Rehabilitation of the Housing Stock in the Earthquake Affected Areas of Chamoli and Rudraprayag

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An earthquake hit the Chamoli/Rudraprayag region on 29th March,1999 at midnight hours measuring 6.8 on the Richter scale. The epicenter was located at 30.49 North and 97 29 East, north of Chamoli town. Its depth of focus was about 30 kms below the surface of the earth. The maximum damage intensity observed in the epicentral area was measured VIII on the Modified Mercalli Intensity Scale. Various towns and villages located within a radius of 12-15 kms in the North-South direction and 20 kms in the East-West direction suffered the maximum damages. The epicenter of this earthquake lay in the Zone V of the seismic zoning map of India as per BIS 1984.

The brunt of the earthquake was borne by the Chamoli, Rudraprayag, Tehri and Pauri regions As per estimates as many as 1,60,000 housing units were damaged in these four regions only The earthquake reportedly affected 804 villages and cost damages to public and private property, besides the loss of about 140 human lives and injuries to about 400 persons in the areas including Gopeshwar, Chamoli, Pipalkot, Birahi, Panarani, Jhenipani, Karanprayag, Rudraprayag, Gauchar, Tilwara, Mandakani, Bhatwari, Agastmuni, Nandaprayag and Pagna

Infrastructure services like water supply, electric lines etc. were affected only to a limited extent But the main damage was to roads due to a number of landslides and some cracks developed in the roads across the length and along the length also. These required special and immediate attention before the onset of the monsoon.

Amongst the towns and villages, maximum damage was observed in old Chamoli town where non-engineered buildings built using random rubble masonry in mud with thick walls particularly the Jail building, Forest Department Building and some private houses collapsed totally causing the loss of precious human lives. It was observed that buildings with some engineering input with good quality construction using regular masonry units like concrete blocks/bricks either in load bearing or coloumn beam construction suffered less damage even near the epicentral area.

Non-engineered building collapsed due to eartquake in Chamoli

The State Government and other agencies like HUDCO, BMTPC and CAPART took up the task of assessment of damages and of working out an action plan for rehabilitation of the earthquake victims.

The Action Plan included the following initiatives:

1. Zonation of Affected areas and estimates of total loss of buildings
2. Technical Guidelines for the Field Assessment of Damage by Revenue and Technical officials and trained volunteers
3. Guidelines for identification of settlement and infrastructure and infrastructure vulnerable to landslide and rockfall risk.
4. Development of a Technology package for Repair and Reconstruction of damaged buildings and specifications and cost estimates of the same
5. Technical Manuals for Repair, Reconstruction of buildings
6. Community based rehabilitation and disaster mitigation measures and the role of NGOs and the community
7. Preparation of Financing Plan based on the above Reconstruction Action Plan, for presentation to Financing Institutions.

Initiatives

Zonation of Affected Areas and Estimates of Total Loss of Buildings

Initial damage assessment was carried out at Rudraprayag and Chamoli districts immediately after the earthquake by the untrained Revenue Officials. They reported 12,306 houses as completely damaged and 71,333 as partially damaged in Chamoli district and 7,014 houses as totally destroyed and 14,677 as partially damaged in Rudraprayag district. 3,532 villages were reported affected in Chamoli and 643 in Rudraprayag district. Most of the affected villages came under the Mandakini and Alaknanda basins Also the resultant landslides had blocked four main roads in the regions, Chamoli-Gopeshwar, Gopeshwar-Okhimath, Karnaprayag-Almora and Rudraprayag-Gaurikund roads

