Original Research Paper Engineering

Earthquake Disasters in Hilly Areas(Case Study Uttarakhand) –Part II

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ABSTRACT

The earthquake of 1991 in Garwal district of Uttarakhand diverted attention towards salient features of local construction material, the points of vulnerability and listing of recommendations for precaution/rescue in case of such a disaster. In the continuation of paper "Earthquake Disasters in Hilly Areas" Part I this paper focuses on damage assessment and reconstruction in case of slight, moderate and severe disaster conditions. It highlights sensitive approach required in the architecture of hills which could enable disaster risk management from an architect's point of view.

KEYWORDS Earthquakes, Hilly Terrain, Vernacular Construction

Introduction

The winter of 1991-92 caused considerable hardship to the homeless people in the region of Uttarkashi, Tehri Garhwal and Chamoli districts of Uttar Pradesh. Not only did the housing and infrastructure was affected, but a large number of live stocks and a fair proportion of agricultural terraces were devastated. The difficult process of reconstruction was done by the outside agencies. People faced series of hurdles and difficulties before they can feel relative rescue. This process of reconstruction took two to four years during which time, the poor elderly and those families perished in the earthquake lived out in their emergency shelters. Disasters and associated losses cannot be measured but thoughtful construction methods can help reduce life loss and can certainly guide in better reconstruction of habitats.

Damage Assessment and Reconstruction

The following tabulations are an indicative guide for assessment and classification of damage listing, major repair and reconstruction activities. These are only broad guidelines which can be modified to meet local conditions. The damage classifications are based on the MSK scale and field data collected on the predominant mechanisms and forms of damage.

Table: 1 Guide to Damage Assessment and Repair of Earthquake Affected Buildings in Case Of Slight and Moderate Damage

Form Of Damage	Building Material			
	Timber or thatch roofed buildings on stone or other masonry walls	Slate roofed buildings on stone or other masonry walls	CGI roofed buildings on stone or other masonry walls	RC framed or roofed buildings on stone or other masonry walls
Cracking or fall of plaster	Usually unplastered./ Replaster in earth or cement mortar	Usually unplastered. Re-plaster in earth or cement mortar	Re-plaster in earth or cement mortar	Re-plaster in earth or cement mortar
Few small cracks in walls	Underpin affected masonry. Rake joints, wet and repair with long stone inserts or steel bars in rich cement mortar	Prop (support) immediate floor or roof. Underpin affected masonry. Rake joints, wet and repair with long stone inserts or steel bars in rich cement mortar	Underpin affected masonry. Rake joints, wet and repair with long stone inserts or steel bars in rich cement mortar	Prop immediate floor or roof. Underpin affected masonry. Rake joints, wet and repair with long stone inserts or steel bars in rich cement mortar
Damage to projections and chimneys	Remove or demolish and reconstruct with adequate reinforcement and rich cement mortar only if absolutely necessary.			

Source: Mitigating Natural Disasters, UNDRO. 1991: A Manual of Earthquake Resistant Non-Engineered Construction, ISET, 1989 and TARU field data.

Table: 2 Guide to Damage Assessment and Repair of Earthquake Affected Buildings in case of Heavy Damage

Form of Damage	Building Type			
	Timber or thatch roofed buildings on stone or other masonry walls	Slate roofed buildings on stone or other masonry walls	CGI roofed buildings on stone or other masonry walls	RC framed or roofed buildings on stone or other masonry walls
Few large and deep cracks in walls	Reduce roof load on walls. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire and rich cement mortar	Remove slate, timber, sub-structure and dead load of upper storey wall (if necessary). Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire and rich cement mortar	Reduce roof load on wall. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel bars, wire mesh and rich cement mortar	Prop roof slab. Reduce roof load on walls. Underpin affected wall section. Rake cracks and wet. Repair with long bond stones, steel reinforcing bars, wire and rich cement mortar

