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Additional Information

# RECENT TRENDS IN STRENGTHENING STRUCTURES AGAINST EARTHQUAKES

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Every new earthquake tests the resistance of both traditional masonry buildings and those of modern design, based principally on steel and concrete structures. However, it must be said that there are times when these structures are not ideally suited to resisting seismic action. There are even cases in which structures that comply with all the building regulations fail under these conditions, which shows there is a clear need to modify the existing standards.

Many examples can be given of earthquakes that have given rise to multiple structural collapses with a high cost in both lives and financial terms. For example, there have been serious earthquakes in recent years in Nepal, China, The Philippines, Pakistan, Japan, New Zealand, Chile, Italy, Turkey, Afghanistan, etc.

In view of the continuous risk from seismic movements, there is at the present time a growing interest in studying how to strengthen structures against their effects, and for this a number of different approaches can be used.

## **SPECIAL THEMED ISSUE IN THE PROCEEDINGS OF THE ICE-STRUCTURES AND BUILDINGS**

Of the different ways of minimizing the effects of earthquakes on structures, three can be highlighted for their importance: a) finding elements to dissipate the energy transmitted by earth movements in both new (Khoshnoudian and Hemmati 2014) and old structures (D'Ayala and Paganoni, 2014); b) finding materials to increase a structure's resistance, even if it has previously been damaged (Yaman and Canbay 2014; Ismail and Ingham 2014); c) finding ways to optimize existing resistance schemes or procedures (Ghasemi and Farshchin 2014, Faella, Lima, Martinelli and Realfonzo 2014). The forementioned methods have been described in a special issue of the Proceedings of the ICE-Structures and Buildings, which contains six papers contributed by 14 authors at present engaged in research on techniques of strengthening structures against earthquakes.

## **PRESENT TRENDS**

The studies currently being carried out on strengthening structures against earthquakes focus on the use of both modern materials, such as FRP, and the more classical concrete, steel, mortar, etc.

In all cases of strengthening, an attempt must be made to increase the capacity of the structure to dissipate energy and improve its resistance while keeping deformation to an acceptable level, with the aim of avoiding the loss of human lives.

Present studies on concrete structures are looking into the use of composite materials to strengthen beams, columns and beam-column nodes. Other techniques being studied include concrete and steel jackets.

In the area of steel structures, the latest studies focus on the use of bracing systems and on modifying the resistant sections in order to improve ductility and structural strength.

Other studies on historical masonry structures analyze the use of mortar, compound materials and steel, with the aim of increasing structural integrity while at the same time keeping any negative effects on the building's aesthetic qualities to a minimum.

Lastly, some research groups are approaching the problem by looking into the use of dampers to dissipate seismic energy and thus avoid catastrophic structural damage.

## **SUMMARY**

As has been seen from recent seismic episodes all around the world, a large number of structures require strengthening in order to be able to withstand the forces generated and thus keep the numbers of human casualties to a minimum. A wide range of strengthening techniques is available against seismic forces, and a lot of effort is being put into expanding the current knowledge on the use of these techniques.

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Collapse of a building in Lorca (Spain) during an earthquake in 2011.