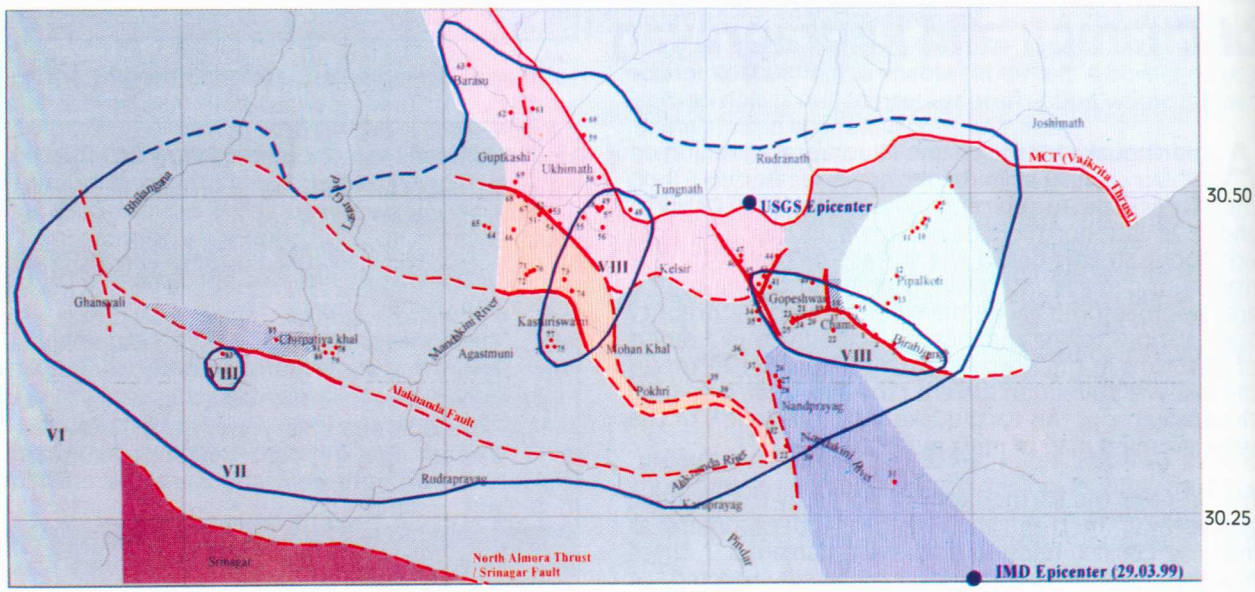
The primary cause of damage to buildings in this area was identified as failure of random rubble masonry in mud mortar like corner separation of masonry, damage and collapse of gable wall masonry, delamination, vertical, horizontal and diagonal shear cracks and masonry bulging

The damages were assessed on the basis of various parameters like the extent of cracking and the extent of collapsed structural elements in each unit They were categorized in damage categories G0 (no damage) to G5 (total collapse) that have been developed by CBRI.

About 200 teams of technical staff from different State Government departments were constituted for conducting the damage assessment scientifically. On an average each team surveyed approximately 200 villages and took 15 to 30 days to complete the survey In each house each and every detail regarding the current situation was recorded. Community asset buildings like Schools, Gram Panchayat office etc. were also inspected and the total loss expected was to the tune of Rs.57,00,00,000 An abstract of the survey report is presented in Table 1. It can be seen from the Table that extensive damage had been caused in the Rudraprayag region especially in the G4 and G5 categories.

Map of Area Affected by the Chamoli Earthquake (29 March 1999)

showing Gelological Features, Observed Ground Fissures and Damage Intensities



GEOLOGICAL FORMATIONS

- Baijnath Crystalines
- Carbonates of Tejam Formation
- Vaikrita Group
- Garhwal Groups
- Munsiyari-Bhilangana Group
- Granitoids Within Garhwal Group
- Almora-Dudatoli Crystalines
- Intrusive Granite Gneisssma

LEGEND

- Fault/Thrusts
- Active Fault/ Thrusts
- •31 Fissures (with Indentifier Number)
- Isoseismal VIII Zone
- Isoseismal VII Zone

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BMTPC/TARU Chamoli Earthquake Repair & Reconstruction Plan

As an intermediate action, the task force felt that the survey information could be used to identify the exact causes of failures and could help in identifying measures to prevent such failures. The study could then be used to develop type designs with appropriate construction materials and technologies for a disaster resistant construction especially in the hilly terrain. Competitions could be invited for a wider participation and more creative input.

