The simplicity of the traditional structure was an essential attribute of safe construction. A simple rectangular or square plan was followed with the height restricted to double the length of the shorter side.

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TRADITIONAL GENIUS AND EARTHQUAKES

BY **PIYOOSH RAUTELA**

Traditional building techniques have always existed in regions vulnerable to earthquakes. Unfortunately, aspirations to modernity have tended to bury these norms, resulting in heavy casualties in recent times.

Just as other tectonically active regions of the world, Uttarakhand too has witnessed devastating earthquakes in 1720 (Kumaun Earthquake), 1803 (Garhwal Earthquake), besides the Uttarkashi and Chamoli earthquakes in 1991 and 1999. Despite these, hundred year old multi-storied houses are common in the region. Barring cattle sheds, single storied structures are practically never built. Both Kumauni and Garhwali have distinct words for the four different floors of a house, linguistics suggesting the prevalence of multistoried houses since ancient times. *Ghot*, *chak*, *pan* and *chaj* in Kumauni, and *koti*, *manjua*, *baund* and *baurar* in Garhwali indicate the four different floors of a traditional home. Thus, the people of the region adapted themselves to natural disasters by settling on firm, high ground, and based on traditional knowledge devised a set of rules and architectural styles to be followed for their own safety.

Site selection: Before undertaking construction, the suitability of the place and bearing capacity was assessed. This assessment could well be based upon soil texture, composition and presence of humus and moisture. There could well be an objective algorithm where final comments would depend upon the correlation of the observed variables.

Foundation: As a rule, foundation was dug until firm ground or in situ rocks were reached. Customarily, the foundation would be exposed to rains. This ensured that the ground was settled and settlement cracks common to present day constructions could be prevented. Tall buildings were constructed on raised and elaborate stone-filled solid platforms raised directly above the filled in foundation trench. The height of such platforms varied between 6 and 12 feet above the ground. Dry stone masonry was used for the construction of these platforms so that the centre of gravity and centre of mass were in close proximity and close to the ground. This minimised an overturning effect during seismic loading.

Simplicity: The simplicity of the structure was an essential attribute of safe construction. A simple rectangular or square plan was followed with the length of the sides varying between 4 and 8 m. The ratio of the two sides of the structure varied between 1.1 and 1.4 and the height was restricted to double the length of the shorter side.

This was in keeping with building codes that prescribe simple rectangular symmetrical plans with respect to both mass and rigidity so as to minimise torsion and stress concentration.

Small openings: Openings in the walls cause weakness and therefore additional reinforcement was often resorted to overcome it. Traditional houses here have always had a single small entry and relatively small windows. Strong wooden empanelment around all openings compensated for the loss of strength. Besides seismic safety, this helped in energy conservation.

The walls: In keeping with the precepts of seismic safety, people meticulously used wood and stone in different shapes and sizes for the construction of walls for seismic safety. Besides the use of corner and through stones, ample wooden beams were provided.

Consequently, it resulted in a mixed structure with two types of load sharing mechanisms;

- Vertical load being taken care of by thick walls running in all four directions, and
- Horizontal load being taken care of by interconnected wooden joists running in both directions. On the two sides of the structure, wooden beams were often provided from the outside. This is a special provision of shear keys to enhance seismic performance.

How could they do so?

Experimenting with designs to validate their efficacy during earthquakes is not that easy, especially since earthquakes do not return within short intervals. Detailed documentation of both, the design utilised for construction of the building and performance of the building during subsequent earthquakes therefore becomes necessary.

Oral tradition may not have been the only mode of transmission where such elaborate design and planning in artisanal skills is concerned, passed down from generation to generation.

Present scenario

A study done in the urban areas of Mussoorie, Nainital and Bageshwar has revealed that more than 15 per cent of the buildings fall in the highest damage grade. The situation in the rural areas is also equally deplorable.

How has this happened, despite a rich prevailing tradition in earthquake-resistant construction? Masons from this region had perfected the art of constructing safe houses using locally available stone and wood. Environmental consciousness over

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the past few decades has resulted in restrictions on quarrying and felling. Reduced availability of wood and stone combined with the growing demand of houses in urban areas has led to the introduction of brick, cement and RCC construction in the region. Yet, the necessary technology transfer and capacity building with regard to new building materials did not accompany this change. Newer houses were thus constructed by masons who lacked the know how of using new building materials, resulting in its vulnerability.

