basic score which is calculated on the basis of different structural parameters that highly influence the vulnerability of the building (number of stories, plan and irregularities, quality of building).Final score is calculated by adding scores of each building structure parameter and the vulnerability of individual buildings is classified into five different categories based on the total score the tables of which are given in Table 2.

TABLE-2: Vulnerability class of the structures

Final Score	Vulnerability Class
< 4	Extreme
5 - 9	Very High
10 - 14	High
15 - 19	Moderate
> 19	Low

Earthquake Casualty Model

Casualties caused by a postulated earthquake can be modeled by developing a tree of events leading to their occurrence. As with any event tree, the earthquake related casualty event tree begins with an initiating event (earthquake scenario) and follows the possible course of events leading to loss of life or injuries. The logic of its construction is forward (inductive). At each node of the tree, the (node branching) question is: What happens if the preceding event leading to the node occurs? The answers to this question are represented by the branches of the tree. The number of branches from any node is equal to the number of answers defined for the node branching question. Each branch of the tree is assigned a probability of occurrence. As noted earlier, data for earthquake related casualties are relatively scarce and therefore, to some extent the casualty rates are inferred from the available data statistics and combined with expert opinion. As an example, one particular severity of casualty, the expected number of occupants killed in a building during a given earthquake, could be simulated with an event tree as shown in Figure 4.

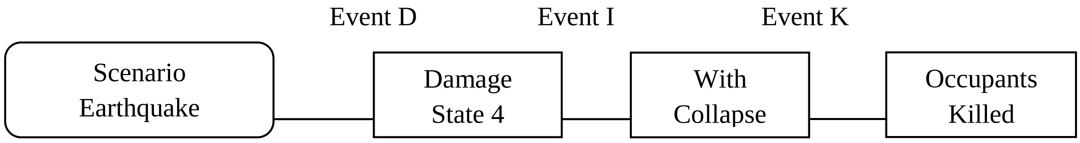

FIG.4: Casualty Event Tree Modeling

For the purpose of illustration it contains only "occupants killed," as events of interest and does not depict lesser severities of casualties. Evaluation of the branching probabilities constitutes the main effort in the earthquake casualty modeling. Assuming that all the branching probabilities are known or inferred, the probability of an occupant being killed (Pkilled) is given below:

Pkilled/ Collapse = PD × PI × PK --------------------------- (i)

The expected number of occupants killed (EN Occupants Killed) is a product of the number of occupants of the building at the time of earthquake (N occupants) and the probability of an occupant being killed (Pkilled).

EN occupants killed = N occupants × Pkilled / Collapse --------------------------- (ii)

The casualty patterns for people, who evacuate collapsed buildings, either before or immediately after the collapse, are more difficult to quantify. Statistical data on these casualty patterns is lacking, since in most post-earthquake reconnaissance efforts these injuries are not distinguished from other causes of injuries. In some cases, the lighter injuries may not be reported. An assumption may be applied that those who manage to evacuate are neither killed nor receive life threatening injuries. Often it is assumed that 50% of the occupants manage to evacuate. The output from the above model consists of a casualty breakdown by injury severity level, defined by a four level injury severity scale (Durkin and Thiel, 1991; Coburn, 1992; Cheu, 1994). In this study we are considering only injury severity level 4 which is as given below:

TABLE-3: Description of injury at Injury Severity Level 4

Injury Severity Level	Injury Description
Severity 4	Instantaneously killed or mortally injured

For the study, the complete structural damage (with collapse) is considered where Indoor Casualty Rates in case of Casualty Severity level 4 is 10% and for the complete structural damage, the probability of collapse is 15%.

By introducing the substitutions in equation (i), we get

Pkilled / Collapse = PD × PI × PK

Pkilled / Collapse = (15/100 × 10/100 × 50/100)

Pkilled / Collapse = 0.0075

By using the above formula in equation (ii) we get the expected number of people killed.

E.g. if we apply the above formula for residential occupancy type, we get the expected number of died people:

EN Occupants killed = NOccupants × Pkilled / Collapse

EN Occupants killed (at day time) = 4875 × 0.0075 ~ 36

EN occupants killed (at night time) = 7632× 0.0075 ~ 57

Then we get the value after applying the above formula with other occupancy type.

