25 years after Bhuj, the seismic safety lesson is unfinished

SHAMBHAVI DUBE AND DURGESH C RAI

On January 26, 2001, the Mw 7.7-Bhuj earthquake claimed over 13,000 lives, injured more than 1.5 lakh people, and rendered nearly a million homeless. Entire towns collapsed within minutes. It remains one of the most devastating disasters in independent India's history.

But Bhuj did more than destroy buildings. It shook India's understanding of what "safety" truly means. For the first time at a national scale, the entire chain that produces safe structures—planning, design, detailing, construction, supervision, and emergency functionality—was tested together. What failed was not only concrete and masonry but also the way knowledge moved from codes to drawings, from drawings to construction sites, and from sites to accountability.

Bhuj damaged everything considered "modern": reinforced-concrete buildings, masonry houses, bridges, hospitals, schools, industrial facilities, and lifelines. Across thousands of damaged structures, engineers could directly observe how materials, detailing, configuration, and construction quality behaved under severe shaking. The lesson was unmistakable: seismic safety depends as much on detailing and execution as on calculations. Strength without ductility collapses. Design without enforcement is decoration.

India did not lack technical knowledge before Bhuj. IS 1893 addressed seismic design, IS 4326 construction practices, and IS 13920 (1993) introduced ductile detailing. Earthquake engineering education existed in a few institutions. The problem was reach. Seismic design was treated as an "extra load case", not as a performance philosophy. Detailing rules rarely travelled from codebooks into drawings, bar schedules, and site inspections. Architectural layouts were often finalised before structural safety entered the discussion. Bhuj exposed this gap at scale.

The failures were technically predictable. RC columns failed in shear, joints fractured, confinement was missing, anchorage was inadequate, and soft storeys collapsed. Masonry walls separated from floors and failed out of plane. Industrial facilities failed at anchors and connections. Hospitals and schools lost functionality even when they did not collapse. Codal clauses that once seemed abstract became visible failure mechanisms.

Since 2001, progress has been substantial. Governance shifted from response to prevention. The Disaster Management Act (2005), NDMA guidelines, seismic risk assessments, and rapid screening tools reframed preparedness as a continuous responsibility rather than a post-disaster exercise.

Codes evolved sharply. IS 1893 was revised in 2002, strengthened in 2016, and fundamentally reframed in 2025. The latest edition adopts probabilistic seismic hazard assessment and active fault mapping, introduces Zone VI, and incorporates near-fault effects, liquefaction, soil–structure interaction, and non-structural safety. Yet science must remain buildable: safety that cannot be implemented economically is of little help.

For reinforced-concrete buildings, the deeper transformation came through IS 13920. After Bhuj, especially following the 2016 revision, ductility became mandatory. Capacity design, confinement in hinge zones, joint detailing, controlled lap splices, and boundary elements became enforceable requirements. Supporting codes for retrofit, tall buildings, masonry, and steel completed the shift from force-based checks to mechanism-controlled performance.

Equally decisive was the expansion of experimental capacity. Before Bhuj, testing facilities were limited. After Bhuj, India built a national experimental ecosystem. IITs, IISc, CSIR laboratories, NITs, and state institutions established shake tables, cyclic loading systems, and hybrid simulation facilities. Earthquake engineering moved from paper to proof, allowing codes and retrofit strategies to be validated against Indian materials and construction practices.

Human capital expanded alongside. Earthquake engineering education spread nationwide through new faculty positions, doctoral programmes, and professional training. Continuing education initiatives at IIT Kanpur since the early 1990s and the Government of India-sponsored National Programme on Earthquake Engineering Education (2003-2008) marked a turning point in capacity-building. Platforms like NICEE carried knowledge beyond specialists to engineers, architects, students, and even schoolchildren. Seismic safety entered professional culture.

Post-Bhuj reconstruction also demonstrated the value of global knowledge transfer. Confined masonry—long practised in Latin America—was adapted to Indian conditions. Its consistent performance showed that reinforced masonry can be a safe, economical alternative to RC for low- and mid-rise buildings, now visible in institutional campuses such as IIT Gandhinagar.

Yet, subsequent disasters delivered sobering reminders. The 2004 tsunami exposed vulnerabilities in coastal infrastructure. The 2011 Sikkim and 2015 Gorkha earthquakes revealed fragility in ordinary housing. The 2016 Imphal earthquake was especially troubling: publicly funded buildings performed poorly. The problem was not lack of knowledge but failure of compliance.

This remains India's central challenge. Vulnerability today arises not from absence of codes or research, but from inconsistency in implementation. Municipal review capacity is limited. Approvals often prioritise bylaws over seismic detailing. Proof-checking is uneven. Poor construction quality erodes safety margins assumed by design. The greatest risk lies in existing buildings never designed for ductility.

India's next leap must begin with strict compliance in new construction, so unsafe buildings are no longer added to the stock. This requires enforceable review mechanisms, construction-stage quality control, systematic audits and retrofitting of hospitals, schools, and lifelines, and a sustained research-to-practice pipeline in which earthquake lessons continuously update design and training.

Earthquakes are natural. Disasters are engineered. Bhuj still asks one question: when the next major earthquake comes, will India's progress be visible only in documents and laboratories—or in buildings that stand, hospitals that function, bridges that remain open, and communities that recover faster?

(The writers are with the Department of Civil Engineering, IIT Kanpur)