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Editorial

Key Building Design and Construction Lessons from the 2023 Türkiye–Syria Earthquakes

Iftekhar Ahmed

School of Architecture and Built Environment, University of Newcastle, Callaghan, NSW 2308, Australia; ifte.ahmed@newcastle.edu.au

Two 7.8- and 7.5-magnitude earthquakes struck Türkiye and Syria in February 2023, but it is not only the magnitude of these natural hazards that caused such devastation; when the hazard met conditions of vulnerability, the disaster resulted. The conditions of vulnerability were created primarily because of the type and quality of the buildings. Initial estimates indicate nearly 40,000 buildings were severely damaged or collapsed, about 10–20 per cent of the building stock in four of the most affected provinces. Additionally, the timing of the first earthquake, occurring at 4:17 am in the early morning when people were sleeping, was unfortunate, and many people were crushed by collapsing structures [1].

Most of the affected buildings were multi-storey with reinforced concrete roofs, frame structures, and unreinforced masonry infill walls [1,2]. Generally, concrete provides compressive strength and is strong under pressure, but it can disintegrate when exposed to lateral stress such as that caused by seismic movement or shaking. On the other hand, steel reinforcing bars (or rebars) have a high tensile strength and can effectively resist lateral stress. The combination of concrete and rebars, that is, reinforced concrete (RC) brings stability to a building structure via a balance of compressive and tensile strength. The strength of the concrete mix, with cement, sand and aggregate in the right proportions; the dimensions and spacing of rebars, columns, and beams; and the thickness of roofing slabs, among other structural elements, are specified in the structural design of a building according to the context, size, and function of a building. In the case of buildings designed for resilience to earthquakes, the design of the steel reinforcement is critical due to the ability of steel to withstand tensile stress posed by seismic forces [2,3]. The term 'ductility' [4]—the ability to stretch or bend within a limit without deforming—is a key property of most types of rebar. Therefore, other than the RC frame structure, earthquake-resistant design also requires the reinforcement of masonry walls in vulnerable places, such as the corners of door frames and windows, as well as continuous tie beams at different levels within walls. Building codes for areas at risk of earthquakes provide specifications for such structural designs.

Beyond the basic form of earthquake-resistant design and construction, there is a wide range of other concepts to consider, for example, the concept of 'base isolation', which separates a building from the ground and places the foundations on flexible pads, thereby allowing it to shake during an earthquake without toppling [5]. There are many other similar measures that involve higher costs and technical expertise. However, even if basic principles are followed with proper steel reinforcement, a significant proportion of the devastation and consequent loss of lives and injury can be avoided. Such basic principles for earthquake resistance have been advocated for a long time, and key proponents such as Arya et al. [6] have suggested that even 'non-engineered' buildings can benefit from such principles. Tragically, this was not the case in Türkiye and Syria; it has now become evident that the disaster was exacerbated by a widespread disregard and lack of implementation of building codes, which posed a great risk to communities. The lack of adequate steel reinforcement meant that buildings were already brittle, causing them to collapse in the earthquakes. Despite this, in an earthquake of such a high magnitude, even buildings

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with earthquake-resistant designs may experience some damage. However, the number of casualties could still be reduced, and due to a better ductility, structures can bend to withstand earthquakes and only experience repairable damage.

The situation is unclear in Syria, where it is likely that earthquake codes were not mandated. However, in Türkiye, since the devastating 1999 Izmit Earthquake, a strong institutional and professional attitude towards building codes has developed, which has been consistently updated, even as recently as 2018 [1,3,7]. It appears that many of the buildings that collapsed were older and were not built according to these codes [1,2]. Footage from the disasters shows almost fully intact buildings standing right next to collapsed ruins, despite the level of seismic stress being similarly distributed. However—due to widespread corrupt practices; the avoidance of codes by unscrupulous builders and property developers; the poor quality of construction by skimping on steel reinforcement; and the use weak concrete mixes to save cement, reduce costs, and increase profits (see [7–9])—it is unclear whether the buildings collapsed due to their old age or the disregard of codes. One report indicates that, in a newly constructed housing estate in Antakya municipality, extensive building collapses killed many people, yet in nearby Erzin, there were no collapses because of compliance with building codes [7]. There are also reports that apartments were sold by developers with the claim that they incorporated earthquake-resistant designs, but these multi-storey buildings toppled like dominoes. In some areas, while these newly constructed building collapsed, it is reported that older buildings remained standing [9].

An estimated 50 percent of buildings in Türkiye do not comply with building codes [8], which is a great concern, given that the country is located in a seismically active region. A web of corruption spanning from government bureaus to design/construction professionals and builders/developers, i.e., the entire built environment sector, has now come into the limelight. Government amnesties in the name of facilitating rapid, affordable urban developments have also caused the institutionally sanctioned neglect of building codes [7,8]. In the coming days, if a proper damage assessment and investigation are conducted after emergency responses, more data on the buildings that collapsed can be uncovered, perhaps informing future policy and action, although the pervasive and insidious web of corruption sheds doubt on such optimism.

While the affected communities suffer extreme hardships, living outside in the open during the cold season, it is now important to consider early recovery, leading to the longer term to settling people in safe, permanent housing. However, this is unfortunately expected to be a protracted process given the typical pattern of constructing multi-storey housing, which is expensive to build. It would require significant funds and time to rebuild the extensively damaged infrastructure, and despite the initial demonstrations of international support and generosity, a series of disasters are occurring around the world, for example, the recent floods and a cyclone in New Zealand [10], as well as floods and landslides in Brazil [11], which require global attention and support. In addition, the ongoing war in Ukraine has destabilized the global economy, and the recent COVID-19 pandemic is also taking its toll. Therefore, there is a long road ahead. It is going to be a huge task to rebuild the devastated areas of Türkiye and Syria, and sadly, it is unlikely to happen quickly.

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