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सत्यमेव जयते
Government of India
Ministry of Home Affairs

Manual for Restoration and Retrofitting of Rural Structures in Kashmir

How to Reduce Vulnerability of Existing Structures in Earthquake Affected Areas of Jammu and Kashmir

IN/2007/CL/18

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This manual is based on the Technical Guildelines for "Repair, Restoration and Retrofitting of Masonry Building in Earthquake Affected Areas of Jammu & Kashmir" by the National Disaster Management Division, Ministry of Home Affairs, Government of India.

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Foreword and Acknowledgements

UNESCO's project on Natural Disasters and the Built Environment was initiated by UNESCO New Delhi in cooperation with UNESCO Islamabad in November 2005, following the tragic earthquake of October 2005. The project began with documentation and assessment of the damage to the built environment undertaken in collaboration with Ritsumeikan University of Kyoto, Japan, INTACH Jammu & Kashmir Chapter and students from the Bangalore School of Architecture. As a result of this initial reconnaissance, UNESCO identified the need to discuss and display a practical approach to the restoration and retrofitting of Kashmir's rural buildings.

UNDP and its Disaster Management Team (UNDMT) joined as a key partner in this initiative. UNDMT has been working in tandem with the Government of India to evolve a National Disaster Management Plan to combat natural disasters. The major goal of the UN mission in India has been to advocate for a reduction in vulnerability and engage with the Government of India in building capacity for disaster preparedness and management, thus reducing the incidence of complex emergencies and natural disasters and promoting sustainable recovery and transition after they occur. In this regard, UNDMT has been involved in relief, rehabilitation and capacity building programmes in Disaster Risk Management in earthquake prone states such as Gujarat and Kashmir, and has undertaken a large number of training workshops on repair and retrofitting of the built environment with the guidance of Prof. A.S. Arya, National Seismic Adviser to the Government of India.

International experts in seismic engineering and cultural heritage from around the world gathered in March 2006 to discuss and review a first draft of the present *Manual for Restoration and Retrofitting of Rural Structures in Kashmir* commissioned by UNESCO and prepared by the National Centre for People's-Action in Disaster Preparedness (NCPDP) of Ahmedabad. A UNDP/UNESCO workshop for engineers in Kashmir, held in June 2006 in Srinagar and supported by the Government of Jammu and Kashmir, helped to focus the manual on the composite rural structures of Kashmir. As a result the manual concentrates on buildings mainly constructed with load bearing stone and brick masonry with reminiscent of the traditional *Dhajji Dewari*, *Taaq* and wood constructions, altered and added to with non-traditional interventions such as concrete walls, floors and corrugated iron roofs. These mixed non-engineered structures are highly complex in their reaction to earthquakes and particularly dangerous for the people living in them. There is an urgent need for an engineers' analysis to understand their potential reaction to earthquakes, as well as an initiative to retrofit them for better earthquake performance in order to help reduce the risk of these structures collapsing and people dying under the rubble.

This manual is based on the experience gathered by the NCPDP team during several months of visiting the earthquake areas of Kashmir following the 2005 earthquake, as well as earlier visits to the earthquake shaken regions of Maharashtra, Uttarakhand, and Gujarat. During these visits, the team worked with the local population on the assessment of the damaged buildings, their restoration and retrofitting. The case

studies displayed were developed with the kind support of Aga Khan Development Network (Daki in the Uri region of Kashmir) and the Building Materials and Technology Promotion Council (BMTPC), Government of India (Sub-District Hospital in Kupwada).

We would like to express our gratitude to the many institutions and individuals who generously supported this project, starting with Prof. Arya for his continuous guidance; the master building artisans Ustaad Nazir Ahmed, Ustaad Jalil Ahmed and Ustaad Mohmed Khalil and their teams, who retrofitted the Sultan Daki School; the J&K State Government for their partnership in the training of engineers, as well as the Ministry of Home Affairs, Government of India, for their assistance and cooperation in this effort. Thanks also go to the students of Bangalore School of Architecture, Mr Dakshath M Kidiyoor, Mr Kartnik Balla and Mr Rahul Kumar, to Mr Saleem Beg and Mr Hakim Sameer of INTACH J&K and the members of the UNDP team, Mr Sushil Kumar, Mr Sushil Chaudhary, Ms Ranjini Mukherjee and Ms Shafali Rajora. I also wish to thank my colleagues of the UNESCO team, Dr Ahmed Fahmi, Dr Rohit Jigyasu and Ms Nicole Bolomey. Last but not least, our deep appreciation goes to the authors of this manual, Mr Rajendra and Mrs Rupal Desai of NCPDP. The knowledge they have brought to bear from many years of research and field work has enabled UNESCO to disseminate through this publication the lessons learned from Kashmir. We hope they will be widely used by engineers, architects and construction companies as well as by the government officials concerned, to ensure together the future safety of the people who live in the beautiful region of Kashmir.

Minja Yang
Director and Representative
UNESCO New Delhi Office

1 July 2007

Preface

This manual has been prepared to assist in the restoration and retrofitting of structures located in the rural areas of earthquake affected Kashmir, situated in the northernmost area of India and in Pakistan. The earthquake that struck this area on 8 October 2005 destroyed and damaged several thousand houses and killed around one hundred thousand people.

The Kashmir region has witnessed frequent earthquakes in the past. But this earthquake demonstrated how extremely vulnerable the buildings in this region are. It also showed that when people build houses they do not seem to be aware of the threats posed by earthquakes.

As has been observed in other earthquakes, people are unable to assess the root causes of earthquake destruction. The 2005 earthquake shook the confidence of many Kashmiris in local building materials, and even in the techniques they had been using to build houses for centuries. The immediate reaction has been a strong desire to abandon traditional architecture and building systems and adopt cement- and steel-based construction, without understanding the long-term consequences as well as the viability of such introduced systems in the local context.

Some structures were totally destroyed by the earthquake. But many more were left standing, either damaged to varying degrees or with no damage at all. People in slightly damaged houses are likely to simply patch up the damage and continue living in them. But those in moderately damaged houses often think that these are beyond repair and thus want to demolish and rebuild them. Two main questions arise: 1) Is it really necessary to tear such a building down? 2) Are there enough resources and adequate knowledge to build a new earthquake-resistant structure? Financial assistance has been made available from a variety of sources, but the knowledge to assess the extent of the damage, to take decisions about restoration or new construction, and finally to decide on how to retrofit the existing structure or how to build a new earthquake resistant structure, is missing. This leads to a vicious circle in which post-earthquake construction perpetuates the vulnerability of buildings and their inhabitants to earthquakes.

There are simple ways to reduce the vulnerability of surviving buildings through a process known as retrofitting. This technique can be applied to buildings that appear to be severely damaged on account of delamination or collapse of their masonry walls, but whose roofs are completely intact and in place. In the absence of an awareness of the retrofitting option, most house owners will dismantle these houses at great cost and try to rebuild, usually at an even higher cost. This entails a huge and irrecoverable economic loss for the area, while people may end up with houses that are smaller and quite possibly unsafe.

