01 May 2013 Doda Earthquake Post-Earthquake Reconnaissance Survey Report

by

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1. BACKGROUND

The M 5.8 earthquake hit Jammu & Kashmir (J&K) state on 1 May 2013 at 12:27 hours IST. As per India Meteorological Department (IMD), the epicentre of the event was located at 33.1°N 75.8°E (about 17 km NE of Bhadarwah town in J&K state near the border of the states of J&K and Himachal Pradesh), and focal depth 15 km. The United States Geological Survey reported the epicentre at 33.1°N 75.838°E and focal depth of 9.8 km near Bhadarwah.

The earthquake was a shallow-focus event with ground shaking lasting for about 40 seconds in the epicentral region; it was felt across north India including Delhi. It was followed by four aftershocks of magnitudes 3.7, 4.6, 3.7 and 3.5 till 5 May 2013. One death was reported in J&K state after this event due to rolling boulder, and about 25,000 houses declared to be partially, severely or fully cracked. The National Disaster Management Authority (NDMA) constituted a Post-Earthquake Reconnaissance Team (PERT) (vide Office Memorandum No. NDMA/SS(CBDM)169/2013, dated 08 May 2013) to study the damages sustained in the areas affected by the 1st May 2013 Earthquake in Doda and Kishtwar districts of J&K state during 11-15 May 2013. The terms of reference included:

1. Collect perishable data related to the built environment in the affected area;
   (a) Identify vulnerable construction typologies and their performance;
   (b) Identify main reasons for observed performance of masonry, RC frame, traditional and other constructions; and
   (c) Evaluate performance of structural, non-structural and functional elements in major critical and lifeline buildings and facilities, such as hospitals, where feasible.

2. Give guidance on Earthquake-induced Landslides
   (a) Identify and study impact of landslides occurred due to earthquake; and
   (b) Identify possible short-term and long-term remedial measures for landslide risk mitigation and suggest land use control measures; AND

3. Give specific guidance on possible
   (a) Procedure for assessment of earthquake damaged buildings,
   (b) Strategies for intermediate shelter designs,
   (c) Strategies for retrofitting of damaged buildings,
   (d) Guidelines for construction of future buildings and recommendations for good construction practices,
   (e) Improvements in development control regulations and municipal bye-laws for towns and villages, and
   (f) Strategies for SDMA/DDMA and other stakeholders towards disaster mitigation, including awareness campaigns among the community.

The NDMA’s Post-Earthquake Reconnaissance Team (PERT) members visited the earthquake affected areas in the districts of Doda and Kishtwar in the State of J&K. The team consisted of C. V. R. Murty (Professor, IIT Madras), Ajay P. Chourasia (Scientist, CBRI, Roorkee), Anup Karanth (Senior Risk Specialist, TARU Leading Edge, Gurgaon), Hari Kumar (President, Geohazards Society, New Delhi), Pradeep Kumar Ramancharla (IIIT Hyderabad), and Ashok K. Jain (NDMA, New Delhi). During their visit, the PERT members held discussions with engineers, government officers and citizens. The main observations captured by the team members during the above reconnaissance visits are summarised in this report. This report gives quick insights into effects of the earthquake on the built environment and initial important perishable observations. Also, it provides answers to some important questions leading to reducing earthquake risk in future earthquakes on
(1) Vulnerability of built environment,
(2) Need and extent of rehabilitation programmes, and
(3) Effectiveness of post-earthquake response.

2. THE EARTHQUAKE
The Himalayan region in the Indian subcontinent is seismically active due to continental collision of the India and Eurasia plates, with the Indian Plate subducting under the Eurasian Plate. In the past, the J&K region of the Himalayas has faced many earthquakes of M>7; 1770 M 7.7 Srinagar Earthquake and 2005 M7.6 Muzaffarabad earthquakes are the largest documented events in the J&K region. The $M_w$5.8 event of 1 May 2013 is a smaller event in comparison with these two big events. Preliminary information suggests that the earthquake occurred by shallow intra-plate strike-slip faulting on the Eurasian Plate transverse to the prominent MCT and MBT features of the region. As per IMD, this earthquake was followed by four aftershocks of magnitudes 3.7, 4.6, 3.7 and 3.5 till 5 May 2013, and nine events of magnitude 3+ till 16 May 2013.

The $M_w$5.8 that struck the J&K state at 12:27pm IST on 1 May 2013, caused a maximum intensity of shaking of about VI+ on the MSK scale (Figure 1). The earthquake was centered about 17 km northeast of Bhadarwah (Doda District of J&K) at a shallow depth of 15 km. This earthquake caused shaking in many areas adjoining area lasting about 40 seconds. The event was recorded by strong motion accelerographs at 11 stations operated by Department of Earthquake Engineering, IIT Roorkee [http://pesmos.in/2013/](http://pesmos.in/2013/) (Figure 2). The acceleration time histories of all stations are shown in Figure 3. The maximum peak ground acceleration (PGA) of 0.015g was recorded at Chamba station, the one closest to the epicentral area (Table 1). The velocity and displacement time histories are obtained by integrating/double-integrating the acceleration time histories, respectively. The pseudo-acceleration, velocity and displacement response spectra of the recorded ground motion time history at Chamba station are shown in Figure 4. The acceleration response spectra at Chamba station suggest that the input energy is the largest for short period structures (namely stiff structures, such as low-rise unreinforced masonry (URM) load-bearing and RC frames with URM infill walls).

![Intensity Map](image1.png)

**Figure 1:** Intensity Map produced by USGS for main event of 01 May 2013 earthquake
Figure 2: Location of 11 strong motion accelerograph stations operated by Department of Earthquake Engineering, IIT Roorkee around the area affected by the 01 May 2013 event

Table 1: Peak Ground Accelerations (PGAs) provided by 11 strong motion accelerograph stations maintained by IIT Roorkee [Source: http://pesmos.in/2013/]

<table>
<thead>
<tr>
<th>Station</th>
<th>EW direction</th>
<th>NS direction</th>
<th>Vertical direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambala</td>
<td>0.015g</td>
<td>0.020g</td>
<td>0.006g</td>
</tr>
<tr>
<td>Amritsar</td>
<td>0.008g</td>
<td>0.008g</td>
<td>0.008g</td>
</tr>
<tr>
<td>Chakrata</td>
<td>0.003g</td>
<td>0.003g</td>
<td>0.002g</td>
</tr>
<tr>
<td>Chamba</td>
<td>0.015g</td>
<td>0.011g</td>
<td>0.011g</td>
</tr>
<tr>
<td>Jammu</td>
<td>0.005g</td>
<td>0.004g</td>
<td>0.004g</td>
</tr>
<tr>
<td>Kasauli</td>
<td>0.010g</td>
<td>0.006g</td>
<td>0.002g</td>
</tr>
<tr>
<td>Mandi</td>
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<td>0.007g</td>
<td>0.004g</td>
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<td>0.010g</td>
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<tr>
<td>Rampur</td>
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</tr>
<tr>
<td>Roorkee</td>
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<td>0.002g</td>
<td>0.001g</td>
</tr>
<tr>
<td>Una</td>
<td>0.016g</td>
<td>0.014g</td>
<td>0.010g</td>
</tr>
</tbody>
</table>