In long term actions those units needed to be identified that required retrofitting to make them disaster resistant. The notified unsafe houses were to be reconstructed. Necessary support in the form of technical and financial terms required to be made available. Help of NGOs could be taken to mobilize public awareness and need for such measures. Also, for new construction in these areas Techno-Legal and Techno-Financial regime needed to be strictly enforced. Any new construction required compliance with the IS codes and loan assistance to be granted only after such compliance.

Technical Guidelines for the Field Assessment of Damage by Revenue and Technical Officials and Trained Volunteers

The survey teams were drawn from the revenue and the engineering departments of the Government of Uttar Pradesh. It was essential to devise a methodology of survey so that it could be conducted with minimum scope for manipulations as the grants were being released. The field staff and the volunteers had to be trained on the intricacies of the procedure. For this extensive training was imparted, initially to a selected staff of 107 engineers by CBRI (on classification and assessment of damage) and subsequently to 175 engineers by HUDCO and BMTPC under the guidance of Dr. A.S. Arya.

The performa used for the survey incorporated details on structural damage, type of construction method for walls, roofs, flooring, type of mortar and details of columns and beams for RCC structures. It also included sketches of each floor with standard indications for types of damages to be shown in these sketches.

Intermediate and long-term perspectives included standardization of categorization of damages for different geo-climatological regions of the country. The standardization would ensure systematic damage assessment that could be related to various rehabilitation efforts and could be easily understood by all. This helped in saving precious time in the post-disaster scenario.

The Guidelines for Identification of Settlement and Infrastructure Vulnerable to Landslides and Rockfall Risk

The Uttarakhand region of the Himalayan ranges has been identified as extremely prone to landslides and rockfall, as witnessed in the earthquake in the recent past as well as during the Malpa and the Okhimath region landslide. The University of Roorkee has done considerable work to identify high hazard zones of landslides in the Chamoli region under the leadership of Dr A.K.Pachauri.

The State Government has also identified 22 villages that need to be relocated to safer locations from the point of view of landslides and rockfalls. The concerned District Magistrates are preparing the final list.

The identification is being done in coordination with the Geological Survey of India and the Dept. of Geology of the State Government. This depends on geological data, stability of slopes, soil properties, drainage profiles and activities like mining which make the area vulnerable.

The relocation of villages is a sensitive issue regarding close coordination between the Dept. of Forests, Dept. of Environment, Dept. of Industries, and other land owning agencies of the State Governments in close association with the local communities. In an exclusive Task Force meeting at Lucknow, the important issue of designing proper drainage system co-related with microsheds was identified as an important aspect that could reduce the risk of landslides and rockfalls considerably. Dr.Pachauri's micro-zonation map could be of significant use here.

> It was also brought out in the meeting that the villagers were reluctant to move to safer locations due to socio-economic reasons. Therefore the community would need to be involved right from the beginning in finalizing the new location of where they were to be shifted.

In intermediate and long term initiatives, it was felt that a detailed study was required for exploring landslide events and their possible correlation with earthquakes and rupture zones using GPS measurements and crustal deformation. Early warning systems needed to be installed. The Task Force also stressed on the need for community involvement to ensure the success of the relocation exercise. No disaster mitigation strategy can succeed in the hilly regions unless it is a part of an overall comprehensive hill area development efforts including zonation, settlement plan, water resources planning including construction of dams, control over mining and other activities

Development of a Technology Package for Repair and Reconstruction of Damaged Buildings and Specifications and Cost Estimates of the same

The rehabilitation of the damaged and vulnerable houses by strengthening, retrofitting and reconstruction using disaster resistant technologies invariably calls for a package identifying the right choice of building materials coupled with appropriate building construction methods. The skills of local artisans need to be upgraded for them to be able to successfully implement these technologies in the field. The community as a whole must accept the changes required to make their dwellings disaster resistant The resistance of the community can be addressed only by providing them complete information on this and by showing them that these indeed are beneficial to them

Some of the actions initiated in the affected areas to showcase the technology package are:

1. DEMONSTRATION UNITS – These serve a two-fold function
   - to propagate various earthquake resistant technologies using locally available material, and
   - to incorporate the vernacular architectural style and tradition prevailing in the area 20 demonstration units have been taken up in the districts of Chamoli (10 nos.), Rudraprayag (5 nos.), Tehri-Garhwal (3 nos.) and Pauri (2 nos) with the grant-in-aid assistance from HUDCO to the tune of 30 lacs. Out of these 12 are in advanced stages of construction
2. BUILDING CENTRES – The survey of the damage assessment showed that the main reason for the extent of damage of buildings was due to non-engineering building construction without incorporating the earthquake resistant features and the poor quality of workmanship. One of the main aspects of rehabilitation and mitigation methods is to train local people and masons on the need to incorporate earthquake resistant features and better workmanship The availability of materials is also equally important. New and innovative building materials also need to be made available to the people. In view of the same, 8 Building Centres, 4 Sub Centres and 2 Mobile centres are being established These will act as training centres, production centres and will be able to execute work of demonstration value. 5 are already functional and the remaining 3 would soon be functional. So far 175 engineers and 414 masons have been trained and each centre is expected to be able to train 500 persons during the next 4-month period. Pamphlets published jointly by the State Government, HUDCO and BMTPC highlighting the measures to be taken to make an earthquake resistant building have been widely distributed. BMTPC has also prepared a technical manual to be circulated amongst the technical staff of various government departments and building centres. The trainees are being given hands-on experience on building material production and its use A stipend of Rs 75/- per day has also been fixed to meet conveyance and boarding expenditure Training schedules are being published in various newspapers and video coverage on training is also being given
3. MODEL VILLAGES AND MODEL BASTI – To make live implementation of earthquake resistant technologies (for houses under G4, G5 categories) and repair and retrofitting methods (for houses under G1, G2, G3 categories), HUDCO has adopted 2 model villages (1 in Chamoli – village Gingarana and 1 in Rudraprayag – village Kansali) and 1 model basti in Gopeshwar. HUDCO has provided a grant assistance of Rs 35,00,000 for each of these model villages and the model basti totaling Rs 1,05,00,000.

Intermediate and long-term initiatives include establishing demonstration units at many locations, continued training of masons, introduction of relevant courses relating to disaster awareness and management from school level to undergraduate level, opening an institute at Srinagar/ Gairson to be called 'Disaster Mitigation and Management Center' to exclusively focus on disaster related issues, establishment of a center of excellence at Kumaon to demonstrate various local building materials and construction techniques with special reference to disaster resistant features and establishment of a 'Museum of Damages and Safer Construction Technologies' .

Technical Manuals for Repair, Reconstruction of Buildings

Proper documentation of right technologies and appropriate building material for disaster resistant construction is important for effective implementation of the same. Technical manuals are therefore of extreme importance and they need to be brought out in a comprehensive manner

In this regard HUDCO has brought out various guidelines incorporating do's and don'ts for reconstruction, repair etc. using disaster resistant features showing pictorial representations of the common mistakes that are committed during construction and also the simple precaution that need to be taken to make the unit disaster resistant. These pamphlets have been brought out in vernacular languages for a wider reach. More than 20,000 copies of these pamphlets have been distributed in the various affected areas.

BMTPC has brought out general technical brochures on guidelines for damage assessment and post-earthquake action giving details of methodology for repair and

retrofitting of building affected by the earthquake and also special ones for Chamoli.

In the intermediate and long-term perspective it is essential to sustain the public interest in alternative technologies This requires that the initial stages of the work be of high quality and a strict quality control mechanism be put into place with adequate facilities for field testing and strict supervision

Building materials produced in the various building centres must adhere to requisite quality standards and the State Government should set an example to use these materials and technologies.

These building construction features can also be propagated through posters displayed in prominent areas. A manual can be brought out incorporating basic designs for various types of dwelling units as used for the demonstration units being constructed by HUDCO. A competition can be organised for a wider participation and creative inputs. As a confidence measure, efforts made for a live demonstration of the effectiveness of the retrofitting measures in 5-10 villages can be filmed for subsequent use.