Apart from being more cost-effective than rebuilding, retrofitting offers important advantages that make it a viable and attractive option. It can be done in phases depending upon the availability of funds, beginning with making a part of the house safer for immediate occupation. This eliminates the need for a temporary

shelter. In addition, the expense of demolition and debris removal is completely eliminated and the cost for new material substantially reduced. Finally, by transporting less material, the process of post-earthquake reconstruction becomes more ecologically viable.

Kashmir is a seismically active area, and earthquakes big and small will continue to occur. It is not possible to predict when and where an earthquake will strike, nor its intensity. It is therefore hoped that this manual will be useful to engineers, architects, contractors, masons and people who may be planning to retrofit existing houses and public buildings to reduce their vulnerability to future earthquakes.

The retrofitting measures recommended in this manual are compatible with the sustainable use of the most commonly observed materials in the existing built fabric in rural areas. The manual does not focus on traditional structures but looks at the practical implications of the existing mixed types of constructions commonly observed in Kashmir today. Furthermore, at this stage of housing rehabilitation in the areas affected by the 2005 earthquake, newly built houses which do not conform to the code requirements for earthquake safety could be made less vulnerable to future earthquakes through the application of these retrofitting measures.

It is important to note that the recommendations for restoration and retrofitting given in this manual are intended for the most common composite structures in rural areas of the State that were affected by the 2005 earthquake. These measures are not designed for the basic conservation of traditional and vernacular heritage buildings.

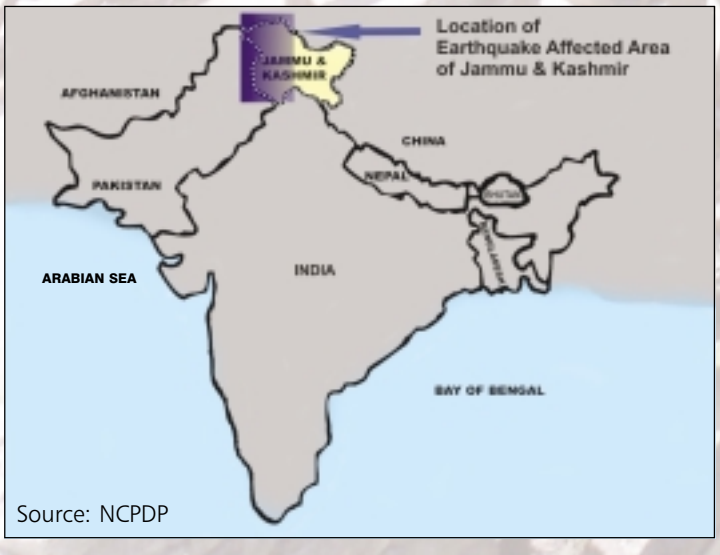
This manual is based on (a) a study that was undertaken immediately after the earthquake by a team of experts from NCPDP; (b) retrofitting work carried out in the earthquake affected area by the same team, on behalf of Building Materials and Technology Promotion Council (BMTPC), Government of India and Aga Khan Development Network (AKDN); (c) the *Guidelines for Repair, Restoration and Retrofitting of Masonry Buildings in Earthquake Affected Areas of Jammu & Kashmir*, issued by National Disaster Management Division, Ministry of Home Affairs, Government of India. The preparation of this manual was given a firm foundation by the team's practical experience over the past one-and-a-half decades in retrofitting hundreds of vernacular structures in widely differing regions of the country, including Maharashtra, Uttarakhand, Gujarat and Kashmir.

The manual contains sketches and detailed instructions that will be required by the engineer as well as the contractor. It also contains two case studies of buildings that were restored and retrofitted, to facilitate better understanding of the concepts and the system. Finally, to save the reader from having to search for the government's guidelines on new construction as well as retrofitting, a condensed version of these is provided in tabular form along with useful quantitative information. It is hoped that all this information will be put to use to reduce the vulnerability of all buildings that have not been built to withstand any future earthquakes in Kashmir.

Rupal Desai
Rajendra Desai
NCPDP

Contents

Chapter 1 Introduction to Area



Source: NCPDP

Kashmir is a region well-known around the world for its natural beauty and handicrafts. It is situated in the northern-most corner of the subcontinent with China along its eastern and northern boundaries. Since 1947 when India and Pakistan came into existence, the parts of Kashmir contiguous with Pakistan have been under Pakistan control and the rest have been under Indian control.

Common Precautions to be exercised, Based on Mistakes Observed at Sites

Basic Rules for Planning an Earthquake-Resistant House

1. When selecting a site on the sloping hill side for a building, a site adjacent to a stable slope should be chosen.
2. Any site near a hillside that is liable to slides during an earthquake should be avoided.
3. A site subject to the risk of rock falls should be avoided.
4. On a sloping site it is preferred to place several individual blocks independently on stepped terraces rather than placing the whole structure along a slope with footings at different heights.
5. Locating a structure on very loose sands or sensitive clays must be avoided.
6. Locating a structure on hard soil and rocky ground is preferred.
7. Constructing a number of smaller buildings is better than constructing one very large building.
8. In an earthquake a building with a square or round plan is safer than that with a rectangular plan.
9. If a rectangular plan is used, the length of the building should not be more than three times the width of the building.
10. A building plan symmetrical about both axes is better than an asymmetrical plan. 'L', 'T', 'C' and 'H' shaped plans are to be avoided.
11. If a projection of a room from the main structure is required, the length of the projecting wall must be limited to 15% of the overall length of the structure in that direction.
12. Symmetry is desirable in the placing of door and window openings.
13. Simplicity is the best approach for building design. Ornamentations involving large cornices, vertical or horizontal cantilever projections, facia stones and the like must be avoided.
14. A four-sided pitched roof is better than a two-sided pitched roof.
15. The height of the parapet walls in the terrace or balcony must be limited to three times the thickness of the parapet wall. It is better to build a lower masonry wall and provide an iron railing above.

During restoration pay attention to the following Principles of good practice;

The Making and Use of Mortars

1. Mix all dry ingredients of concrete and mortar thoroughly before adding water.
2. Do not use very fine sand in cement concrete.
3. Mud for mud mortar must be of good quality clayey soil. It must be kept wet at least for three days and must be thoroughly mixed every day before using it for mortar.

The Construction of Masonry Walls

1. Use only one type of mortar in the construction of the wall.
2. Wet the masonry units, including brick, stone, concrete block, etc. thoroughly in drums or tanks just before placing them on wall, so that they do not suck the water out of cement mortar. Reduction of water content in the mortar means weaker mortar.
3. In order to ensure good bond with the next course, on completing a masonry course its top surface must be clean with no mortar spread over it unless masonry units are going to be placed immediately on top of it. Hardened mortar weakens the joint with the next course or the band that will be placed above it.
4. Keep all vertical joints in the masonry wide enough so that the finger can be inserted in them and fill them properly with mortar.
5. Use tube level in every third or fourth course while use string in every course to maintain level and alignment, and for ensuring uniform thickness of mortar.
6. Use plumb-bob frequently during construction to ensure that the walls are vertical.

