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Planning for Building Damage Assessment for Earthquakes Risk Management

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Abstract—*The entire Himalayan belt lies between zone IV and zone V of the seismic zoning map of India. Earthquakes have devastated the Himalayan seismic belt several times in the past and will continue to do so. A hypothetical earthquake scenario of magnitude 7.5 is generated for the Narendranagar Block of Tehri Garhwal district with epicenter near Tapowan at 30^0 08'10"N and 78^0 20'30"E. The effect of this earthquake on residential buildings estimated that almost 5.14% buildings of Narendranagar block would experience collapse while other 19.8% buildings would experience high damage, rendering almost 26% total population homeless. The human casualties in these buildings are estimated to be 990 (0.96%) persons would be dead or unsavable. The scenario studies underscore the vulnerability of the selected area. Immediately after an earthquake there is an emergency phase which is the most crucial one. The unpredictable nature of earthquakes makes prior planning essential. Damage assessment is the most important and crucial activity which has to be performed immediately after the earthquake. Preliminary assessment gives an understanding about the intensity of the earthquake and the geographical extent of the area affected by the quake. The findings of preliminary damage assessment facilitate planning of all the other operations like rescue, relief distribution etc., and hence any delay or misinformation can hamper all other critical activities. The paper gives a detailed framework for carrying out the preliminary damage assessment in most effective manner in Narendranagar Block. Such plans with suitable modifications can be developed for other Himalayan regions also.*

1. INTRODUCTION

Earthquakes have devastated the Himalayan seismic belt several times in the past and will do so in the future too. This is because the tectonic evolution of the Himalayas has rendered the terrain highly metamorphosed, faulted and folded and this is reflected in the highly sheared, fractured, jointed and consequently weak rocks that are also prone to erosion. High topographic relief, extremes of precipitation, steep slopes, together with neo- tectonic activity further make the terrain highly vulnerable to natural hazards. Hence the risk from earthquakes to populations living in Himalayas is increased. [8, 18, 19]

Landslides are a common feature in the Himalayas, which prove to be hazardous during earthquakes. Also other crucial aspects of hills like inaccessibility of settlements, narrow hilly roads, poor infrastructure like roads, electricity, water supply, telecommunication and community facilities like hospitals, schools etc., increase the vulnerability and hence risk of the population living in Himalayas. The risk increases with time because of increase in population, economic activity and infrastructural activity. Hence every passing day the risk in any particular area, where natural calamities can take place is increasing and mitigation steps should be taken to avoid disasters. [4, 9, 15]

Damage assessment is the most important and crucial activity which has to be performed immediately after the earthquake. Preliminary assessment gives an understanding about the intensity of the earthquake and the geographical extent of the area affected by the quake. The findings of preliminary damage assessment facilitate planning of all the other operations like rescue, relief distribution etc., and hence any delay or misinformation can hamper all other critical activities [3,17].The paper gives an analysis for Narendranagar block of Tehri Garhwal district of Uttarakhand state and suggest strategies for damage assessment after an earthquake.

2. EMERGENCY MANAGEMENT

The major earthquakes are often followed by extremely chaotic situations. During emergency phase of various past earthquakes, it has been seen that activities are generally uncoordinated, there is poor communications among different groups of communities and the population is unaware of the actions which needs to be taken [3]. The efficiency of emergency response depends on the nature of the type of emergency and the effectiveness of mitigation / preparedness measures [20]. PERI [10] gives many aspects, important checklists and roles and responsibilities of emergency managers for effective emergency management for any community. For ensuring a most efficient emergency response for earthquake it is vital to have an effective damage assessment mechanism.