(a) E-W Component
Figure 3: Acceleration Time Histories provided by strong motion accelerograph stations maintained by IIT Roorkee [Source: http://pesmos.in/2013/]
Figure 4: Ground Motion Time Histories at Chamba Station, closest to the epicentral region of all 11 stations for which data is available: (a) Acceleration, (b) Velocity, (c) Displacement; and corresponding response spectra: (d) pseudo-acceleration, (e) velocity, and (f) displacement.
The seismic zone map of India given in Indian Seismic IS:1893 (Part-1)-2002 places most of J&K in Seismic Zone IV (High Damage Risk Zone, MSK VIII) and a small part mainly around Srinagar, Baramula, Kupwara, Badgam and Anantnag districts in Seismic Zone V (Very High Damage Risk Zone, MSK IX or more) (Figure 5). The expected intensity of earthquake shaking as per the Indian Seismic Code is about intensity VIII in seismic zone IV areas and IX in seismic zone V areas. The earthquake generated a maximum seismic intensity of about VI on MSK scale in the hills of Doda and Kishtwar districts. Thus, the earthquake of 1 May 2013 is much smaller than that expected in this region.

3. PERFORMANCE OF BUILT ENVIRONMENT

The landscape of Doda town shows settlements on both hill slopes and river terraces (Figure 6); this is typical of most other towns too (like Gandoh and Premnagar). These hill slopes and river terraces are composed of heterogeneous materials – highly weathered sand rock, some granite outcrops, rounded to angular but smooth river boulders, cobbles, gravel, sand, silt, clay and other suspended matters that have been collected over centuries in the river terraces and hill slopes. For this reason, the ground shaking is not necessarily uniform all through the affected area. Another prominent feature of development in the area is that the same types of constructions are noticed in the valley as well as steep hill slopes (Figure 7).
Figure 6: Ariel views showing dense development on hill slope and river terrace, of (a) Doda town, (b) Gandoh town, and (c) Premnagar town
Figure 7: Ariel views showing sparse development on hill slopes: (a) relatively shallow slopes, and (b) steep slopes
In general, foundations did not suffer damage of buildings and structures along hill slopes; in rare occasions, when ground settled, there is some cracking in the foundations also. Three cases are observed:
(1) Houses built along the rim of river terraces showed signs of settlement (soil cracks were visible along the rim). These were very few.
(2) Houses on the flat land seemingly had no such foundation damage; and
(3) Houses founded on soft soils in towns of valley areas (like Kishtwar town), vertical cracks were visible in foundation arising from the soil. But, these seem to have been created well before the earthquake.
In general, damage to buildings in the affected area was limited to poorly built house. The pointers to identifying poorly built houses include:
(a) Weak construction material,
(b) Informal construction practices with incremental changes made over time with different materials and styles of construction,
(c) Absence of earthquake resistant features, and
(d) Significant vertical irregularities largely attributed to sloped ground and floors meeting the ground at different levels. The earthquake shaking is input to the building at multiple floor levels; this causes excessive damage especially when the structure has features (a)-(c) mentioned above.
In addition, buildings are constructed too close to each other, sometimes with no gap between adjacent buildings resulting in damage due to pounding of buildings.

3.1 Housing

Typical housing in Doda and Kishtwar districts of J&K state are 1 or 2-storeyed in the hills and up to 4-5 storeys in town areas. Five structural systems are practiced in the region, namely:
(1) Dhajji-Dewari houses;
(2) Unreinforced masonry (URM) load-bearing houses with burnt clay bricks and mud/cement mortar;
(3) Unreinforced masonry (URM) load-bearing houses with stone and mud/cement mortar;
(4) Reinforced Concrete Moment Resisting Frames buildings with URM infill walls, and
(5) Hybrid construction, i.e., combination of two or more of systems in items (1)-(4) above.
Only the first four are discussed in this section.

3.1.1 Dhajji-Dewari Houses

This traditional Dhajji-Dewari style of building construction uses wood frame with burnt clay brick or stone masonry wall panels infilled in the bays created by the wood members (e.g., Figure 8). These constructions are observed largely in the interior areas of districts of Doda and Kistwar and in old areas in towns. Typically, the foundation is made of stones readily available in the hills; random rubble stone masonry is common. Sometimes, even the plinth masonry is made of random rubble stone masonry. These are up to 4 storeys tall. Walls in all storeys are made of wood frame (consisting of horizontal, vertical and diagonal wooden members). The roof was originally made of wood planks topped with mud. A typical floor is made of wooden joist (100x150 mm) placed at 400 mm centers. Over these joists, 25 mm thick wooden planks are laid, which in turn is topped with 50 mm thick stone chips. The final course is either a mud or cement concrete flooring of 125mm thickness. And, the typical roof has the same configuration as mentioned above for floors, with mud topping of 200-300 mm thickness. But, in recent times, roofs are made of corrugated GI sheets are used over timber trusses resting on wood wall plates atop the stone/brick walls.
Figure 8: Variant of Dhajji-Dewari Houses: (a) without diagonal wood members, and (b) with no Dhajji (wood frame) in the ground storey

This is a housing typology in which traditional wisdom has been embedded gradually over centuries; since earthquakes have been perennial concern for people living in the Himalayan region, a well done Dhajji-Dewari House has excellent earthquake-resistant features. But, over time, the transmission of traditional knowledge may not have been completely efficient, especially in recent times, when the modern construction has become an aspiration of the larger populace. Seismic safety has been jeopardised when earthquake-resistant architectural and structural concepts are compromised. A number of seismic deficiencies were identified in the recent editions of this typology, including:
(a) Large openings,
(b) Large size rooms,
(c) Tall storeys,
(d) Poor connections between foundation-and-wall, wall-and-wall and wall-and-roof,
(e) Absence of continuous plinth, sill and lintel bands except in houses belonging to the affluent,
(f) Loosely packed infill masonry,
(g) Low strength of mud mortar, and
(h) Heavy roof.

Even though this typology did the best amongst all housing typologies prevalent in the area affected by the 01 May 2013 event, the recent versions of this housing typology may perform poorly during the strong earthquake shaking expected in the J&K region.

3.1.2 URM Load-Bearing Houses with Burnt Clay Bricks and Mud/Cement Mortar

Use of unreinforced masonry with burnt clay brick is on the rise in Doda and Kishtwar districts. Houses are being made with this system up to 4 storeys, even though houses are common up to 3 storeys (Figure 9). Generally, they are rectangular in plan. Bricks are manufactured locally using top soil of agricultural land in terraced farming practiced in these hills; their quality varies depending on how well the they are fired (Figure 10). Mica is commonly noticed in these handmade bricks. The walls (generally 230mm thick above plinth level) are made with mud mortar in most cases, and with cement mortar in limited cases. When cement mortar is used, the mix varies between 1:6 and 1:8 (by volume). When mud mortar walls are used, they are plastered on the outside alone by cement mortar, when the owner can afford, else they are left as such. In most cases where cement mortar is used, they are plastered on the inside.
Figure 9: Brick masonry houses: (a) houses with RC floors did better even though they had no earthquake-resistant features like horizontal bands, and (b) houses with heavy wood floors did poorly; the walls dilated outwards in both plan directions and reduced the bearing of wood floors on the walls.