7. Brick or stone masonry column of single-storey height must have at least one 12 mm TOR rod that is adequately anchored in the base of foundation and to the roof at the top.
8. Doors and window openings must not be located at the room corners.
9. Provide the lintel level of all the openings at the same height.
10. The total width of all the doors and windows in a wall must not exceed 40% of the length of that wall.
11. Strictly adhere to the following Random Rubble masonry rules:
    a. Place each stone flat on its broader face.
    b. Place the stone in the wall such that its length goes into the thickness of the wall, resulting in the interlocking of inside and outside wythes.
    c. Provide at least one through stone in every 0.8 sq m (8 sq ft) of wall.
    d. Place long stone at the corner of each course, with length of the stone placed parallel to the length of that wall.
    e. Do not leave voids in masonry. Fill all voids in masonry using small chips of stone with minimum possible use of mortar.
    f. Never use rounded stones for masonry. Stones must be angular. It is not necessary to dress the stones fully like in Ashlar masonry.

The Construction of Floors and Roofs

1. Use a minimum of two nails for a proper wood-to-wood joint and always pre-drill all the timber before nailing.
2. Anchor RC slab to masonry wall by properly connecting the vertical reinforcement in the wall to that in the slab.
3. Use 6 mm MS or 8 mm TOR rod dowels suitably located and anchored in eave-level RC band and projecting up adequately, to anchor roof deck elements including truss bottom chords, beams and joists.

Dealing with Timber Elements

1. Adhere to good practice in wood construction using proper joinery.
2. When using nails or screws make sure that
    a. Holes are pre-drilled to minimize splitting of wood.
    b. Screws are never driven by hammer.

The Construction of *Dhajji* Walls

1. Top and bottom wall plates should be anchored to the RC band at top and bottom of the wall respectively, using MS brackets or 8 mm TOR rod dowels.
2. All connections between the vertical posts and the top and bottom wall plates should be made using metal strap and nails. The end posts adjacent to the masonry walls must be anchored to walls using 8 mm TOR dowels.
3. Horizontal struts must be installed at a vertical spacing not of 1 m between consecutive posts.
4. Diagonal bracings must be installed in every vertical bay between consecutive posts maintaining continuity from top of the wall to the base.
5. All connections of horizontal struts and bracings to vertical posts must be made using good carpentry practice in the joinery, but may be supported by wooden blocks no less than 50 mm thick to reduce splitting.
6. Where possible, the wooden blocks are to be attached first to the posts, followed by attachment of bracing and strut to the block.
7. When attaching the wooden block to the post, pre-drill the blocks in order to prevent splitting.
8. Chicken Wire Mesh may be installed on both faces of the wall to ensure confinement of the filler material. It must be well stretched to be effective in tension.

During Retrofitting Pay Attention to the Following Principles of Good Practice

Seismic Belt and Vertical Reinforcement

1. Study the possible alignment of full seismic belt before its installation to avoid unexpected obstructions later.
2. Use tube level to mark out the seismic belt alignment before plaster removal for better aesthetics.
3. Use electric grinder to make a groove along the top and bottom of belt alignment in order to minimize damage to plaster during its removal and to reduce cost.
4. Rake all joints adequately and clean the wall surface with wire brush within the limits of the belt and in vicinity of vertical reinforcement to ensure a good bond with the wall.
5. Ensure total embedment of WWM belt in cement mortar by keeping a 1/2" gap between exposed wall surface and WWM with the use of spacers, so that the mortar reaches behind the mesh.
6. Ensure adequate concrete cover on vertical reinforcement by ensuring a gap of 1½ to 2" between the rod and the wall.
7. Use wire nails for anchoring WWM in brick or concrete block walls, and use square headed nails in case of rubble wall. Remove and relocate loose nails to ensure that they are secure.
8. Concrete for vertical reinforcement must contain aggregates no larger than 1/2".
9. WWM must be galvanized for all applications on exterior wall
10. No end of WWM should be left unattached to other WWM: it should be attached either directly through overlap or indirectly through the use of overlapping dowel bars.

Shear Connectors and Bond Elements

1. Make dumbbell-shaped holes for shear connector and bond element, with the core just wide enough to permit insertion of the 8 mm TOR rod with hooked ends, in order to ensure its effectiveness in holding the wythes together and to reduce mortar consumption.
2. Prior to concreting, remove all loose material from holes and clean it with water.
3. In the case of rubble masonry walls, use aggregates no bigger than 1/4" in concrete. In the case of brick masonry walls, use only coarse sand in mortar.
4. Reinforcing bars must be fully encased in concrete.

Roof and Floor

1. With "in-plane" bracings made of wood, use at least two bolts at each end. If made of multiple strands of GI wires, use carpenter's hammer to pull each wire tight while installing, followed by twisting all the wires together in one direction for pre-tensioning.
2. For timber-to-timber connections use a minimum of two nails or screws for each joint. Pre-drilling is a must to prevent cracking of wood.
3. Secure the roof structure properly to the walls using MS angle brackets and bolts.

Dhajji Walls

1. All panels must have diagonal bracings to ensure continuity moving from the top to the bottom of wall.
2. Pre-drilling is a must to prevent splitting of wood.
3. Connections must be established between *Dhajji* wall and adjacent masonry walls.
4. Chicken Wire Mesh may be installed on both faces of the wall to ensure confinement of the filler material. It must be well stretched to be effective in tension.

Appendices

The information given in the following pages can be used to help calculate the quantity of materials required and the cost of the work to be carried out. The government's condensed guidelines provide useful quantitative information on various items that can be used for the retrofitting of different types of buildings.

Materials Quantity Estimate

Restoration & Retrofitting Work					
Sr. No.	Description of Items	Unit	Labour Rate	Materials Rate	Total Rate
1	Cast in-situ concrete Bond Element in 350 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	33.0	18.1	51.1
2	Cast in-situ concrete Bond Element in 450 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	38.0	22.8	60.8
3	Cast in-situ concrete Shear Connector for Seismic Belt in 350 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	33.0	19.9	52.9
4	Cast in-situ concrete Shear Connector for Seismic Belt in 450 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	38.0	24.6	62.6
5	Cast in-situ concrete Shear Connector for Vertical Rod in 350 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	35.0	23.5	58.5
6	Cast in-situ concrete Shear Connector for Vertical Bar in 450 mm thick wall with 8 mm TOR rod and infill of concrete 1:2:4	No.	40.5	23.5	64.0
7	Vertical bar foundation anchor 750x300x300 mm filled with 1:3:6 concrete	No.	81.0	281.5	362.5
8	Vertical bar at corners 12 mm dia TOR encased in 4"x4" triangle of 1:½":3 micro concrete	R.mt.	60.0	69.2	129.2
9	Vertical bar at corners 16mm dia TOR encased in 4"x4" triangle of 1:½":3 micro concrete	R.mt.	60.0	104.5	164.5
10	Vertical Seismic Belt 400 mm wide from foundation to top of wall, including bottom anchor, made with WWM having 14 - 13 gauge galvanized wires in longitudinal direction and cross wires at 50 mm spacing plus 2-6 mm dia MS and 1-12 mm TOR bars.	R.mt.	125.6	290.0	415.6
11	Vertical Seismic Belt 400 mm wide from intermediate floor to roof made with WWM having 14 - 13 gauge galvanized wires in longitudinal direction and cross wires at 50 mm spacing plus 2-6 mm dia MS bars.	R.mt.	122.6	232.3	354.8
12	12 mm MS Tie Rod for 1 m span (0.45 th. wall) threaded at both ends with 2 nuts and 100x100x5 mm MS bearing plate at each end.	R.mt.	51.3	182.5	233.8
13	G1 Crack Sealing with 1:2 cement sand mortar	R.mt.	1.9	5.9	7.9
14	G3 Crack Grouting with cement sand (1:2) mortar using appropriate grouting plasticizer	C.mt.	1,416.0	4,884.6	6,300.6

Note: All rates are based on 2006 June local rates for Uri area by road side site only. They are purely indicative only and should not be taken as standard.