Failure of corner masonry bond	Reduce roof load on walls. Underpin affected corner section. Reconstruct using long bond stones, Cast concrete block and vertical steel reinforcing bars, where possible in rich cement mortar	Remove slate, timber, sub-structure and reduce dead load of upper storey wall (if necessary). Underpin affected corner section. Reconstruct using long bond stones, Cast concrete block and vertical steel reinforcing bars, where possible in rich cement mortar	Reduce roof load on wall. Underpin affected Corner section. Reconstruct using long bond stones, steel bars, Cast concrete block and vertical steel reinforcing bars, where possible in rich cement mortar	Prop roof slab. Reduce roof load on walls. Underpin affected corner section. Reconstruct using long bond stones, steel bars, Cast concrete block and vertical steel reinforcing bars, where possible in rich cement mortar
Gable wall damaged with large and deep cracks	Remove roof cladding and sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate, trusses and then relay cladding. Buttressing the gable wall or trying it at immediate level with steel tie rods are useful techniques.	Remove slate and timber sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate and trusses and then relay cladding. Buttressing the gable wall or trying it at immediate floor level with steel tie rods are useful techniques.	Remove roof cladding and sub-structure. Demolish damaged wall. Reconstruct masonry using proper through, corner stones or cast concrete blocks with vertical reinforcement bars in rich cement mortar if possible. Rebuild roof with wall plate, trusses and then relay cladding with adequate bracing. Buttressing the gable wall or trying it at immediate floor level with steel tie rods are useful techniques.	No Gable walls
Wall damage due to lack of wall plate restraint	Remove roof cladding and sub-structure. Repair damaged masonry using proper through stones. Lay and fix wall plate rigidity to the wall. Erect trusses and relay roof cladding	Remove slate and timber sub-structure. Repair damaged masonry using proper through stones. Lay and fix wall plate rigidity to the wall. Erect trusses and relay roof cladding	Remove roof cladding and sub-structure. Repair damaged masonry using proper through stones. Lay and fix wall plate rigidity to the wall. Erect trusses and relay roof cladding with adequate bracing.	Flat roof.
Shear cracks in masonry between openings	Reduce roof load on walls. Underpin wall above damaged masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RC bond	Remove slate and wooden sub-structure to reduce load on wall. Underpin wall above damages openings. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RC band	Underpin wall above damages masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RC band	Prop roof slab to reduce load on walls. Underpin wall above damages masonry. Reconstruct wall with small, centrally located opening. Bond new masonry to old with steel ties and rich cement mortar. Reinforce openings with a heavy timber frame or RC band
Minor foundation settlement	Reduce roof load on affected walls. Shore and Underpin overbearing wall and insert plinth beam across settled masonry section. This may require technical supervision.	Remove slate and timber sub-structure to reduce load on settled section Shore and Underpin overbearing wall and insert RC plinth beam across settled masonry section. This may require technical supervision.	Reduce roof load on affected walls. Shore and Underpin overbearing wall and insert RC plinth beam across settled masonry section. This may require technical supervision	Prop roof slab to reduce roof load on settled section. Shore and Underpin overbearing wall and insert RC plinth beam across settled masonry section. This may require technical supervision

Source: Mitigating Natural Disasters, UNDRO. 1991: A Manual of Earthquake Resistant Non-Engineered Construction, ISET, 1989 and TARU field data.

The technological options for building reconstruction in Garhwal will have to be drawn from both earthquake engineering experience and what is acceptable to the local people, otherwise, the reconstruction programme may risk a failure similar to the early years of the Indira Awas Yojna (IAY) programme or even the lack of use of the emergency "Kedar Hut" community shelters provided by the government. The applicability of these inputs has to be appropriate and also timely.

The local population was found to be fairly clear about the materials that they would like to use in the reconstruction. In most areas slate and RCC have been rejected as roofing options, because they have caused considerable causalities. Random rubble walls in mud mortar have also been perceived as the major cause of failure. However, the lower floor of building will continue to be built in stone. Two situations to the masonry failure problem have emerged locally: timber framing or RCC tie beams and CGI sheets as the only roof cladding option.

The dominant view is to retain the traditional form of house, especially in the higher altitudes where poor communities are dependent on cattle. The broad building specifications would therefore be a ground floor in stone masonry with adequate reinforcement, an immediate timber floor, an upper floor with timber framing and planks and a roof CGI sheet on timber planking.

Given the high altitudes, remoteness and poverty of the people, the scale of reconstruction work is large, both in terms of logistics and investment. The judicious use of technical input to augment and re- direct local effort would, therefore, enable cost reduction, faster execution and medium term disaster mitigation. An indicative set of technology related interventions would, therefore be:

- Providing access to timber, stone and CGI sheets for low income households.
- Up gradation and reinforcement of traditional walling.
- Construction with light weight materials.
- Upgrading masonry and carpentry skills on a mass scale.
- Setting up a material production and technical support system through permanent building centers or sub centers.
- Demonstration of earthquake resistant house design.
- Resetting building and settlements on risk free sites.
- Demolition and/or propping up of hazardous buildings.

Conclusion

Following the earthquake, most households have very low asset holdings and incomes and will not be able to afford to repay loans for houses with conventional technology in near future. It will, therefore, be necessary to largely rescue building materials (slate, timber and stone local materials of the area) from collapsed or demolished houses. The estimated investment required for unit will now range from Rs. 1,500 to Rs.1, 00, 000.

The primary agency of reconstruction should be the local people using local materials being supplied through the state government. Technical support and training should be provided on a large scale to artisans and contractors with the help of agencies like District Building Centers, Central Building Research Institute, the Building Materials and Technology Promotion Council, along with qualified non-government Organizational groups. The coordination between locals and government along with retrofitting measures can strengthen preparedness for the calamity.

References

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