3. STUDY AREA

The entire Himalayan belt lies between zone IV and zone V of the seismic zoning map of India [1]. Narendranagar block of

Tehri Garhwal district in Uttaranchal State of Himalayas is chosen for risk assessment of human settlements (Fig. 1) due to several reasons. These are: It lies in seismic zone IV, that is the second most vulnerable of all zones identified on Seismic zoning map of India [1]. Earthquakes of damage potential more than MSK VIII and accelerations of 0.25g can be expected in this region. Narendranagar block lies within the most vulnerable zone on the seismic micro-zoning map [13, 14]. Narendranagar block is prone to earthquake effects like landslides, ground fissures, damage to human settlements, casualties and injuries [5]. Narendranagar block has the second highest population density in this hilly district. A population of 81,604 is spread over 219.29 sq.km. [16]

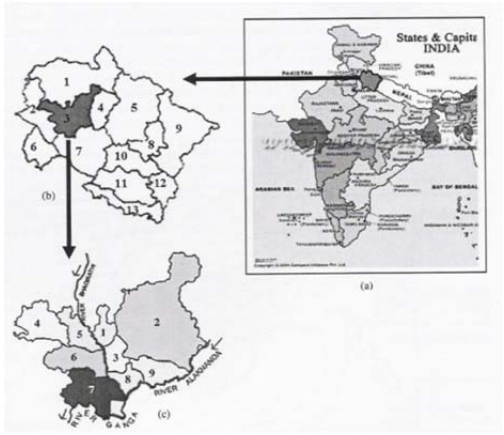

Fig. 1: Location of Narendranagar Block

Narendranagar block is subdivided into 40 Kshetra Panchayats which are further divided into 103 Gram Panchayats composed of 214 villages. There are total 17 identified market towns (Fig. 2). A market town is a census town or a nodal village (Rural Central Place) having (1) a minimum of 20 perennial commercial establishments for trade (functional units), (2) not less than three government offices and (3) serving a dependent population of at least 2000 excluding its own [11]. The 17 identified market towns are Narendranagar, Muni-ki-reti, Duadhar, Bedadhar, Hindolakhal, Fakot, Agrakhal, Jajal, Khadi, Gaja, Gular, Chaka, Pav-ki-devi, Kunjapuri, Gheradhar, Byasi and Kaudiyala.

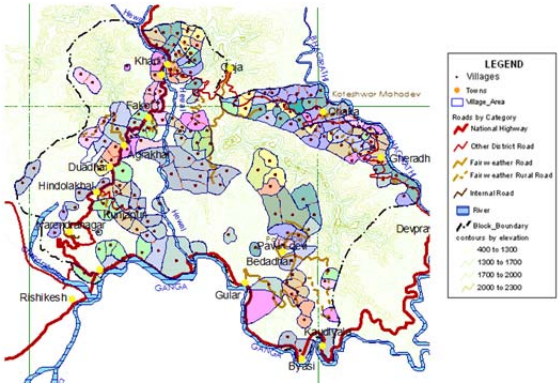

Fig. 2: Administrative sub divisions of Narendranagar block

4. RISK ASSESSMENT

The elements at risk considered in this paper are the people, their houses and roads. Vulnerability of these elements was assessed through several field visits to sample villages Gaja, Kodarna, Malas, Maun, Berni badi, Pukhri, Loyal, Jamola, Kharsad, Timli and Tapovan [6]. Various factors observed during field visits, which increase the risk, are as given below.

Construction technology-In the older houses, locally available building material was judiciously used; like long thick wooden logs, stones, slates and clay. The traditional practice of house construction that earlier had all the elements of earthquake resistance has now been replaced by modern construction practices and technology [2, 12]. This is because of various reasons, the main one being increasing restrictions imposed due to environmental protection. A traditional right to felling of trees has been curbed, which has led to its scarcity, growing demand and increase in price due to these and transportation costs. Quarrying of stone has also met the same fate.

Almost all houses in interior villages of Narendranagar block have a wall made of random rubble stone masonry. The sloped roof is made of slate, which has long, flat and thin faces on top and bottom, which is a desirable character. These materials are locally and abundantly available hence affordable. The newer houses in interior villages have RCC slab over stonewalls.