Restoration & Retrofitting Work

Sr. No.	Description of Items	Unit	Labour Rate	Materials Rate	Total Rate
14a	G3 Crack Grouting in 350 mm thick brick wall with 30% cavity in crack	R.mt.	2.8	9.5	12.3
15	G3 Crack Grouting in 450 mm thick UCRC wall with 150% cavity in crack	R.mt.	17.0	58.6	75.6
16	Connection between belts using 2-10 mm TOR dowels through the 350mm wall with cavity grouted with 1:2:4 concrete	No.	66.0	69.3	135.3
17	Connection between belts using 2-10 mm TOR dowels through the 450 mm wall with cavity grouted with 1:2:4 concrete	No.	76.0	90.6	166.6
18	Timber attic floor to UCR wall anchor made of MS Angle 50x50x3 mm mounted on 600x250x35 mm wooden plate with 3-12 mm dia.bolts and connected to floor joist with 3-12 mm dia. bolts, with plate mounted on the Seismic Belt with 4-12 mm dia. bolts at its corners.	No.	167.1	216.2	383.4
19	Timber attic floor to brick wall anchor made of MS Angle 50x50x3 mounted on MS plate 150x150x3 with full length welding along both edged, connected to floor joist with 3-12 mm dia. bolts and connected to wall with 2-12 mm dia. studs that are anchored in to 15 mm holes and grouted with polyester/epoxy grout.	No.	167.1	312.7	479.8
20	Horizontal Seismic Belt 280 mm wide for length of wall < 5 m and also for opening encasement with 250 mm WWM having 10 - 13 gauge wires at 25 mm spacing and cross spacing of 75 mm plus 2-6 mm dia MS bars	R.mt.	66.0	149.4	215.4
21	Horizontal Seismic Belt 280 mm wide for length of wall length of 5 to 6 mt. with 250 mm WWM having 10 - 13 gauge wires at 25 mm spacing and cross spacing of 75 mm plus 4-6 mm dia MS bars	R.mt.	72.7	165.7	238.3
22	Horizontal Seismic Belt 280 mm wide for length of wall length of 6 to 7 m with 250 mm WWM having 10 - 13 gauge wires at 25 mm spacing and cross spacing of 75 mm plus 5-6 mm dia MS bars	R.mt.	76.6	173.8	250.4
23	5"x3" Wooden Bracing between vertical posts in varandah	No.	135.0	261.1	396.1
24	Wooden Bracing & Struts on upper side of wooden attic floor (approx)	Rmt	33.8	26.8	60.5
25	Horizontal Seismic Belt 280 mm wide for length of wall < 5 mt with 250 mm WWM having 10 - 13 gauge wires at 25 mm spacing and cross spacing of 75mm for crack stitching	Rmt	66.0	133.2	199.2

Note: All rates are indicative only and should not be taken as standard and are based on 2006 June local rates for Uri area by road side site only.

Material Quantities for Repair & Retrofitting Items

Sr. No.	Description	Quantity	Unit	Rate (Rs)	Amount (Rs)	Item Quantity	Item Unit
1	Cast in-situ concrete Bond Element in 350 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.18	kg	30.40	5.40		
	Cement	0.86	kg	6.14	5.31		
	Sand	0.00	cm	1,058.70	1.26		
	Aggregates	0.00	cm	1,293.97	3.09		
2	Cast in-situ concrete Bond Element in 450 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.22	kg	30.40	6.61		
	Cement	1.11	kg	6.14	6.83		
	Sand	0.00	cm	1,058.70	1.62		
	Aggregates	0.00	cm	1,293.97	3.97		
3	Cast in-situ concrete Shear Connector for Seismic Belt in 350 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.23	kg	30.40	6.91		
	Cement	0.86	kg	6.14	5.31		
	Sand	0.00	cm	1,058.70	1.26		
	Aggregates	0.00	cm	1,293.97	3.09		
4	Cast in-situ concrete Shear Connector for Seismic Belt in 450 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.27	kg	30.40	8.11		
	Cement	1.11	kg	6.14	6.83		
	Sand	0.00	cm	1,058.70	1.62		
	Aggregates	0.00	cm	1,293.97	3.97		
5	Cast in-situ concrete Shear Connector for Vertical Rod in 350 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.33	kg	30.40	9.91		
	Cement	0.86	kg	6.14	5.31		
	Sand	0.00	cm	1,058.70	1.26		
	Aggregates	0.00	cm	1,293.97	3.09		
6	Cast in-situ concrete Shear Connector for Vertical Bar in 450 mm thick wall					1	ea.
	Steel - 8 mm TOR	0.33	kg	30.40	9.91		
	Cement	0.86	kg	6.14	5.31		
	Sand	0.00	cm	1,058.70	1.26		
	Aggregates	0.00	cm	1,293.97	3.09		

Note: All rates are indicative only and should not be taken as standard and are based on 2006 June local rates for Uri area by road side site only.

Material Quantities for Repair & Retrofitting Items

Sr. No.	Description	Quantity	Unit	Rate (Rs)	Amount (Rs)	Item Quantity	Item Unit
7	Vertical bar foundation anchor 750x 300x300 mm filled with 1:3:6 concrete					1	ea.
	12 mm TOR steel	1.02	kg	30.40	31.08		
	Cement	14.87	kg	6.14	91.30		
	Sand	0.03	cm	1,058.70	32.59		
	Aggregates	0.06	cm	1,293.97	79.66		
8	Vertical bar at corners 12mm dia TOR encased in micro concrete					1	rmt.
	12 mm TOR steel	1.24	kg	30.40	37.83		
	Cement	2.00	kg	6.14	12.30		
	Sand	0.00	cm	1,058.70	2.19		
	Aggregates	0.00	cm	1,293.97	5.36		
9	Vertical bar at corners 16 mm dia TOR encased in micro concrete					1	rmt.
	16 mm TOR steel	2.21	kg	30.40	67.26		
	Cement	2.00	kg	6.14	12.30		
	Sand	0.00	cm	1,058.70	2.19		
	Aggregates	0.00	cm	1,293.97	5.36		
10	Vertical Seismic Belt 400 mm wide from foundation to top of wall, including bottom anchor, made with 13 gauge WWM plus 2-6 mm dia MS and 1-12 mm TOR bars.					1	rmt.
	galvanited WWM g13 50x50 mm	0.46	Smt	215.20	97.92		
	Steel - 6 mm	0.64	kg	30.40	19.59		
	Steel - 12 mm	1.29	kg	30.40	39.18		
	Cement	6.59	kg	6.14	40.49		
	Sand	0.01	cm	1,058.70	14.45		
	Nails	0.67	kg	45.00	30.00		
11	Vertical Seismic Belt 400 mm wide from intermediate floor to roof made with WWM plus 2-6mm dia MS bars.					1	rmt.
	galvanited WWM g13 50x50 mm	0.42	Smt	215.20	90.38		
	Steel - 6 mm	0.60	kg	30.40	18.24		
	Cement	6.59	kg	6.14	40.49		
	Sand	0.01	cm	1,058.70	14.45		
	Nails	0.67	kg	45.00	30.00		

Note: All rates are indicative only and should not be taken as standard and are based on 2006 June local rates for Uri area by road side site only.

