Research Article

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Advancing seismic performance: Isolators, TMDs, and multi-level strategies in reinforced concrete buildings

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Abstract: This study evaluates seismic mitigation methods, including high damping rubber bearing, lead rubber bearing, double sliding pendulum (DSP), and tuned mass damper (TMD), considering earthquake intensity, building height, and isolation level. Moreover, the study delves into a novel approach that incorporates multi-level isolation and multi-level TMD. Reinforced concrete buildings, ranging in height from 4 to 40 storeys, were nalysed and nalysed using SAP2000 under the seismic influence of the Badra, El Centro, and Northridge earthquakes. The study reveals a significant rise in the fundamental period (T) with base isolation systems, reaching 378% of the fixed base value for a six-storey building. Building height directly affects T values, with simplified equations introduced for calculation. DSP proves 5% more efficient in reducing base shear (BS), while TMD is effective in weaker earthquakes for minimizing lateral displacement. Base isolators outperform mid-level isolation and TMD at the top storey. Combining base isolators with TMD at the top storey is deemed impractical and uneconomical. The study recommends multilevel isolation or multilevel TMD for enhanced seismic isolation efficiency, with four-level isolation achieving an 80% reduction in BS for 12-storey buildings. In addition, four-level TMD outperforms TMD at the top storey with a 44.5% reduction in BS, surpassing the 26.6% reduction achieved with TMD at the top storey only.

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1 Introduction

Generally, the earth structure consists of inner core, outer core, mantle, and crust. The crust and the upper part of the mantle layer form the tectonic plates. There are seven large and several smaller plates [1]. The boundaries between these plates are named faults. These plates move relatively to each other [2]. As tectonic plates move, they can get stuck at their edges due to friction. Stress builds up in these areas, and when it exceeds the rocks' strength, a sudden release of energy causes an earthquake or seismic wave. The size and severity of an earthquake are estimated by intensity and magnitude [3,4].

Earthquakes can be destructive to people and economy as well. It is found that around 10,000 people die every year due to earthquakes. Also, many towns and villages were destroyed around the world [5].

Since earthquake events cannot be predicted or avoided, implementing measures to minimize damage and protect communities becomes crucial. Many seismic construction design and technology have been developed to reduce the effect of earthquakes on the structures. In traditional methods, the building's resistance to earthquakes is provided by either high strength and rigidity or high ductility of the structure. Increasing the structure's stiffness reduces the vibration period, causing a rise in acceleration and amplified seismic loads. Concurrently, higher ductility contributes to an increase in interstory drift demands [6,7]. The negative side of this method is that the building has to absorb all the lateral forces induced by the seismic ground motion. A modern method was developed to overcome the disadvantage of the traditional method by isolating the structure from the earthquake effect by using flexible material at the horizontal level called isolators (Figure 1) [3]. Base isolators come primarily in two major types: elastomeric