Villages very close to metal roads and located on main roads use brick for wall construction. The sloping roof is sometimes made of slate, and mostly of RCC slab. Local masons construct these RCC slabs without incorporating earthquake resistant construction technology. In past earthquakes it was observed that RCC slabs are more prone to damage during earthquakes than slate roofs because the latter are built over timber frames and hence more flexible. A few houses of people below the poverty line have thatched roofs over stonewalls. Sheds for cattle usually have thatched roof or CGI sheets where the village is near metal roads or fair weather jeep routes.

Roads-Roads within Narendranagar block are of three different types: metal roads, fair weather jeep routes, and pedestrian tracks. Villages are generally situated away from metal roads, sometimes requiring long arduous treks of up to 8 kilometers. Agriculture is the main occupation; hence, these villages are located on comparatively low slopes for the benefit of terrace farming. Villages do not occupy areas of steep slopes. Roads at many places are prone to landslides due to earthquakes and rains. These cut off villages and hamper rescue and relief operations.

Infrastructure Facilities-The level of availability of important infrastructure facilities like roads, water, electricity, telecommunication, health facility, food go-downs, school buildings etc required for effective management of disasters is

inadequate in Narendranagar block. In any earthquake situation the buildings can collapse due to high earthquake accelerations and health care can become a crucial aspect. Many villagers have to walk as far as 10 to 15 kms for availing any health facility even in normal circumstances. Apart from this, many villages do not have any telephone line or coverage for mobile phones. This may cause isolation in case they are cut off. Community facilities like school buildings etc, if present, do not have earthquake resistant construction. Hence there is hardly any provision for a temporary shelter in case of an earthquakes emergency. All these poor developmental aspects increase the vulnerability and hence the risk of the population living in the region, which could be further aggravated by the occurrence of an earthquake of magnitude 7.0 to 7.5.

Poor awareness-Villagers of Narendranagar block are unaware of the existence of any disaster mitigation plan and earthquake preparedness programs. Voluntary organizations associated with spreading awareness about disasters are absent. People have no idea about what assistance they can get from government agencies in such situations. This poor awareness makes them even more vulnerable to any earthquake disaster.

Time of Day-Risk also varies with the time of occurrence of an earthquake. If an earthquake occurs during the day when most people are working outside the house, human casualties are expected to be fewer compared to a similar situation when people are indoor. The vulnerability increases when people are sleeping indoors at night. This tragic scenario was witnessed in similar kind of houses in Latur earthquake of September 30, 1993, which occurred at 3.56 a.m. IST, when people were caught indoors while sleeping, and more than 10,000 lives were lost.

5. A HYPOTHETICAL EARTHQUAKE SCENARIO IN STUDY AREA

Gupta et. al [7] have generated an earthquake scenario in the study area. A hypothetical earthquake scenario within the region is developed with epicenter near Tapowan at $30^0$08’10” N and $78^0$20’30”E and magnitude 7.5 determined from the major tectonic elements and microzonation studies. The effect of this earthquake on residential buildings estimated that almost 5.14% buildings of Narendranagar block would experience collapse while other 19.8% buildings would experience high damage, rendering almost 26% total population homeless. The human casualties in these buildings are estimated to be 990 (0.96%) persons would be dead or unsavable. The locations of most probable landslides and the settlements rendered inaccessible due to landslides are identified. [6]