Figure 10: Manufacturing of hand-made bricks using locally available agricultural soil in hill slopes.

In general, walls have NO horizontal bands (Figure 9) and NO vertical corner reinforcement, which are required by the Indian Standard for seismic resistant of such houses. Even though most houses have gable ends, no instances were encountered during the field visit of the use of gable bands (Figure 11). In limited houses, a lintel band is seen from the outside; in many cases, the same are not provided at one level and sometimes not connected adequately at wall junctions. Knowledge does exist in the region of the need to use bands in walls, but ignored in most cases. Window openings are usually small and placed away from corners. Most openings are in the long direction of the house leading to more flexibility along longer direction. Cut lintels made of wood are used over these openings; in limited occasions, RC lintels are noticed. Many times, the RC lintel band is employed only along the exterior walls and not along the interior ones too.
The unreinforced brick masonry houses with mud or cement-sand mortar (currently built in earthquake affected areas) are unsafe under earthquake shaking. These houses are regular in plan and elevation from architectural considerations, but lack important structural features. Prominent deficiencies of earthquake-resistant features include:
(a) Absence of horizontal bands and vertical reinforcing elements at wall corners;
(b) Absence of gable bands;
(c) Dilation of masonry walls at top floor due to lack of eaves band on which the roof is rested;
(d) Use of plain mud mortar in walls;
(e) Lack of complete roof truss;
(f) Excessively large opening in walls;
(g) Lack of reinforcement around door and window openings;
(h) Use of very heavy floors/roofs;
(i) Direct bearing of roof truss on the masonry walls, not adequately anchored into walls;
(j) Poor masonry courses – all headers in one course, all stretchers in the other, resulting in joints not being staggered; and
(k) Outward bulging of walls at floor levels due to heavy wood floors.
Majority of cracks in houses during the 1 May 2013 earthquake can be attributed to these deficiencies.

3.1.3 URM Load-Bearing Houses with Stone and Mud/Cement Mortar
This is the most common housing construction type in the earthquake affected area. The houses are geometrically regular in plan, and mostly rectangular, and do not have any irregularities in elevation; the openings are small and located away form wall corners. In general, the masonry is random rubble type with slate stones (e.g., Figure 12), river boulders, angularly broken stone or semi-dressed stone (on the outside face); in rare exceptions, dressed stone load bearing masonry was noticed during the field visit. While the recent construction in town areas are moving away from this construction type, newer constructions in the interior hills still adopt this construction.
River terraces, valleys and hill slopes are the usual sites where the vernacular housing is found in the hills. On narrow terraces cut into the hillside, the arrangement of houses is linear following the profile of the terrace. A typical house is one to two storeys, except in situations where access from motorable road allows/necessitates inclusion of a third storey. The foundation is shallow strip foundation with stone masonry in a shallow trench, and plinth masonry is 600-750mm thick and made with locally available large-sized sedimentary stones. Walls of many houses are built without mortar, and when cement-sand mortar is used, the mix is lean (1:10 by volume); but, the quality of masonry work is good, resulting in perfect plumb of walls and straight edges at wall corners. Timber (i.e., deodhar, pine or sal) trusses are used for providing a sloped roof (35° - 45°) with corrugated galvanised iron sheets; in many cases, the gable end is filled with heavy stone masonry of tall heights. In many houses, heavy flat roof is made with wooden joist, transverse battens, wood planks, stone chips, polythene sheet and 300 mm thick mud topping - in all about 600 thick.

This housing typology has good architectural design from earthquake safety point of view, but poor structural characteristics. The limited **negative architectural features** include:
(a) Built adjoining the neighbouring ones or with inadequate separation between houses; this causes pounding damage to themselves as the adjoining ones;
(b) Re-entrant corner plan houses, usually L- or U-shaped, though in limited cases; and
(c) Mismatch of floor and roof levels, when houses are built touching each other.

The main **structural deficiencies** include:
(a) Knowledge does not exist in the region of the need for use of through-stones leading to independent two leafs of stone masonry walls;
(b) No connectivity of two perpendicular walls at T- and L-intersections;
(c) Stone masonry is not dressed, but outside surface is ensured to be plumb; half dressed stones with pyramidal shape are prone to rotating outwards;
(d) No bands are used in walls at any level, i.e., roof, lintel, sill or plinth levels; cut lintels in wood are used over openings in walls;
(e) Weak mortar, both of mud and cement-sand mix;

**Figure 12:** (a) Two-storey stone masonry house with *basic earthquake-resistant features* of seismic bands **MISSING**, and (b) Two-storey stone hybrid masonry house (with Dhajji-Dewari system adopted in upper elevations) but no earthquake-resistant features in lower storeys.
(f) Large mass, especially concentration of large mass at roof level of the building when heavy slate roofs are employed; and
(g) Poor connections between foundation-and-wall, wall-and-wall and wall-and-roof;

Houses of this type have shown cracks that indicate possible poorly performance during strong earthquake shaking. The advantages of this stone masonry construction typology from architectural characteristics (of overall geometry – shape and proportioning, as currently practiced in the region) are out-weighted by its poor structural characteristics. With minimal interventions, such houses can be seismically retrofit to prevent collapse during future strong earthquakes; prominent interventions being introduction of horizontal bands, and use of lighter roofing material (e.g., CGI) in place of heavy wood roofs with mud topping.

3.1.4 Reinforced Concrete Buildings

Reinforced Concrete (RC) buildings are becoming increasingly popular in the area; this was witnessed during this post-earthquake field reconnaissance of the earthquake affected areas, at least for the urban housing and government buildings. The usual flexible RC frame systems adopted in buildings built in low seismic regions are verbatim reproduced in this high seismic region too. The typical damage sustained by these RC buildings includes frame-infill separation, spalling of concrete at top of column (where concreting is poorly done and reinforcement detailing is such that there is extreme congestion of steel reinforcement) and cracking/falling of bathroom tiles, as observed in the yet-to-be commissioned Tourism Department building (Figure 13). Similar, damage is noticed in the newly constructed Sub-District Hospital buildings in Badarwah.

This large damage even in the low intensity shaking indicates that the building is too flexible. There is no practice of using RC structural walls in RC buildings in the region. Two checks are required urgently, namely: (a) peer review of all RC constructions by the government through the central design office in Jammu from where these designs are being sent, and (b) training of design and construction engineers in earthquake resistant RC constructions.
Figure 13: (a) TRC building in Baderwah, (b), (c) frame-infill separation cracks in unreinforced masonry infill walls, (d) damage to column tops showing poor concrete and reinforcement detailing, and (e) delamination of tiles owing to damage in infill walls.
3.2 Schools

Around 490 schools in Doda district and 170 schools in Kishtwar district are reported by Government of J&K inspection team to have damages. School children were injured at Government Girls High School (Baderwah), Higher Secondary School (Gandoh), Higher Secondary School (Sinowa) and Higher Secondary School (Kilotran). The injuries in these schools were due to falling stones from the collapse of stone masonry gable wall, separation of walls at junctions, and separation of wythes of walls. Injuries to children in the 1 May 2013 earthquake in Doda and Kishtwar district have disturbed the conscience of the community in the two districts. Most of the schools were closed immediately after the earthquake and children sent back home. Also, the authorities in Doda District ordered closure of all educational institutions for a day keeping in view apprehension of aftershocks. Many classes were being conducted in tents and in outdoors, because school authorities deemed buildings unsafe for occupancy after they sustained damage during the earthquake.