IV. RESULTS

TABLE-4: Indoor Causalities for Complete Structural Damage

Occupancy Type	Number of Occupants at day time	Number of Occupants at night time	Expected No of Occupants killed at day time	Expected No of Occupants killed at night time	Total causalities
Cinema Hall	**860**	**211**	**6**	**2**	**8**
Hotel	**209**	**1205**	**2**	**10**	**12**
School	**8296**	**59**	**62**	**1**	**63**
Residential & Commercial	**2421**	**1374**	**18**	**10**	**28**
Residential	**4875**	**7632**	**36**	**57**	**93**
Commercial	**1967**	**100**	**15**	**1**	**16**

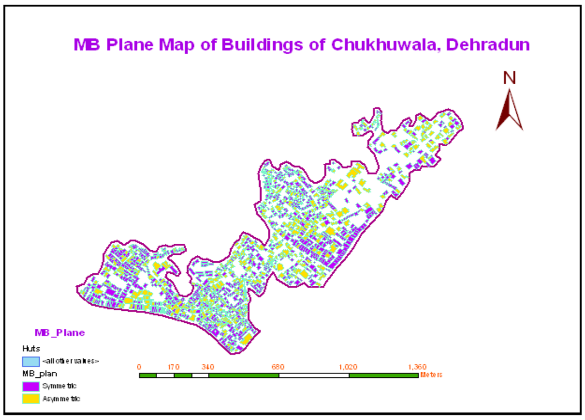

FIG.5: Map showing MB Plan of Buildings

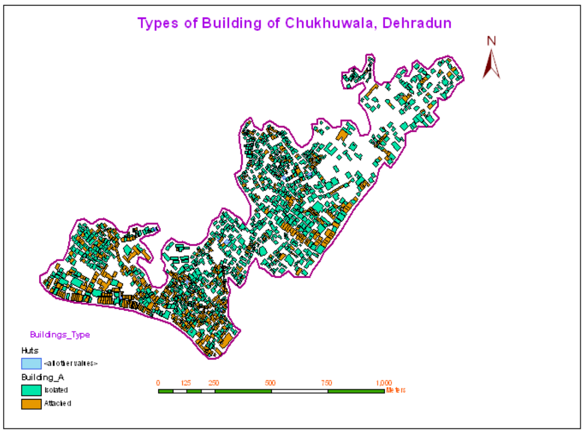

FIG.6: Map showing Type of Buildings

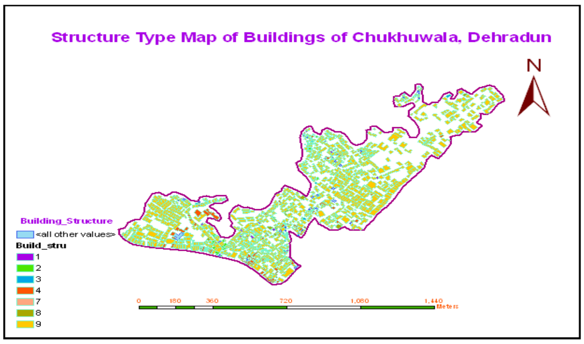

FIG.7: Map showing Building Structure Type

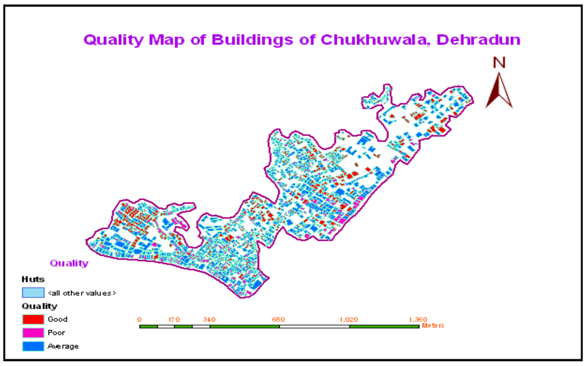

FIG.8: Map showing Quality of Buildings

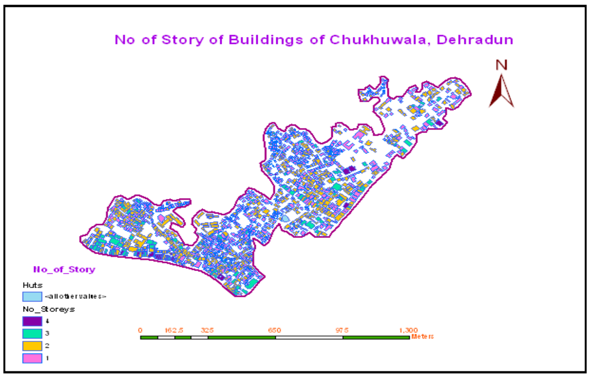

FIG.9: Map showing Number of Stories

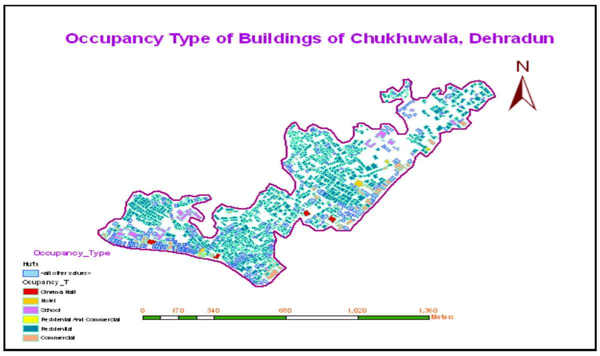

FIG.10: Map showing Occupancy Type Buildings

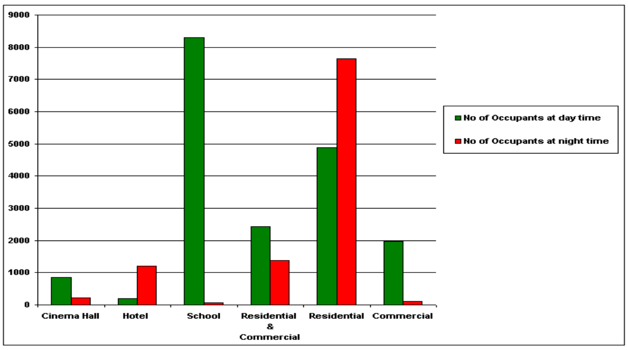

FIG.11: Number of people for different Occupancy Types

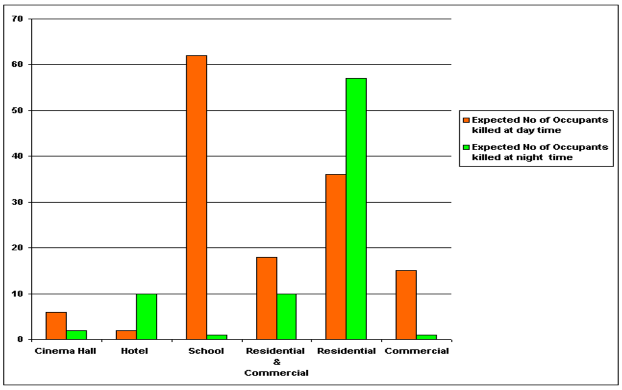

FIG.12: Expected number of People killed under different Occupancy Types

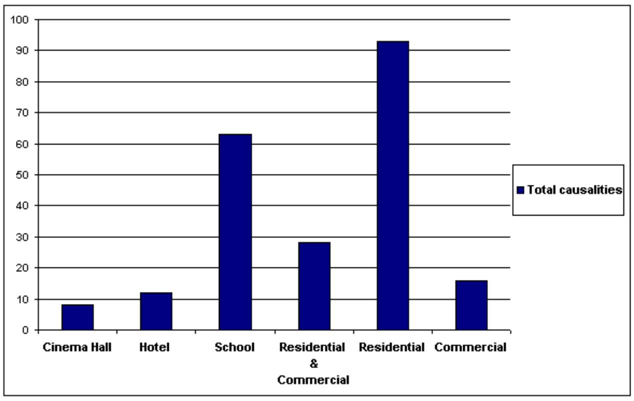

FIG.13: Total expected Casualities for different Occupancy Types

Outline for the preparation of mitigation policies

Preparation of mitigation policies requires realistic risk assessment, which cannot be done without reliable database. We need to know effective understanding of building stock, its vulnerability and socio-economic risk parameters such as type of occupancy, population densities etc. The study is thus intended to provide a sound balance for planning effective mitigation strategy for seismic risk reduction.

- Identification of hazard has to be done with coordination of locals.
- Proper disaster management plans must be prepared and disseminated among local authorities and local representatives.
- Workshops and training/awareness programs for the dissemination of information related to this subject matter need to be organized as they are very useful.
- In disaster reduction, as in other aspects of public health, there is much more work to be done in educating the local people about risks and prevention.
- We cannot stop nature from unleashing its forces but the ensuing disaster can often be prevented.
- The present study would be beneficial to local authorities, Government for preparing better disaster management plan as well as for development planning.
- It would be beneficial for better response during disasters.

V. ACKNOWLEDGEMENT

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