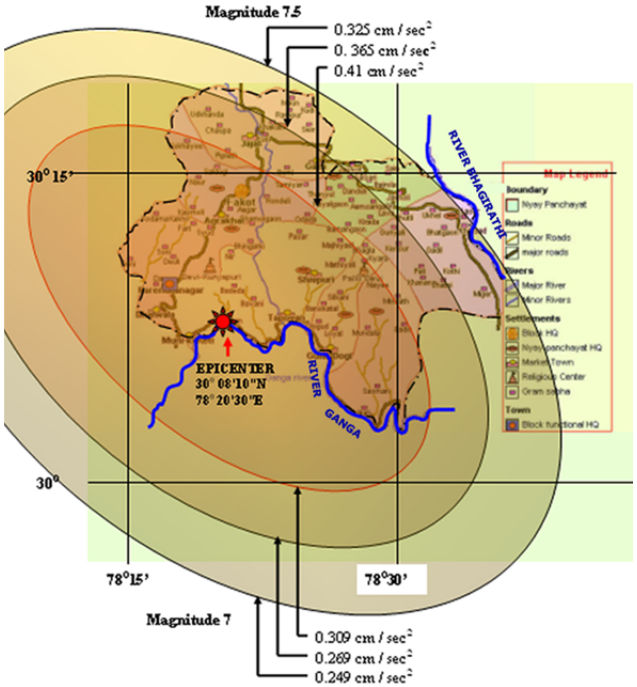

Fig. 3: Acceleration contours with epicenter at Tapowan (30^0 08’10”N and 78^0 20’30”E) for different hypo-central distances elongated parallel to the trend of Main Boundary Fault. [7]

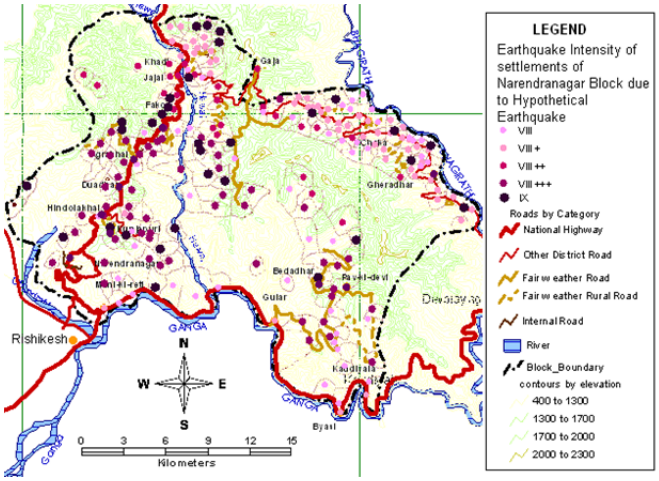

Fig. 4: Predicted Intensity of Settlements [6]

6. PRELIMINARY DAMAGE ASSESSMENT

Preliminary damage assessment is rough estimation of losses caused due to earthquake. It is of critical importance because by gaining quick overview of extent of building damage and loss of life with actual locations of occurrence all the other operations like rescue, relief distribution etc could be started. Preliminary damage assessment must start immediately after the earthquake strikes and should be completed within 6-8

hours. The assessment must be objective. It can be done by links established with the pre appointed representatives in the affected areas. In India government setup reaches up to village level which can be gainfully used in getting the preliminary information on earthquake damage. Media can also play an important role in this activity. For effective preliminary damage assessment, the emergency communications network is most crucial to ensure the flow of information, track emergency needs and deployment of the emergency personnel. Satellite images may also be used to save time and get reliable first hand information.

7. ORGANIZATIONAL STRUCTURE FOR DISASTER MANAGEMENT

One of the most important preparedness measures for emergency phase is the setting up of an organizational structure for earthquake disaster management with procedures for the reception and dissemination of information. The shortcomings of the present structure [6] emphasize the need for alteration in existing organizational structure of disaster management in the block. Hence a hierarchy is proposed consisting of one block level disaster management center, eight monitoring centers and thirty four relief centers (Fig. 5 a; b). The block level disaster management center is located at Narendranagar, which is the headquarter (Fig. 6)