Schools buildings performed poorly, when earthquake resistant features are absent. Most schools were built on cut, levelled land. Older schools were made of traditional Dhajji-Dewari (Figure 14) or stone masonry with mud mortar. Newer constructions were in burnt clay bricks with cement mortar. Structural and non-structural damages were observed even under the relatively mild intensity shaking of VI on MSK Scale, especially schools built recently under the Sarva Siksha Abhiyan scheme.

Figure 14: Two-storey school with basic earthquake-resistant Dhajji-Dewari system in upper storey
The salient deficiencies in school buildings and damages to them sustained during the 01 May 2013 event are listed below:

1. In schools built with burnt clay brick or stone masonry, the much needed bands are missing. In some cases (e.g., the Government High School in Baderwah), the concrete was poured for the lintel band, but the reinforcement was not provided (Figure 15a) and the crack ran through vertically at the wall junctions. In many instances, separation cracks at wall junctions indicating absence of bands;

2. Some left over material from the 2005 Kashmir earthquake of asbestos-cement-styrofoam sandwich panels was used to make school rooms (Figure 15b). These rooms have shown no major signs of damage in this small intensity shaking event, but can prove fatal in the future large intensity shaking events expected in the region; this is because the actual capacity to withstand strong shaking has not been verified experimentally school rooms at a full-scale testing facility;

3. In most schools buildings, the roof was pitched. The gable ends were filled with stone and brick, with no gable band (Figure 16). Also, in most cases, the truss itself was incomplete, and hence stones in gables collapsed out of plane even in this small shaking event of 1 May 2013;

4. When stone masonry walls are used, separation of wythes also was noticed in older constructions. Random rubble construction being currently practiced should be prohibited for construction of schools in seismic zones IV and V;

5. The fear of aftershocks has caused all school activity to be moved out of the buildings. The make-shift arrangements included use of open spaces, tents and promenades in enclosed areas (Figure 17). The third case is a dangerous one (Figure 17c); the area is covered by 2-storey high unreinforced stone masonry walls;

6. False ceilings built are not positively anchored to the roof truss (Figure 18). This has been a major cause for injuries in the schools;

7. When schools buildings are designed at State or national level for Government schools or SSA classrooms, architects, structural engineers and LOCAL construction engineers must work together to ensure that schools building designs have requisite configurations and features that provide adequate seismic resistance to the buildings; and

8. The contents of class rooms also need attention for safety during earthquake shaking; many of them (like overhanging cupboards and laboratory items) are precariously balanced and can cause major injuries and loss in future earthquakes.

In general, the design and construction of school buildings in the two districts was in conformance with the requirements for seismic zone IV laid down by the Indian Standards. Most of the buildings, including recent Sarva Shiksha Abhiyan buildings, were built in random rubble masonry with either mud mortar (in older buildings) or cement mortar. School buildings in Doda and Kishwar districts have many inherent characteristics that make them vulnerable to earthquake damage and collapse, including alphabet-shaped building configuration (plan shapes of C, H, L, T and U), use of weak materials, location along vulnerable hill slopes or in river bed (already affected by slides or settlement of the ground in the past), poor construction and supervision practices, and significant changes made after construction. The problems are compounded by scarcity of construction materials, lack of understanding of building codes, unskilled building professionals, modifications to existing school buildings without consulting with seismic structural engineers to understand ramifications of the alterations attempted, and an overall lack of understanding of earthquake risk reduction measures needed in the region.
Figure 15: (a) Concept of bands not sincerely implemented in construction, and (b) untested prefabricated systems being used for building school rooms

Figure 16: (a) Informal trusses rested directly on stone walls without any wall plates (at Gandoh), and (b) large stones gables not provided with gable bands and gable end trusses are not complete with bottom chord and vertical posts (at Bhalessa)
Figure 17: Makeshift arrangements for schools: (a) Open places, (b) cloth tents, and (c) confined spaces adjoining vulnerable structures.

Figure 18: False ceilings not anchored with positive fasteners to the roof trusses; they are just nailed upwards from the soffit of the truss.
But, there are good examples of traditional constructions in the region, which can stand as examples for emulation in future (Figure 19).

![Figure 19: Wood frame single-storey school room construction with brick masonry up to sill level and light roof](image)

In summary, there is a complete lack of understanding of how masonry buildings behave during strong earthquakes; a sustained capacity building program is required to upgrade the level of engineering for the common constructions being attempted in the region: planning, design, construction and maintenance shall be focus of such programs.
Considering the serious lack of attention to the matter of earthquake safety of schools, the following actions are needed:

(a) Making Buildings Safer

1. New schools shall be constructed with earthquake resistant features as per provisions of the Indian Standards;
2. Existing school buildings shall be assessed and prioritised (including those unaffected by the recent earthquake) for seismic retrofitting to meet the specifications for Seismic Zone IV. A phased retrofitting scheme shall be launched by the State Government to retrofit schools that are found deficient; and
3. A group of engineers should be trained for design, construction and construction supervision of new earthquake-resistant school buildings and retrofitting of existing school buildings.

(b) Making People Safer

1. A school safety awareness programme launched in all schools regardless of ownership in the districts of Doda and Kishtwar;
2. All fire stations mandated to spread awareness on fire preparedness and assist schools in developing evacuation plans; and
3. All schools mandated to submit their School Disaster Management Plans to a nodal officer in the education departments in both district within the next two months.
4. A mass evacuation drill to be organised in all schools in the two districts on Tuesday 8 October 2013, to mark the 8th Anniversary of the Kashmir earthquake of 2005.

3.3 Hospitals

Hospitals are most critical facilities and are expected to be completely functional before, during and in the aftermath of earthquakes to provide critical care to the affected community. In addition, inpatients, medical staff and medical supplies should be safe. But, the earthquake of 1 May 2013 resulted in a maximum shaking Intensity of about VI. Buildings of some health facilities in Doda and Kishtwar districts were damaged and needed to evacuate all patients, and treat the injured in open areas adjoining these health facilities. Even though no hospital building has collapse, most of them suffered cracking, including the Sub-District Hospital in Badarwah, the District Hospital in Doda and Sub-District Hospital in Gandoh. The cracked hospital buildings caused panic amongst the patients and personnel of medical departments, even though most facilities were functional within the hospital building; patients evacuated themselves to open spaces adjoining the Hospitals. Electrical power supply was disrupted in most, but was restored within an hour.