Material Quantities for Repair & Retrofitting Items

Sr. No.	Description	Quantity	Unit	Rate (Rs)	Amount (Rs)	Item Quantity	Item Unit
12	12 mm MS Tie Rod in 0.45 th. wall with necessary fixtures					1	rmt.
	Steel - 12 mm dia MS	0.89	kg	48.00	42.67		
	Steel - MS Bearing Plates - 2 Ea.	0.47	Kg	48.00	22.61		
	Misc. - Nuts, threading, washers etc.	2.00	Nos.	31.00	62.00		
	Cement	2.22	kg	6.14	13.65		
	Sand	0.00	cm	1,058.70	3.25		
	Aggregates	0.01	cm	1,293.97	7.94		
13	G1 Crack sealing with 1:2 cement Sand mortar					1	rmt.
	Cement	0.65	kg	6.14	4.00		
	Sand	0.00	cm	1,058.70	0.95		
14	G3 Crack Grouting with non-shrink Cement Sand mortar						
	Cement	603.86	kg	6.14	3,707.73		
	Sand	0.83	cm	1,058.70	882.25		
	Grouting Plasticizer	1.81	Litre	275.00	498.19		
14a	G3 Crack grouting in 350 mm thick Brick wall with 30% cavity in crack					1	rmt.
	Cement	0.94	kg	6.14	5.78		
	Sand	0.00	cm	1,058.70	1.38		
	Grouting Plasticizer	0.00	Litre	275.00	0.78		
15	G3 Crack grouting in 450 mm thick UCRC wall with 150% cavity in crack					1	rmt.
	Cement	5.80	kg	6.14	35.59		
	Sand	0.01	cm	1,058.70	8.47		
	Grouting Plasticizer	0.02	Litre	275.00	4.78		
16	Connection between belts using 2-10mm TOR dowels through the 350 mm wall					1	rmt.
	10 mm Steel	1.54	kg	30.40	46.91		
	Cement	0.97	kg	6.14	5.97		
	Sand	0.00	cm	1,058.70	1.42		
	Aggregates	0.00	cm	1,293.97	3.47		

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Material Quantities for Repair & Retrofitting Items

Sr. No.	Description	Quantity	Unit	Rate (Rs)	Amount (Rs)	Item Quantity	Item Unit
17	Connection between belts using 2-10 mm TOR dowels through the 450mm wall					1	ea.
	10 mm steel	1.67	kg	30.40	50.67		
	Cement	2.22	kg	6.14	13.65		
	Sand	0.00	cm	1,058.70	3.25		
	Aggregates	0.01	cm	1,293.97	7.94		
18	Timber attic floor to UCR wall anchor made of MS Angle with all fixtures					1	ea.
	Anchor Brackets - MS Angle 50x50x3 12"x12" with three 13 mm holes in eacharm	1.38	kg	48.00	66.24		
	18"x10"x1.25" wooden plank	0.46	rmt	29.61	13.54		
	10" long 12 mm Dia. Bolt with 2 nos. woshers & 1 nos nut	1.00	kg approx.	60.00	60.00		
	3" long 12 mm Dia. Bolt with 2 nos. woshers & 1 nos nut	0.57	kg approx.	60.00	34.29		
	2" long 12 mm Dia. Bolt with 2 nos. woshers & 1 nos nut	0.38	kg approx.	60.00	22.50		
19	Timber attic floor to brick wall anchor made of MS Angle with all fixtures					1	ea.
	Anchor Brackets - MS Angle 50x50x3 mm 150x600x150mm long with holes in one arm	2.07	kg	48.00	99.36		
	Steel - MS Bearing Plates - 2 Ea.	1.06	kg	48.00	50.87		
	2-12mm dia. studs	0.67	kg approx.	60.00	40.00		
	3-12 mm Dia. 10" long Bolt with 2 nos. woshers & 1 nos nut	1.00	kg approx.	60.00	60.00		
	Hole grout with plasticizer	2.00	Nos.	17.01			
20	Horizontal Seismic belt 280 mm wide for length of wall <5 m & also for opening encasement					1	rmt.
	galvanited WWM gauge 13	0.25	smt.	215.20	80.00		
	Nails	0.45	kg	45.00	40.50		
	6 mm M.S.steel	0.44	kg	30.40	42.15		
	Cement	4.44	kg	6.14	31.96		
	Sand	0.01	cm	1,058.70	2.60		

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Material Quantities for Repair & Retrofitting Items

Sr. No.	Description	Quantity	Unit	Rate (Rs)	Amount (Rs)	Item Quantity	Item Unit
21	Horizontal Seismic belt 280 mm wide for length of wall 5 to 6 mt.					1	rmt.
	Galvanited WWM gauge13	0.25	smt.	215.20	80.00		
	Nails	0.45	kg	45.00	40.50		
	6 mm M.S.steel	0.89	kg	30.40	42.15		
	Cement	4.44	kg	6.14	31.96		
	Sand	0.01	cm	1,058.70	2.60		
22	Horizontal Seismic belt 280 mm widefor length of wall 6 to 7 mt.					1	rmt.
	Galvanited WWM gauge13	0.25	smt.	215.20	80.00		
	Nails	0.45	kg	45.00	40.50		
	6 mm M.S.steel	1.11	kg	30.40	42.15		
	Cement	4.44	kg	6.14	31.96		
	Sand	0.01	cm	1,058.70	2.60		
23	5"x3"x9' 6" wooden bracing connection to post in verandah					1	ea.
	5"x3"x9"6" long wooden member	1.00	Nos.	231.71	231.71		
	5" long nails - 3 at each end	0.15	kg approx.	38.00	5.70		
24	Wooden bracing & strut upper side ofwooden floor (Approx)					1	rmt
	8"x0.75" wooden planks	1.00	rmt	19.78	19.78		
	4" long nails Approx.	0.12	kg approx.	38.00	4.56		
25	Horizontal Seismic belt 280 mm wide for crack stitching					1	rmt.
	Galvanited WWM gauge13	0.25	smt.	215.20	53.80		
	Nails	0.45	kg	45.00	20.25		
	Cement	4.44	kg	6.14	27.25		
	Sand	0.01	cm	1,058.70	9.73		

Note: All rates are indicative only and should not be taken as standard and are based on 2006 June local rates for Uri area by road side site only.

Materials & Labour Rates for Kashmir (To be used for reference only)

Sr.No.	Items	Rs.	Unit
1	Aggregates	1293.97	cmt
2	Binding wire	50.00	kg
3	Bolts M.S.	60.00	kg
4	Bricks	3.33	no.
5	Carpenter	300.00	day
6	Cement	6.14	kg
7	Galvanited wire	60.00	kg
8	GI WWM	215.20	Smt.
9	Lime	6.00	kg
10	Mason	300.00	day
11	MPT	56.40	Smt.
12	MS plate	48.00	kg
13	MS section	48.00	kg
14	Nails	45.00	kg
15	5" long Nails	38.00	kg
16	Nuts	5.00	kg
17	Planks	54.00	cm
18	Plasticizer	240.00	Lts.
19	Rubble	399.19	cmt
20	Grouting Plasticizer	275.00	Lt.
21	Sand	1058.70	cm
22	Steel	30.40	kg
23	Timber	52935.00	cm
24	Unskilled	150.00	day
25	Water	0.50	Lts.