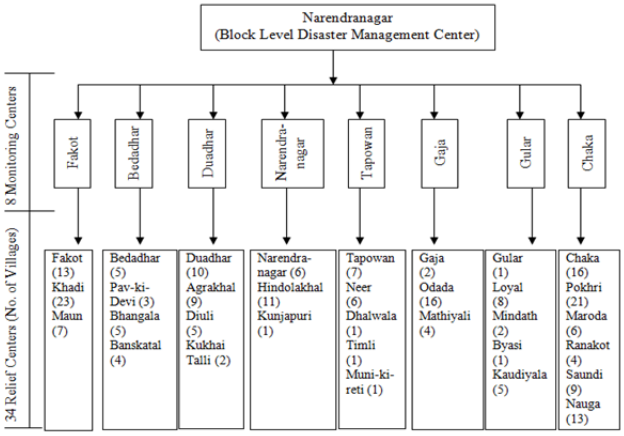

Fig. 5a

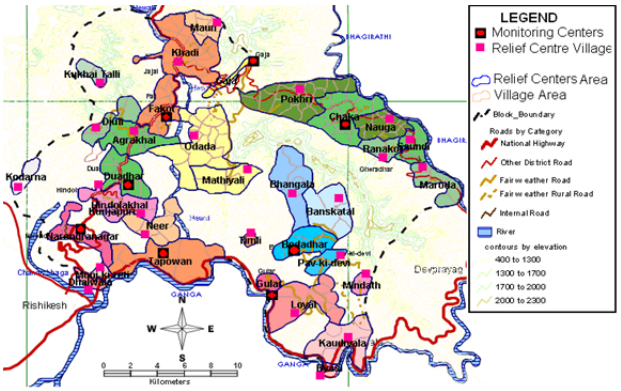

Fig. 5b

Fig. 5 a and b: Proposed organizational structure for disaster management in Narendranagar block

Fig. 6: Block level disaster management centre, Narendranagar

Monitoring Centers

Monitoring centers are market towns of the block which are of strategic importance due to their accessibility, available infrastructure and uniform magnitude of damage within the dependent settlements. These monitoring centers would coordinate preparedness measures and would be important links in communication and relief distribution during emergencies. Eight market towns identified to serve as monitoring centers are Narendranagar, Duadhar, Fakot, Gaja, Chaka, Gular, Tapowan and Bedadhar (Fig. 5 a; b). The accessibility of all these identified market towns is of very good accessibility category, except for Bedadhar which is located on a fair weather road.

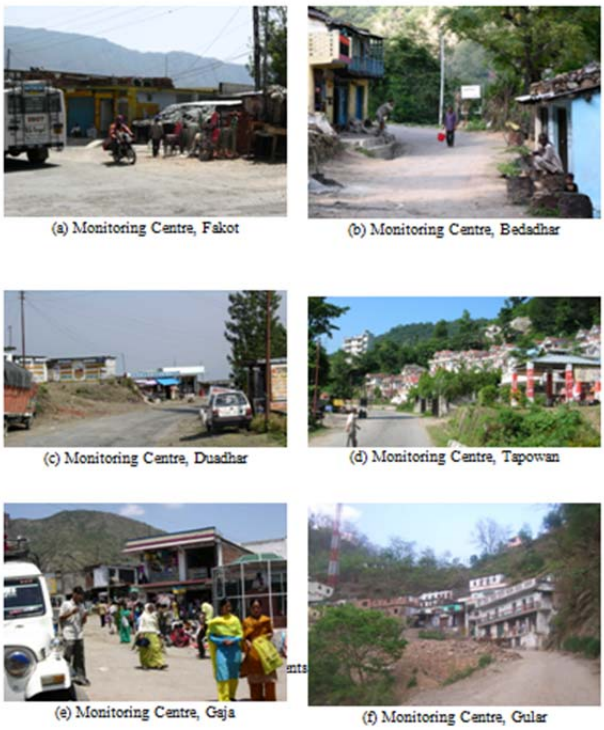

Fig. 8: Monitoring Centers of Narendranagar Block

These towns have better infrastructure availability as compared to other settlements. A wide variation in the cumulative damage experienced by the settlements under different monitoring centers would introduce complexities for higher level decision makers during emergencies. Uniform damage quantities would facilitate ease for resource allocation and formulation of policies for preparedness measures. The range of building damage assessed in terms of human casualties under each monitoring center is taken as 100 to 150 dead or un-savable persons and 150 to 220 life threatening cases.