In the newly built Sub-District Hospital at Badarwah (Figure 20), a false ceiling came down in a ward, resulting in a hasty evacuation by patients and bystanders. In the same hospital, a water tank sustained damage, when the relatively stiff pipes running from across the expansion joint pulled out during earthquake shaking; this resulted in water leak from the top floor. Infill walls of this RC frame structure developed cracks, especially near staircases; this made occupants feel unsafe and were evacuated. A number of people who came from other earthquake affected areas with minor injuries had to be treated in the open areas adjoining the hospitals. In a hospital building that has been constructed recently (some finishing work was still going on during the field visit), it is unacceptable to have any kind of damage in such low intensity earthquake shaking. Similar damage was observed in the District Hospital in Doda, which too was completed earlier this year. There was no damage to utility systems such as electricity, water or medical gases supply in this event. But, the diesel generator set of the hospital was not anchored to the ground, and can slide and become unserviceable in a shaking of higher intensity.

Immediate steps need to be taken to ensure that at least the two district hospitals and the three sub-district hospitals remain functional, to ensure that medical facilities are available in these districts after future earthquakes also. Functionality of hospitals depends on (i) hospital structure is safe, (ii) Medical staff is safe and prepared, (iii) Medical equipment is functional, (iv) Utilities (like water, power and gas) are functional, (v) communications are functional, and (vi) medical supplies are available. Following urgent steps are needed for hospitals in areas affected by this earthquake:
Figure 20: Sub-district Hospital in Baderwah sustained minor structural damage to masonry infill walls, but reasonable non-structural damage to false ceilings and water tanks

(1) Safe Buildings
   (a) Technical Peer Review of structural design and construction of all new health facilities to be undertaken by the State Government. Since J&K State falls under Seismic Zones IV and V, all future health facilities need to be designed and constructed as per specifications more stringent than normal houses and buildings;
   (b) Much damage in this earthquake is attributed to collapse of gable walls and many hospital buildings have gable walls. These vulnerable gable walls need to be removed and replaced with lighter materials with good thermal insulation properties.

(2) Medical Staff safe and prepared
   Earthquake preparedness programmes should be initiated in at least the five priority hospitals at the District and Sub-District levels in Doda and Kishtwar Districts. These hospitals should be mandated to develop preparedness plans after initiating capacity building programmes for staff members in emergency preparedness, mass casualty management and personal preparedness.

(3) Non-Structural Risk Mitigation
   Earthquake safety should be assessed of medical equipment and utility systems to withstand the expected shaking in future earthquakes, and deficiencies corrected immediately. The electrical back-up systems shall be anchored to the ground or floor (Figure 21). False ceilings (especially in critical areas such as operation theatres and emergency wards and access areas thereof) shall be braced to perform better in future earthquakes.

(4) Supply Management
   Doda and Kishtwar Districts do not have a redundant road network along the brittle hills with steep slopes. They can be cut-off for a few days from the rest of the state in future earthquakes, if major landslides occur. Thus, adequate supplies (emergency medicines, medical oxygen, etc.) shall be stock-piled to provide emergency medical care to affected persons. Health Department shall review the current restocking procedures.
Figure 21: Sub-district Hospital in Badarwah sustained minor structural damage to masonry infill walls, but reasonable non-structural damage to false ceilings and water tanks

3.4 Utilities
3.4.1 Electrical Power

The 132-KW high voltage transmission line of National Hydroelectric Power Corporation (NHPC) services the districts of Doda and Kishtwar of J&K state, through the Kishanpur grid. As such there was no loss in power transmission during or the aftermath of the earthquake, because there was no surface rupture due to the earthquake, which is normally expected in earthquakes with higher intensity of shaking. However, it was reported that there was a power surge and followed by shut down for a brief period. But, the typical transmission lines are seated on soft soil adjacent big vertical cuts (Figure 22), which are vulnerable. Also, there are possibilities of slope failures during heavy rains.

Figure 22: Transmission towers running across Doda and Kishtwar districts pass through difficult terrains: (a) soft soils, and (b) adjoining vertical cuts made for roads
3.4.2 Water

Water supply to towns is from natural springs, which are around 20-30 km away. Public Health Engineering (PHE) Department reported no major problem with water supply systems. No cracks in water reservoirs and filtration ponds. In general, the penstocks are about 300-600 mm in diameter. Some damages were reported in local distribution pipes (Figure 23); these are attributed to sliding of the concrete pedestal on the hill slopes. There is an urgent need to review the safety of these pipelines in the two affected districts.

![Figure 23: Water pipelines follow the terrain slopes and sometimes rest on soil strata that becomes loose during earthquake shaking](image)

3.4.3 Communications

No serious loss was reported in communication facilities. But, there was one-hour downtime in mobile communication systems owing to breakage in the optical fibre cables; the service was restored back in two days. The RC frame buildings in which the communication facilities were housed, sustained frame-infill separation cracks especially in the ground floor. The DG set building of BSNL (Figure 24) is made up of unreinforced stone masonry. Even though the intensity of shaking is small, this building with weak random rubble masonry and heavy roof attracted huge inertia force. All the corners indicate serious cracks with the wall separating from each other, and the building is precariously balanced. BSNL should take urgent retrofit action on this structure. The area has no satellite phones; at least the senior government officers should have such phones.

![Figure 24: DG power supply system of BSNL in Doda town was housed in a stone masonry building with no earthquake resistant features. The building is precariously balanced with major cracks that threaten the safety of the building](image)
3.5 Transportation Systems and Landslides

Doda town is located about 175 km from Jammu and about 200 km from Srinagar. The general mode of transportation in the District is by road. The District has mountainous terrain, and is connected by two National Highways, NH-1A and NH-1B. The roads are freshly cut on the hill slopes, which are not yet stabilised (Figure 25). In several stretches, there is accumulation of loose hill slope material, which is sliding from these open cut slopes; even with little rain, the road becomes un-motorable. Also, there are many stretches of the road, which see regular rock fall. In the event of a major earthquake, these segments of the road are likely to be broken, either due to rock fall or sliding. This will render Doda cut-off from rest of the state. R&B department officials clarified that all depends on this one national highway with no redundancy.

Figure 25: The only major road in the Doda district sees major landslides regularly. Solutions are required urgently to protect these roads and to add redundancy in the road network.
Over 20 bridges were studied during the visit. Owing to the low intensity of ground shaking, no damage was observed in bridges. In general, bridges were suspension bridges on stone piers and steel cables and steel deck, steel truss bridges, and RC bridges (Figure 26). Also, there were some wooden bridges, largely used as walkway bridges. The RC bridge superstructures are stiff, and would not bend much during strong earthquake shaking, but can off-seat from the supports. In new bridges along the National Highways, RC vertical upstands are provided as lateral restrainers along longitudinal and transverse directions (Figure 26d). These restrainers should be provided in the existing older bridges too, which have small seat widths on pier caps. The suspension bridge at Gandoh needs urgent retrofitting of the random rubble stone towers at the ends; it is a critical lifeline between the national highway and the town of Gandoh that is largely on the other side of the bridge. In the past, the 1991 Uttarkashi earthquake showed similar instances of anchor blocks and towers being severely damaged; under stronger shaking, such a situation is likely to occur in this J&K region also.