Note: All rates are indicative only and should not be taken as standard and are based on 2006 June local rates for Uri area by road side site only.

Tools and Equipment List

Equipment and Miscellaneous Items Needed

For Wall Preparation and Making Holes

- ✓ Rotary power drill with adequately long extension cord (if electric power is available), and drill bits of 1" and 2" dia. 12" long
- ✓ Electric grinder for plaster cutting
- ✓ Brick masonry hole-making tool: 1.25" dia. GI pipe 12" and 18" long
- ✓ Wire brush to clean the wall
- ✓ Tool for raking mortar joints

For Anchors and Concreting

- ✓ Bar bending set up (steel preferred to wooden) with rods welded to it
- ✓ Bar bending tool or 2' long 1" dia. And ½" dia. GI or MS pipes
- ✓ 5 kg sludge hammer
- ✓ Different size chisels for cutting steel rods, WWM and concrete, tongs to hold chisel
- ✓ Pliers with wire cutter, binding wire tightening tool
- ✓ Spanners for the wall anchor bolts
- ✓ Sheet metal for form work of corner vertical reinforcement concreting
- ✓ 6" to 4" long square-top nails, 6" to 4" long wire nails, both withwashers longer nails for walls in mud-mortar

For centering

- ✓ Scaffolding including wood poles and plans extending to min. 10' length along one wall and 15' length along another.
- ✓ Ladders (2 to 3 numbers) high enough to reach the upper storylintel level
- ✓ Coir String for scaffolding

For Mortar Mix & Plastering

- ✓ Shovel
- ✓ Pans
- ✓ Sieve for coarse sand
- ✓ Trowel
- ✓ Plastering tool
- ✓ 2"x1" wood batten for forming the lower edge of the ferro-cementseismic belt plaster, minimum 15' long and an aluminium straightedge 6' long.

Miscellaneous

- ✓ Torch
- ✓ Cotton string for marking
- ✓ Chalk / Marker / Charcoal

Materials

- ✓ Water
- ✓ Cement
- ✓ Polymer additives
- ✓ Coarse sand
- ✓ Aggregates (1/4") and (1/2")
- ✓ Adhesive powder or solution for good bond between old and newconcrete
- ✓ Steel rods 8 mm TOR, 10 mm TOR, 12mm TOR or MS as required
- ✓ Galvanized WWM as per the NDMD Government Guidelines.
- ✓ Binding wire
- ✓ 10 mm studs approximately 220 mm long.
- ✓ 1"x4" Planks
- ✓ 4" Wood nails with washer
- ✓ 2.5 mm or 3 mm GI wire

Glossary

English	Urdu	Pronounciation
Damaged	مخدوش	*Makhdush*
Shaking	تھرراہٹ	*Thartharaahat*
Continue	مسلسل	*Musalsal*
Severity	شدت	*Shiddat*
Construction	تعمیر	*Taamir*
Stepped	بتدریج	*Batadrij*
Basic rules	بنیادی اصول	*Buniyadi usoolo*
Severely damaged	شدید نقصان	*Shadid nuksaan*
Earthquake	زلزلہ	*Zalzala*
Dismentled	ڈھادینا	*Dha dena*
Structure	ڈھانچہ	*Dhancha*
Support wall / Load bearing wall	پشتہ کی دیوار	*Pushta ki diwar*
CGI roofing sheets	نالی دار چادر	*Nalidar chadar*
Totally collapsed	شدید نقصان	*Mukammal taur pe gira hua*
Damaged	نقصان زدہ	*Nuksan Zhada*
Restoration	اصلی حالت پر لانا	*Asli halat par lana*
Partially collapsed roof	جزوی طور پر گری چھت	*Zujavi taur par giri chat*
Inadequate	ناکافی	*Nakaphi*
Interlocking between stones	پیوست پتھر	*Bil aakhir*
Eventually	باالآخر	*Ehtiyat*
Fill up	منڈھنا	*Dambal numa*
Carefully	احتیاط	*Surakh*
Dumbell shaped	دمبل نما	*Mand na*
Hole	سوراخ	*Pevast Pathar*
Proportion	تناسب	*Tanasud*
End	سِرا	*Sira*
Different types	مختلف	*Mukhtalif*
Seismic belt	سیزمک پٹہ	*Sizmik patta*
Lintel	چھتنی	*Chhatni*
Eave	اولتی	*Aulti*
Frame	چوکھٹ	*Chokhat*
Level	سطح	*Satah*
Sloping edge	ڈھلواں سطح	*Dhalwah satah*
Galvanized	جستہ	*Jasta*
Raking	کریدنا	*Kuredana*

English	Urdu	Pronounciation
Reinforcement	سلاخ	*Salakh*
Inadequate bonding	ناکافی بندھن	*Nakaphi bandhan*
Option	اختیار	*Ikhatiyar*
Satisfactory bond	اطمینان بخش	*Itmenan Bakhsha*
Opening	شگاف	*Shighaf*
Anchor	پیوست	*Pevast*
Encase	خانہ بند	*Khana band*
All around	اردگرد	*Ird-gird*
Wooden / Truss	شہتیر	*Shatir*
Diagonal bracing	ترچھی لکڑی	*Tirchhi lakadi*
Strut	لمبی لکڑی	*Lambi lakadi*
Wood plank	تخت	*Takht*
Features	خصوصیات	*Khususiyat*
Affordable	قابل برداشت	*Kabile bardasht*
Easy to execute	آسان عمل	*Amal Aasan*
Local	مقامی	*Maqami*
Quality	معیار	*Mayar*
Same time, Together	بیک وقت	*Bayak-waqt*
Buttresses	پشتہ بندی	*Pushta bandi*
Resistant	مزاحم	*Muzahim*
Metal strap	دھات کی پٹی	*Dhat ki patti*
Wire-nail	تار کی کیل	*Tar ki kil*
Number, Quantity	تعداد	*Tadad*
Control	محدود رکھنا	*Mahdood rakhana*
Bond / Stitch	پیوند	*Pevand*
Enclose	احاطہ کرنا	*Ahata karna*
Plumb	شولہ	*Shola*
Tongue groove	چیری زیب	*Chiri Zheb*
Lap	وُڈبدھر	*Wudbathar*
Staggered	ٹھان پٹ	*Than pat*
Header	سیرو	*Siro*
Stretcher	باہی	*Bahi*
Through stone	بینڈ اسٹون	*Bond stone*
Wood chisel	تیشہ	*Tesha*
Saw	آری	*Aari*
Jack plane	رندھا	*Randha*
Hand drill	برما	*Barma*