With the affluent class alone able to construct so-called modern houses, the latter ended up being recognised as symbols of vertical mobility and a higher social status. Consequently, many took to dismantling their traditional wood and stone roofs, replacing them with RCC slabs so that these could resemble modern homes. Since the traditional stone walls were not designed to take the load of RCC slabs, they ended up as far more vulnerable. In fact, the heavy toll in the Uttarkashi Earthquake is attributed to this practice; the collapse of many traditional homes resulted in RCC slabs crushing hapless victims.

Restricted availability of wood and stone has also had an adverse impact on the maintenance of houses in recent times. The central wooden log supporting the weight of traditional roofs have often not been replaced by many householders, making them vulnerable. The heavy toll in the 1999 Chamoli Earthquake is attributed to the lack of maintenance of traditional homes. In turn, the destruction of many traditional homes, as also widespread advocacy in favour of new construction material have shaken the people's faith in traditional construction practices.

The increase in tourists and pilgrims visiting the region in recent times has found many locals keen to cash in on the business boom. This has, in turn, seen many put up guest houses and hotels to make the most of this opportunity. A network of ill-reinforced and unplanned beams and columns that defy the slope of hills of Uttarakhand are in place today. Even riverbeds have been encroached upon to make a neat profit out of tourism. Heavy structures sited over elongated columns and multiple storeys on steep hill slopes are the bane of Devprayag, Karnaprayag, Almora, Rudraprayag and Bhatwari. Except for a few urban areas, building codes are non-existent. Even where well-defined building codes are in place, enforcement is weak and defaulters get their constructions regularised by paying penalties if reprimanded.

Awareness is recognised universally as being the key to popularisation of earthquake-safety norms and making the environment resilient. But few give adequate attention to this important aspect.

Firstly, despite being aware of the seismic vulnerability of a region, people remain oblivious to the nature of the risk of such an event. Secondly, people fail to realise that losses from an earthquake can be easily reduced by following certain technological norms. Thirdly, on site technical support remains as yet unavailable to the masses. Fourthly, technical know how remains unavailable in the vernacular. Fifthly, the financial implications of using earthquake-safe construction techniques are yet to be understood by the masses.

In the aftermath of the April and May 2015 Nepal earthquakes, the situation is grim. Seismologists globally have cautioned us that the Nepal earthquakes are only the tip of the iceberg, and a precursor of a great Himalayan earthquake which can strike anytime soon. The challenge lies in preparing ourselves in time before a situation far worse catches us napping.

Way forward

The road map to make our communities earthquake-resilient is simple and straightforward. BIS codes and model building bye-laws have been in existence for a long time. We only need to translate these to the ground through right planning and implementation. For this, we need local-level assessment through detailed studies of the existing building stock and mass awareness of the risks of ignoring building codes.

This will need to be accompanied with access to information and easy-to-understand technical

As opposed to traditional structures, a network of ill-reinforced and unplanned beams and columns that defy the slope of hills of Uttarakhand are in place today. Heavy structures on steep hill slopes are the bane of Devprayag, Karnaprayag, Almora, Rudraprayag and Bhatwari.

solutions for risk reduction, encouraging people to undertake appropriate measures for improving the seismic equations of their houses. Only then can we expect voluntary compliance with disaster-safety measures.

We also need to accept that rural houses would continue to be constructed without appropriate engineering inputs. Special emphasis needs, therefore, to be given to the capacity building of village level masons. Organised institutional arrangements have to be established for the same and incentives have to be devised for people to take up these courses. The shortage of engineers can be overcome by making available customised ready to use drawings to those desirous of building their homes. These could easily be done through state sponsored housing schemes.

Building bye-laws can easily be made compliant with BIS codes and an effective mechanism devised to ensure compliance of these. Non-compliance of bye-laws will need to be dealt with stern punitive action and engineers preparing and certifying the building details should me made accountable for any lapses or losses on their part.

At the same time, traditional construction practices can be improvised so as to keep them in tune with prevailing ground realities.

Lastly, we need to understand that disaster management can never be on the political radar of parties, since the outputs are largely intangible and not likely to result in electoral benefits. Mass awareness and advocacy for a disaster resilient community are the only routes for the safety and security of the masses.

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