Figure 26: Three basic type of bridges commonly found in Doda and Kishtwar Districts: (a) Suspension bridges, (b) steel truss bridges, and (c) RC bridges; (d) a major need for ensuring earthquake safety of bridges is the use of lateral restrainers, that are missing in older RC and steel bridges, but are slowly coming into practice in RC bridges
3.6 Places of Worship

The affected area has mosques that have tall minarets. Since the shaking intensity was low, the minarets were not damaged. This is corroborated by the acceleration response spectrum of the ground motion at Chamba station, which suggests that only stiff structures are likely to be more affected by the shaking. It is unclear, if the masonry minarets are reinforced at Doda Mosque (Figure 27). While the minarets did not sustain damage, the arches in the mosque halls did. It is known that arches perform poorly in earthquakes; the large prayer hall showed separation wall corners and cracks in arches. A cracked arch is not effective in resisting the future earthquakes. Steps are made of concrete and are connected to central column. The minarets did not suffer any damage. The community does not want them to be pulled down. But, people around that building (including the mosque administrators) were worried about the safety of the people around in the event of next big earthquake. Other mosque minarets under construction (Figure 28) near Bhalessa beside the Government school showed poor structural details – floating column of the spiral staircase, improper reinforcement detailing, and RC steps placed on exposed steel bars running across the window openings in the perimeter octagonal masonry minaret.
Figure 27: (a) Brick masonry minarets were a major concern of the people in the neighbourhood of the Doda Mosque, (b) construction details were not known to the administrators of the mosque, and (c) cracking of hallway arches showing concern of the mosque hall
Figure 28: (a) New Mosque under construction near Bhalessa showed details being adopted in the brick masonry piers: (a) RC elements in the main mosque, and (b) vertical reinforcement in masonry piers of the minarets.
4. LESSONS LEARNT

The current trend of constructions is alarming, to say the least; there is no concept of earthquake resistance in the planning, design and construction strategies (Figure 29). The following are some major lessons learnt:

(1) *Landslide potential evaluation* is essential in Doda and Kishtwar Districts, especially along critical roads and in areas with known potential for sliding, rolling, shooting and subsidence, large population and built environment. Development of redundant road networks is critical in these vulnerable areas;

(2) *Creation of a professional and regulated environment* by Government of J&K for design and construction of new RC buildings is crucial in J&K state, if it has to be earthquake-resistant;

(3) Launch systematic *earthquake safety assessment of existing structures*, in a prioritised and phased manner, especially because about 18,80,000 of the about 20,00,000 houses in the state are made of masonry, largely unreinforced. Thus, seismic retrofitting is necessary;

(4) Partnership between Government of J&K, Archaeological Survey of India, and state Department of Archaeology, to plan and protect all cultural structures in state;


(6) Dissemination of technical knowledge to professional architects and engineers in the state on the methodology for *Assessment and Retrofit of Structures Damaged during Earthquakes*;

(7) Development of a cadre of professionals, as part of *Post-Earthquake Damage Assessment Teams*, trained to have capabilities to provide sound judgement on usability of structures damaged during earthquake shaking;

(8) PROHIBIT any new *unreinforced masonry constructions* in J&K, and RETROFIT existing ones, especially critical, lifeline and governance structures with a sense of urgency, and rest in a phased manner;

(9) Documentation of all losses incurred due to damage sustained by *non-structural elements*, and dissemination of technical know-how to architects and engineers on methods of protecting non-structural elements in buildings and structures;

(10) Commission an investigation team to study in detail *reasons behind this loss of communication systems*, and put in place systems to ensure no-blackout of communication systems in any area of the state during future earthquake events; and

(11) Encourage training of engineers each year in *earthquake-resistant design and constructions*; trained engineers advice all stakeholders in state on matters related to built environment.

Figure 29: Unreinforced brick masonry house just built along the slopes of Doda District has no earthquake-resistant features
5. ROAD AHEAD

Virtually, all lessons learnt from this low-intensity earthquake have been noticed also after each of the past 10 damaging earthquakes in India, namely 1988 Bihar-Nepal Earthquake, 1991 Uttarkashi Earthquake, 1993 Killari Earthquake, 1997 Jabalpur Earthquake, 1999 Chamoli Earthquake, 2001 Bhuj Earthquake, 2002 Diglipur Earthquake, 2005 Kashmir Earthquake, 2006 Sikkim Earthquake and 2011 Sikkim earthquake. The built environment does not have earthquake-resistant features. Even though the 2005 Disaster Management Act is in force, no systems are in place yet across the country, either to correct the situation with the existing (gigantic quantity of) built environment through seismic retrofitting or to amend the regulatory framework to ensure that new structures are built to be earthquake-resistant.

No more earthquakes are required to start the tenuous and arduous work in India of undertaking structural changes in governance of the country for
(1) Creating the ethos for earthquake-resistant education, training and research,
(2) Developing and enforcing regulatory framework to ensure compliance of earthquake-safety standards; and
(3) Undertaking phased seismic retrofitting of at least the critical and lifeline buildings and structures.

It is time to take hard decisions to counter the major challenges towards earthquake safety in the Himalayan region (Figure 30). Some initiatives are proposed to address the gap areas in the areas affected by the 01 May 2013 earthquake in J&K. These are presented in the sections below.
5.1 Post-Earthquake Damage Assessment

The 01 May 2013 Doda Earthquake produced a maximum intensity of VI on the MSK Scale. But, many buildings across the affected areas suffered cracking of varying degrees. Aftershocks are underway still, even three weeks after the earthquake. Both the citizens and engineers of the government departments do not seem to have confidence that these buildings are safe for occupancy. In fact, there is no appreciation of the relative seriousness of the types of cracks, e.g., cracks in walls of load-bearing masonry buildings, versus those at the RC frame – infill masonry wall interface. A question that all administrators of the Government of J&K are faced with is: Are the buildings safe or not for occupancy after the cracking sustained by them during 01 May 2013 Doda Earthquake? But, currently, there is no agency (across the nation!!) that has demonstrated experience to have the technical capacity and trained manpower to distinguish between these various types of cracks, to be able to declare the large stock of affected buildings to be either dangerous or not for immediate occupancy.

Government of J&K constituted formal committees (that included one engineer from one of the government departments) for assessing damages sustained by buildings. The damage assessment criterion adopted is in line with that mentioned in the State Disaster Response Fund (SDRF) Guidelines. Damaged buildings are classified into three categories, namely (i) those with less than 15% wall area having cracks, (ii) those with about 50% wall area having cracks, and (iii) more than 50% wall area having cracks. But, in general, there was no understanding of what the type, location and severity of the cracks; engineers in the state do not have the background to assess damages. Based on the above criteria, Government of J&K reported about 25,000 buildings to have been damaged during the M5.8 earthquake of 1 May 2013 in the districts of Doda and Kishtwar. The maximum intensity of ground shaking experienced was only about VI on the MSK scale during the earthquake in these districts of J&K state. Field investigations showed that damage assessment made was considerably on the higher side. While some weak and brittle constructions performed poorly during this event, the claim of ~25,000 houses having been partially or fully damaged is unreasonable.

With residents hesitant to move back into their cracked buildings, even though some of these buildings may be capable of resisting strong aftershocks, and possibly fit for occupation. Thus, there is a need to urgently:

1. Inspect all damaged buildings and categorically declare their safety for occupation;
2. Seek the assistance of national bodies, like NDMA, for identifying professionals to help in evaluating earthquake safety of existing damaged buildings, identify retrofit schemes, and undertake retrofit of damaged buildings (especially housing, schools and hospitals) requiring to be strengthened.