Relief Centers

The identified relief centers are the settlements which would act as central places for group of rural settlements within easily approachable distance of 0 to 8 kms. These relief centers would host various important functions particularly relief camps and medical camps. A total of 34 relief centers are proposed for operation under the 8 monitoring centers (Fig. 5 a; b). The criteria for identifying the settlements as relief centers are:

1. *Accessibility conditions*: The settlements identified as relief centers have better accessibility conditions than the villages it would serve. This would facilitate easy procurement of relief material and easy transportation of material and injured people for the dependent villages.
2. *Part of same administrative sub division*: The existing administrative sub division of settlements is used as far as possible. This means villages under same gram panchayat or same kshetra panchayat are assigned to the same relief centers as far as possible.
3. *Distance of dependent villages*: The distance of dependent villages under each relief center is determined to be between 0 to 4 kms for walking distance and 0 to 8 kms for vehicular distance.
4. *Available facilities*: As stated by UNDRO [17] “a plan must, so far as practicable, use existing structures rather than create new ones. In the atmosphere of crisis and pressure which commonly attend any disaster situation, it is better, whenever practicable, not to ask or require people to change habits of work or their professional associates”. Hence, preference is given to the settlements where important facilities like health, education, food and other infrastructure already exist.
5. *Total Population and Extent of damage*: The total populations under relief centers range from 1500 to 2000 for highly vulnerable villages, while 2000 to 6000 for villages with low vulnerability. This is decided on the basis of estimated building damage calculated by the hypothethetical earthquake scenario studies [6].

Damage assessment activities

Table 1 gives the tasks those need to be performed for preliminary damage assessment at each administrative level, the responsible person and material requirements for each task.

From the table it is known that communication facility is the most important requirement for Preliminary damage assessment. Proposed communication flowchart for damage assessment is given as Fig. 9.

Table 1 Activity analysis: Preliminary Damage Assessment

Administrative Level	Tasks	Responsibility	Requirements
Village, Gram Panchayat	Damage Assessment in village. Passing the information	Village Head	Control Room Satellite Phone
Kshetra Panchayat	Damage Assessment in village. Passing the information	Village Development officer	Satellite Phone Control Room List of Vs under KP
Block Control Room	Damage Assessment in village. Passing the information	BDO	Satellite Phones (10) Control Room Generator Set Computers with Internet Connection Fax Facility
District	Damage Assessment in village. Passing the information to higher admin level	DM	Satellite Phones (15) Control Room Generator Set Computers with Internet Connection Fax Facility

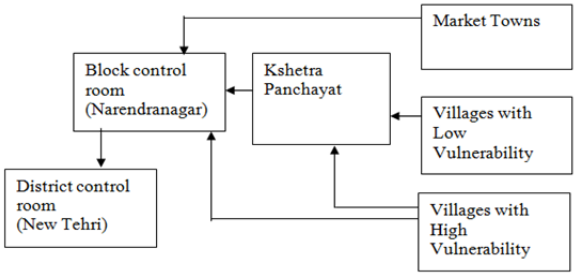

Fig. 9: Flow of information

8. CONCLUSION

Building damage assessment after earthquakes is the most crucial activity of earthquake disaster management as it forms the basis for planning of all the rescue and relief activities. The unpredictable nature of earthquakes and urgency of the damage assessment activity makes the disaster management authorities dependent on the community. Community is always the first responder and hence this important human resource needs to be effectively trained for building damage assessment for planning realistic post disaster management operations.

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