Abbreviations

Abbreviations		Full Form
AC	=	Asbestos cement
approx.	=	Approximately
BBCM	=	Burnt brick in cement mortar
CM	=	Cement mortar
cm.	=	Centimeter
cmt.	=	Cubic meter
CWM	=	Chicken Wire Mesh
dia.	=	Diameter
Dist.	=	Distance
ea.	=	Each
Eqk.	=	Earthquake
Found.	=	Foundation
g	=	Gauge
GI	=	Galvanized iron
horz.	=	Horizontal
kg	=	Kilogram
km	=	Kilometer
ltr.	=	Litre
m	=	Meter
Max	=	Maximum
Min.	=	Minimum
mm	=	Millimeter
MPT	=	Manglore Puttern tile
MS	=	Mild steel
no./nos.	=	Number/Numbers
RC	=	Reinforced Concrete
RCC	=	Reinforced Cement Concrete
rmt.	=	Running meter
RRM	=	Random Rubble Masonry
sft.	=	Square Foot
smt.	=	Square meter
UCRC	=	Uncoursed rubble masonry in cement mortar
UCRM	=	Uncoursed rubble masonary in mud mortar
vert.	=	Vertical
WWM	=	Welded wire mesh
BMTPC	=	Building Material Technology Promotion Council
NCPDP	=	National Center of Peoples'-Action in Disaster Preparedness
NDMD	=	National Disaster Management Division
UNESCO	=	United Nations Educational, Scientific and Cultural Orgnization

Government of India Technical Guidelines at a Glance

Earthquake-Resistant Reconstruction of Masonry Buildings (Category E) For Wall Length of 5 m max.						
Sr. No.	Item	Stone masonry in Mud Mortar	Stone masonry in cement : sand Mortar	Brick masonry in cement : sand mortar	Conc. Block in cement : sand mortar	Additional Information
1	Wall thickness	450 mm 500 max	380 to 400 max	210 mm	200 mm	Stones in wall thickness to be interlocked with each other
2	Mortar	Good quality mud	Foundation 1:6, Wall 1:4	Foundation 1:6, Wall 1:4	Foundation 1:6, Wall 1:4	
3	Height of Masonry Courses	600 mm max.	600 mm max.	NA	NA	
4	Through Stones / Bonding Elements of full length equal to wall thickness	At 600 mm vertical &1200 mm horizontal spacing	At 600 mm vert. and 1200 mm horiz. spacing	Use headers (*Seere*) and stretchers (*Bahia*) and break all vertical joints	Use headers (*Seere*) and stretchers (*Bahia*) and break all vertical joints	50X50 conc. bar with 8mm rod or con.blk. 150X 150mm or wood battens 50X50 can be used
5	Long Stones, Conc.Blocks or wooden batten @ all wall corners & T junctions.	Every 600 mm. height	Every 600mm height	NA	NA	Long Stones to be 600 mm long, Conc. Blocks 150x150x500 mm.
6	Height of one storey	2.7 m max.	3.2 m. Max.	3.2 m Max.	3 m Max.	
7	Max. no. of stories	One	Flat roof -2 storeys/ Pitched roof - 1 Storey + Attic	Flat roof -2 storeys/ Pitched roof - 1 Storey + Attic	Flat roof -2 storeys/ Pitched roof - 1 Storey + Attic	
8	Span of walls between cross-walls	5.0 m max.	7.0 m max.	7.0 m max.	7.0 m max.	

Earthquake-Resistant Reconstruction of Masonry Buildings (Category E) For Wall Length of 5 m max.						
Sr. No.	Item	Stone masonry in Mud Mortar	Stone masonry in cement : sand Mortar	Brick masonry in cement : sand mortar	Conc. Block in cement : sand mortar	Additional Information
9	Pilaster/butress needed at intermediate point if span of wall is more than specified above					
	Spacing between pilasters	3.5 m max.	5.0 m max.	5.0 m max.	5.0 m max.	
	Top width equal to main wall thk.	450 mm	380 to 400 mm	210 mm	210 mm	
	Base width	450 mm or 1/6 of wall height	1/6 of the wall height	1/6 of the wall height	1/6 of the wall height	
10	Control of openings in walls					
	(a) Total length of all openings in a wall	0.33 of wall (outer) length	0.5 of wall outer length in single storey, 0.42 in double-storey bldg.	0.5 of wall outer length in single storey, 0.42 in double-storey bldg.	0.5 of wall outer length in single storey, 0.42 in double- storey bldg.	
	(b) Distance of opening from inside corner	length, Less than 600 mm	Less than 450 mm	Less than 450 mm	Less than 450 mm	
	(c) Pier width betwee consecutive openings	Less than 600 mm	Less than 600 mm	Less than 560 mm	Less than 560 mm	
11	Vertical reinforcement at jambs of openings					

Government of India Technical Guidelines at a Glance

Earthquake-Resistant Reconstruction of Masonry Buildings (Category E) For Wall Length of 5 m max.						
Sr. No.	Item	Stone masonry in Mud Mortar	Stone masonry in cement : sand Mortar	Brick masonry in cement : sand mortar	Conc. Block in cement : sand mortar	Additional Information
	One-storey bldg. or upper storey in two-storey bldg.	12 mm.TOR	12 mm.TOR	12 mm. TOR	12 mm. TOR	Encase in 75mm concrete 1:2:4
	Ground storey of two-story building.	NA	16 mm TOR	16mm TOR	16mm TOR	Encase in 75mm concrete 1:2:4
	When controls of openings are violated	Box Jambs in RCC 1:2:3	Box Jambs in RCC 1:2:4	Box jambs in RCC 1:2:4	Box Jambs in RCC 1:2:4	Thickness - 75 mm with 2 - 10dia TOR bars.
12	Vertical reinforcement at all inside and outside corners					
	One-storey bldg. or upper storey of two-storey bldg.	12 mm TOR or 'L' section of two timber planks 80x30 & 50x30	12 mm TOR	12 mm TOR	12 mm TOR	Encase rods in 75mm concrete 1:2:4. Nail timber planks to timber bands
	Ground storey of two story building.	NA	16 mm TOR	16 mm TOR	16 mm TOR	Encase in 75mm concrete 1:2:4
13	Continuous Horizontal Seismic Bands of 75mm thickness in all internal and external walls	lintel	lintel	lintel		
	Location of bands in Flat Roof building	Plinth, lintle level and at ceiling level if ceiling is of timber	Plinth, lintel levels in each storey & under floor/ceiling level in case of timber floor/eiling	Plinth, lintel levels in each storey & under floor/ceiling level in case of timber	Plinth, lintel levels in each storey & under floor/ceiling level in case of timber floor/eiling	Use 2-10 dia. Bar with 6mm stirrups @ 150mm c/c Overlap of bars-500 mm.