It is time to re-iterate that a national program should be launched on Post-Earthquake Damage Assessment, to

1. Develop technical criteria for post-earthquake damage assessment of different structures,
2. Train select individual engineers and architects in each state of the country in assessment of different typologies of that state with the help of specialists (from within India and from abroad) with background to assess quickly the extent of damage and determine safety of buildings and structures for their continued use;
3. Constitute Post-Earthquake Damage Assessment Teams (PEDATs) comprising of both engineers and architects;
4. Conduct post-earthquake damage surveys after future earthquakes, and update the damage assessment methodologies; and
5. Accord legal status to both the assessment criteria and the trained manpower to undertake the task.
5.2 Intermediate Shelters

The maximum intensity of ground shaking sustained in the affected area of state of J&K during this earthquake was small, only about VI on the MSK scale of earthquake intensity; for this reason, severe damage to buildings and structures was limited. Persons whose houses sustained severe damage moved to tents that were provided by the government. Even some schools, primary health centres and government governance buildings were damaged. There is concern on the safety of these structures and hence even these services are being run either in open air or in the tents. The most difficult question is: Are the houses and structures that are cracked during the earthquake safe for immediate occupancy? Since the government is unable to offer clean answers to the people, there is an increasing demand for temporary shelters.

There are options being placed in front of the J&K government for temporary shelters, e.g., left-over large-panel (asbestos-styrofoam) sandwich prefabricated systems from Uri District of the 2005 Kashmir Earthquake. The key concern with these systems is that they are not demonstrated through full-scale seismic testing to be earthquake-resistant for strong earthquake shaking expected in the south-eastern area of the J&K state along Himalayas. On the other hand, tents are not the systems for housing affected persons in the intermediate term.

Urgent action is required effort for
(1) Identifying acceptable engineering materials, technologies and architectural designs for construction of intermediate shelters to serve the needs of communities, e.g., schools, primary health centres, governance buildings, and housing. Each of these community needs may require different architectural designs in each region, in keeping with the regional choices. Also, much inspiration should be drawn from and confidence laid on traditional construction practices of the region, namely the Dhaji-Dewari Systems.
(2) Undertaking full-scale testing of these single storey (or even two-storey systems for guaranteeing earthquake-resistant behaviour of these intermediate structures during the expected strong shaking the Himalayan region.

Reinforced Concrete is not the dominant construction material in the state of J&K, even though its use is on the rise in the last decade. Also, there is limited expertise in the interior areas of the state of J&K for designing, constructing and maintaining such structures. Most of the damage in RC frame buildings during this Doda Earthquake was limited to frame-infill separation due to the relatively low intensity of shaking. But, these structures were not tested to their full capacity during this earthquake (by ground shaking of at least an intensity of IX on MSK scale that is expected in the region as per the seismic hazard map of the region). Hence, it is unfair to undertake constructions of more of the existing type of buildings, unless a study is undertaken to understand in detail the existing typology of RC structures and its earthquake resistance capacity for the scenario earthquake. Thus, intermediate shelters made of RC are not included in the discussion.

5.3 Seismic Retrofitting

If one message has to be taken out of the 2013 Doda Earthquake, it is that the existing built environment (except some of the traditional constructions) has little or no earthquake resistant features and is highly vulnerable to strong earthquake shaking expected in the region as per the seismic hazard zone map of India.

No collapses were noticed during this 2013 Doda Earthquake, because of the low intensity of shaking of about VI on MSK scale caused during the earthquake. But, some existing structures have sustained cracking that is a tell-tale for the poor behaviour of the vulnerable stock of existing structures during the more severe earthquake shaking expected in future in the region. Based on the current construction practices, a number of the existing structures (including those that were not cracked during this earthquake) are deficient in earthquake resistance. Considering that the construction typologies adopted do not have the requisite earthquake-resistant features, the following are suggested:
(1) Government structures in the affected areas should by a technical body constituted by the Government of J&K. Mandatory seismic retrofit undertaken of critical and lifeline structures found deficient. When funds are limited, this retrofit should be undertaken by the Government of J&K in a phase manner within a specified period of time. This set of structures includes even privately owned, but rented to be run as public buildings, critical or lifeline buildings or facilities. Of course, in this case, the expenditure for the retrofit should be met by the owner and not the government. If the owner fails to undertake the retrofit, government should vacate the premises and look for alternate space;

(2) Government of J&K could arrange for mobile retrofit camps or clinics with technical teams offering sound engineering advice to owners of private buildings and structures, which can be done at their own costs and consequences;

(3) Necessary legislation may have to be passed to mandate retrofitting in at least government owned and rented structures; and

(4) Demonstration projects should be undertaken by the Government of J&K on seismic retrofit of existing structures of different typologies. This will be a major confidence building measure for the people, and the engineers will learn retrofit design strategies hands-on. Understandably, the Government of J&K should arrange from across the country the necessary technical expertise needed initially. This will encourage owners to undertake seismic retrofitting of existing structures at a reasonable speed and price.

5.4 Post-Earthquake Detailed Investigations of Damages to Built Environment

Even though this is a low-intensity earthquake, it offers a number of pointers to the earthquake safety of the built environment. Technical teams should be deployed to study scientific aspects of the earthquake and their effects. Aspects to be studied include:

(1) Study of precise variation in intensity across the affected area;

(2) Study of geology of the hill slopes of affected areas that led to occurrence of landslides and affected the performance of roads along hill slopes, and give guidance on potential future slides and land use;

(3) Damages to critical and lifelines systems, e.g., bridges, water mains & reservoirs, electric supply, communication systems, schools and hospitals; and

(4) Damages to residential houses and buildings and other structures, in particular of the traditional Dhajji-Dewari constructions.

Appropriate national bodies need to be commissioned to urgently undertake each of these tasks. Pending important questions on earthquake-safety will be addressed with these efforts, and thereby improve the quality of post-earthquake retrofitting and mitigation programs that the state of J&K may undertake.

5.5 Study of Housing Typologies and Guidelines for Good Construction Practices

Many observations were made during the field visit in the districts of Doda and Kishtwar. Two prominent ones for improving the construction practices include:

(1) A large repository of good construction practices is already available related to the dominant construction typologies of the region, namely stone masonry houses, brick masonry houses, and RC constructions. The same should be translated into local language and disseminated.

(2) The state of J&K needs a strong techno-legal regime to be enforced urgently, to regulate both new constructions to be made earthquake-resistant and retrofit of existing vulnerable structures.

But, an important message that should be carried to the people at large is the story of encouraging traditional Dhajji-Dewari building type found in the western Himalayas. This form of construction is referred to in the Indian Standards as brick-nogged timber frame construction using local materials – timber and brick/stone masonry infill. The spaces left between the wood-frame members are filled with a thin wall (single wythe) of stone or brick masonry traditionally laid into mud mortar. Completed walls are plastered in mud mortar. The roof is preferably a pitched roof with timber/metal sheeting. The floors of these houses are made with timber beams that span
between walls. Timber floor boards, which span over the floor beams, would traditionally be overlain by a layer of clay (or mud). Because the timber framing and/or bracing is first erected the masonry does not directly carry vertical loads. Such buildings are typically 1-4 storeys tall.