Community Based Rehabilitation and Disaster Mitigation Measures and the Role of NGOs and the Community

The people settled in Garhwal hail from the states of Punjab, Maharashtra, West Bengal and other parts of U P. and Rajasthan, who had migrated from Tibet and settled in the Region more than 1000 years back There are also some communities that have migrated from Tibet. Initially the main occupation was agriculture and animal husbandry but now for about 30 per cent of the families, the source of income is from the defence services or other government jobs and the other 70 percent is from agriculture, animal husbandry, casual labour, wool weaving and other similar businesses Tourism also forms some of the income. The patriarchal, joint family system prevails and the literacy level is around 60 per cent. Normally the average size of the community/village is about 60 families.

Around 1,500 NGOs are registered and are working in the Garhwal Region but very few are working in the field of housing Their main sources of funding are grants from the central and state government organizations They also get funds from international donor agencies like the World Bank, from European countries and from the corporate sector Mahila Mandals are active in most villages and youth organizations, which organize cultural, awareness on sanitation and other such programmes in the area. The NGOs are working at the micro level and are directly responsible to the people. They can play an important role in the proper implementation of any rehabilitation scheme.

Temporary Shelters are the most important relief action taken up by the government in the affected districts to provide a safe roof over the heads of the disaster affected families. For this a total of 1077 sites have been selected out of which 731 are in Chamoli, 380 are in Rudraprayag, 200 are in Pauri and 250 in Tehri and 84 out of these had been handed over by 29th August1999.

CAPART has been identified as the nodal agency to coordinate with various NGOs working in this area for community based rehabilitation and various disaster mitigation measures. In turn, CAPART has identified 8 NGOs to execute 240 temporary shelters and to shift the severely affected families. (215 had been built and 706 families had been shifted till the time this report was being made) A sum of Rs 2,00,00,000 has been earmarked, out of which Rs. 20,00,000 is for activities which also include organizing training programmes for masons and builders Other activities include making the people aware about the earthquake measures to be taken while constructing, future disaster preparedness and forming a group of volunteers in each village. NGOs shall also be working in certain villages vulnerable towards landslide and rockfall, at confidence building measures and at convincing them about the need for relocation

HUDCO through its established Building Centres is seeking involvement of the NGOs from the local areas for providing training, awareness and to involve them in production and marketing of various Building Centre products Volunteers from various NGOs will be selected and shall be trained to propagate these technologies at the villages (100 in Chamoli district, 50 each in Rudraprayag, Tehri and Pauri). This program is proposed to commence from September 15th, 1999 and last upto December 15th, 1999)

Preparation of Financing Plan Based on the Above Reconstruction Action Plan for Presentation to Financing Institutions

The state government has announced the following grant assistance for various categories of damaged housing units in the region

G5	Rs 25,000	
G4	Rs 15,000	For retrofitting
	Rs 25,000	For reconstruction
G3	Rs 7,500	
G2	Rs. 2,500	
G1	Rs. 800	

The total liability of the State Government works out to be Rs. 81,12,00,000. Apart from this the Central Government's assistance under the IAY has been provided for 3,000 units with a grant assistance of upto Rs. 22,000 each. The State Government has also tied up with the State Bank of India (Rs 25 crores to about 7,000 beneficiaries for provision of subsidized loans The State Government would also be giving a one-time interest subsidy of 3 per cent on these loans to SBI. For the repair of damaged Community Asset Building, the funding is yet to be tied up by the State Government. HUDCO has offered to provide the requisite funding to the State Government. CAPART has also contributed about Rs. 2 crores for construction of temporary structures

The grants need not be distributed to the beneficiaries in cash can also be routed in the form of building materials produced by the building centres.

Finally, the Task Force has also made a suggestion towards creation of a 'National Natural Disaster Mitigation Fund', which could be created at the national level with contributions from the State Governments and donor agencies. A mechanism can be developed for the release of such funds in case of any natural disaster

Name of District	Number of Houses Damaged				
	G1	G2	G3	G4	G5
CHAMOLI	19,487	21,900	13,757	2,949	625
RUDRAPRAYAG	9,126	12,518	11,500	5,099	1,008
TEHRI-GARHWAL	21,027	27,043	14,748	3,149	479
PAURI-GARHWAL	7,089	5,731	2,087	183	69
TOTAL	**56,729**	**67,192**	**42,092**	**11,380**	**2,181**