Government of India Technical Guidelines at a Glance

Earthquake-Resistant Reconstruction of Masonry Buildings (Category E) For Wall Length of 5 m max.						
Sr. No.	Item	Stone masonry in Mud Mortar	Stone masonry in cement : sand Mortar	Brick masonry in cement : sand mortar	Conc. Block in cement : sand mortar	Additional Information
	Location of bands in Pitched Roof building	Plinth, lintel and eave levels and at triangular masonry gable top	Plinth, lintel on each storey, eave, masonry gable top and at timber floor level	Plinth, lintel on each storey, eave, masonry gable top and at timber floor level	Plinth,lintel on each storey, eave, masonry gable top and at timber floor level	When distance betwee eave and lintel level is less than 600 mm, lintle band can be intigrated with eave band.
	Material for seismic band	Conc.1:2:4 or timber if timber vert. reinforcement is used	Concrete. 1:2:4	Concrete.1:2:4	Concrete.1:2:4	For timber band use 2-75x38mm with cross links 50x30mm @500 mm c/c
14	Corner strengthening with Dowels	L' or 'T' shaped wooden inserts	NA	NA	NA	timber size 30x50 mm.
15	Gable wall materials	ACor CGI on timber frame or *Dhajji* Wall	ACor CGI on timber frame or *Dhajji* Wall	ACor CGI on timber frame or *Dhajji* Wall	ACor CGI on timber frame or *Dhajji* Wall	
Ref : Guidelines for "Earthquake Resistant Reconstruction and New Construction of Masonry Buildings in Jammu & Kashmir State" by Prof. A.S.Arya and Ankush Agrawal.						

Government of India Technical Guidelines at a Glance

Repair, Restoration & Retrofitting of Masonary Buildings (Category E) for Wall Length 5m. Maximum

	Sr. No.	Description	Concrete/ Mortar	Grout/ Plaster Thk.	Weld Mesh (Galvenized)			Size of Belt		Nails / Dowels			Bonding Element	
					Gauge.	Size	Overlap	Width	Length	Dia	Length	Spacing	Hole Size	Bar Size
RESTORATION	1	Crack sealing & grouting with plastic/aluminium 12 mm Dia nipples @ 150 to 200 mm c/c	Sealing mortar cement: sand 1:3	Non-shrink cem: water 1:1										
	2	Crack sealing and Splicing across crack	Sealing mortar non shrink cem sand 1:3	Plaster cem: sand 1:3 thk. 12mm	Splicing with 16 to 14 gauge weld mesh 25X25mm size			200 to 300 mm	450mm on each side of crack	Wire nails 5mm dia.	100 to 150mm			
		Reconstruction of damaged wall. Provide headers in RR wall											Stone headers @ 600mm vert. lift & 1.2m apart horiz.	
	3	If existing wall is in mud mortar reconstruct with	1:6 cement sand mortar											
		If existing wall is in cem. mortar recostruct with	1:4 cement sand mortar											

Repair, Restoration & Retrofitting of Masonary Buildings (Category E) for Wall Length 5m. Maximum

	Sr. No.	Description	Concrete/ Mortar	Grout/ Plaster Thk.	Weld Mesh (Galvenized)			Size of Belt		Nails / Dowels			Bonding Element	
					Gauge.	Size	Overlap	Width	Length	Dia	Length	Spacing	Hole Size	Bar Size
RETROFITTING	4	Cast in-situ RCC bond elements horizonatally & vetically 1m. apart with 50 cm. horizontal stagger in RR wall.	cem: aggra: sand 1:2:4 concrete										Dum-bbell shape 75mm dia. Hole	8mm bar hooked @both eands.
	5													
		Horizontal seismic belt to be provided on all walls only on one face when wall length is less than 5m	Cem: sand 1:3 or micro conc. 1:1.5:3	First coat 12 mm, second coat 16 mm+ dia of bars.	Weld mesh 10guag e	longtudn al wires @ 2 5mm x transvers e wires up to150mm	300mm	280 mm with10 longit-udnal wires	conti-nuous	5mm with washer	150mm	300mm c/c		
	6	Vertical seismic belt @ corners - One storey or top storey of 2 storey house	Cem:sand 1:3 or micro conc. 1:1.5:3	First coat 12mm, second coat 16mm+ dia of bars.	10g.	Horizon-tal@ 25mm x vertical @ 50mm	300mm	400 mm with 14 longit-udnal. Wires.		5mm with washer	150mm	300mm c/c		
		Bottom storey of 2 story house		same as above	10g.	same as above	300mm	Same as above with 1-12 dia. bar		5mm	150mm	300mm c/c		

Government of India Technical Guidelines at a Glance

Repair, Restoration & Retrofitting of Masonary Buildings (Category E) for Wall Length 5m. Maximum

	Sr. No.	Description	Concrete/ Mortar	Grout/ Plaster Thk.	Weld Mesh (Galvenized)			Size of Belt		Nails / Dowels			Bonding Element	
					Gauge.	Size	Overlap	Width	Length	Dia	Length	Spacing	Hole Size	Bar Size
RETROFITTING		Vertical reinforcing bars at inside corner inleiu of seismic belt- One storey house and in top storey of two storey house	Cem: sand 1:3 or micro conc. 1:1.5:3	min 15mm cover.		12mm bar	300mm						start 450 mm below plinth and continue in to roof/ eave level 7 horizontal band	
	7	Lower storey of two storey house		min 15mm cover.		16mm	300mm							
		Fix bar with wall with 'L' shaped dowel from cast in situ bond elements		non shrink 1:3 cem: sand						8mm 'L' shape	Vert.leg 400mm horiz. leg 150mm	1 m.	Dumb-bell shape 75mm dia. Hole	hooked on horiz. Leg
	8	Seismic belt around openings	Cem:sand 1:3 or micro conc. 1:1.5:3	First coat 12mm, second coat 16mm+ dia. of bars.	10g.	25mm x 150mm	280mm	280mm with 10 vert. wires		5mm	150mm	300mm c/c		
	9	Strengthening of *Dhajji* Diwari - Install diagonal timber brace				20 mm x 40 mm				10g.	75mm	2 nails at each eands.		
	10	Stiffening flat wooden floor / roof strut & diagonal brace of timber planks				100 mm vide x 25mm				10g.	75mm	2 nails at each ends.		

Ref: Guidelines for "Repair, Restoration and Retrofitting of Masonry Buildings in Earthquake Affected Areas of Jammu & Kashmir" by Prof. A.S.Arya and Ankush Agrawal.

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About NCPDP

National Centre for People's-Action in Disaster Preparedness (NCPDP)

NCPDP was created with a focus on disaster preparedness in October, 2000 at the time of Bhavnagr Earthquake in Gujarat state. This was an outcome of seven years of post-earthquake intervention by its two honorary directors in the regions of Latur, Jabalpur and Chomoli in India. NCPDP played a major role in rehabilitation as well as capacity building for long-term preparedness in Gujarat in the aftermath of the Kutchch earthquake, and also worked on capacity building and technology demonstration in quake-affected Kashmir.

NCPDP is one of a few technology-based organizations in the country with first-hand experience of working at the grass roots. It has a firm belief that building capacity of people from within is the only way to mitigate disasters for a safer world. Hence, we believe that intervention by external agencies in the aftermath of a disaster must work towards this end. Upgrading the skills of building artisans should form the backbone of this approach.

NCPDP strives to bring viable, eco-friendly and sustainable technologies to help people reduce their vulnerability against future disasters. It strives to remain prepared for timely intervention in the aftermath of major disasters. It is continuing to work on disaster mitigation through (a) training of engineers and building artisans, (b) awareness and confidence building programs in communities, (c) preparing ready-to-use technical information for people, (d) research on structural behaviour of masonry structures, (e) building vulnerability studies in different parts of India, (f) vulnerability reduction through retrofitting, and (g) policy interventions.

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