Although this construction type is not formally engineered and is a relatively basic construction system, well maintained ones performed reasonably well during the 8 October 2005 earthquake in both Pakistan and India. The recent earthquake in Doda region (1 May 2013) also indicates that this building typology continues to be a reliable performance building system in earthquake prone areas. This traditional earthquake-resistant construction is being forgotten and the switch over to reinforced concrete buildings is happening rather fast. RC buildings could prove damaging in future earthquake events, if building materials are not understood and engineering inputs are absent. Governments should actively provide support to building/repair homes with the Dhajji-Dewari system. With adequate skill training to carpenters/masons, making availability of raw materials and minimal fabrication requirements (typically required for other construction types), Dhajji-Dewari is a more sustainable construction practice for construction of residential buildings in this region. There is urgent need to demonstrate confidence in this technology and identify aspects around the availability of required raw materials, training/capacity building and technology promotion.

5.6 Development Control Regulations & Municipal Bye-laws

The urban population of J&K State (Census 2011) is indicative of the growing urbanization in the State. The percentage share of total urban population by residence has increased from 24.81% in 2001 to 27.21% in 2011 census. Among hill states of India, J&K is the most urbanized state and cities are the focal points of urbanization. This increase in urban population puts increased pressure on urban services, social infrastructure and housing sector. Municipal bodies are challenged by this unprecedented growth and this is compounded further with acute shortage of capacity, especially disaster risk management. While cities have become engines of economic growth, urban development has assumed utmost importance. The planners and the administration of the state have come a long way towards improving the living conditions of people through an integrated planning approach.

The State of J&K is vulnerable to multiple hazard risks; people are exposed to threats form earthquakes because of the poor seismic performance of the housing stock (residential, commercial, institutional and life-line buildings). The widespread impact of low intensity earthquake shaking (1 May 2013) on the building stock is a clear indication that the built environment has not incorporated earthquake-resistant features. The reconnaissance visit (during 11-15 May 2013) to Kishtwar and Doda Districts of Jammu region, reaffirms that earthquake-resistant design codes and building construction code of practice are generally not followed, except in a negligible fraction of building stock. With increase in investments and rapid urbanization it is important for the State to reduce the vulnerability of existing structures and ensure structural safety in all new construction. The existing situation of building code implementation is extremely low, and thus has created an alarming situation which cannot be ignored.

Relief assistance (Central and State Government), existing and future development schemes/programmes of the Government implemented through the State Departments or private parties shall adopt and actively implement the Bureau of Indian Standards Code of Practice for construction and earthquake safety. There is an urgent need to translate knowledge into practical implementation through making additional provisions in development control regulations and structural safety in building regulations / bye-laws. Provisions can be made for defining mitigation measures for risks from natural hazards as part of Building Byelaws (land use zones, structural safety on basis of hazard zones). Building code plays an important role in public safety and loss prevention. Active enforcement of the building code in Government, Commercial and Private Properties is the only effective way to reduce personal injuries, property damages and minimize economic losses. In all the existing Acts, Rules and Bye-Laws in the State of J&K, provisions should
be made for hazard risk mitigation. The Model Building Bye-laws for natural hazard zones in India lists minimum items to be covered. The recommendations in it have been made keeping in mind the scale of the urban/rural and the availability of the technical manpower to implement the regulations/bye-laws. The development and construction activities in high seismic prone regions have to be regulated and controlled by the respective urban local body. Separate provisions may be developed for rural, town and city developments in areas affected by the earthquake.

5.7 Mobile Clinics for Earthquake Resistant Technologies

The damage caused in the October 2005 Kashmir earthquake and the recent earthquake of May 2013 indicate poor performance of building to ground shaking. Absence of earthquake-resistant features in majority of the construction types (leaving aside the traditional Dhajji-Dewari type) was the reason for damage of building to varying grades. This is an occasion to re-examine construction projects on anvil in the Doda and Kishtwar Districts with the assistance of competent engineers for ensuring compliance with Seismic design codes.

Establishment of Mobile Technical Clinics is one way to promote earthquake-resistant design and good construction practices. Mobile clinics manned by a small group of trained personnel, will include a trained civil engineer and a trained construction artisan, who will give advice to house-owners, engineers, developers, contractors, masons, and material supplier on earthquake safety. The clinics shall house a portable desk with resource materials (IEC materials), building prototype models which demonstrate earthquake-resistant features, and a small working model (portable shake table) to demonstrate impact of ground shaking on buildings with seismic and non-seismic resistant features. Also, the clinics can move to construction sites of owner-built building construction or community infrastructure, such as school buildings, and offers free advice. For existing small and non-engineered buildings, which require seismic upgradation, free consultations shall be provided to the house owners, who want to retrofit their houses.

5.8 Earthquake Resistant Design & Construction Education

The area does not have any engineering college and a polytechnic college has just been started in 2012. All engineering design inputs are received from the regional offices in Jammu for all departments. Some smaller structures are built with local engineering inputs from engineers of the government departments. The engineers confess that they have not undergone formal training in earthquake resistant design and construction. The earthquake has reminded once more of the need and importance of starting a major capacity building effort at the earliest.

Two pronged strategy is essential for enabling engineers to undertake good construction practices, namely short-term awareness and long-term training. Towards this end:

1. Faculty members in the newly started Government Polytechnic in Doda should be trained in the subjects of earthquake resistant design and construction of Dhajji-Dewari houses, burnt clay brick and stone masonry houses, RC buildings, RC bridges and long-distance water pipelines;
2. Engineers and architects of all government departments and private architects and engineers (if any) should be given 5-day short courses introducing them to the basic concepts of earthquake resistant design and construction of the systems commonly constructed in the region – Dhajji-Dewari houses, burnt clay brick and stone masonry houses, RC buildings, RC bridges and long-distance water pipelines;
3. Only a comprehensive Human Resource Development plan can make quantum improvements in the existing situation. Such a plan should include:
   a. Long-term Training of Engineers through degree programs,
   b. Licensing of Engineers in the state of J&K to ensure competence in those who are responsible for new constructions and retrofit of existing constructions; and
   c. Certification of Artisans of different trades, e.g., masonry and carpentry.
5.9 Earthquakes Awareness and Preparedness Campaign

The PERT members experienced the prevailing concerns, challenges and lack of awareness on earthquake-related issues. Three gap areas need to be plugged urgently, to make communities prepared to face future earthquakes with less uncertainty. These are:

(1) Earthquake awareness campaigns to make people aware of the prevalent high seismic hazard in the region, the associated perils and the needed preparedness steps to be undertaken individually and collectively;

(2) Mock drills shall be arranged in schools, hospitals, communities and offices as a regular feature to help people internalise the needed actions in the aftermath of earthquakes; and

(3) Help people appreciate the possible earthquake damages to their houses and buildings, and being able to take informed decisions on retrofitting their own houses and buildings. In particular, house owners need to appreciate the distinction between earthquake-resistant constructions and earthquake-proof constructions.

All forms of IEC strategies may be adopted, e.g., video, street-play, posters in local languages, and booklets.

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