UNIVERSITI TEKNOLOGI MARA

DESIGN ENHANCEMENT OF TWIN-TOWER SEISMIC ISOLATION STRUCTURES WITH AN ENLARGED BASEMENT THROUGH MODAL COMPARISON

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ABSTRACT

In recent years, seismic isolation, as an emerging technology, has found broader application in seismically active regions. However, most applications are limited to buildings with regular geometries, and few have been implemented in those complex structures like Twin-tower structures with an enlarged basement(2TSLB). Although some studies have investigated the seismic isolation techniques in 2TSLB structure, few studies have systematically compared the performance of inter-layer isolation and base isolation schemes. The limited findings are often inconsistent, leading to unclear conclusions. Furthermore, few studies have adopted the Structural Separation Design Method (SSDM) for this type of 2TSLB structure or considered the influence of its various height-to-width ratios on the selection of isolation schemes. Based on these research gaps, the main objective of this thesis is to investigate and compare the seismic isolation efficiency, safety performance and cost of 2TSLB structures with base isolation and interlayer isolation, while considering the influence of applying SSDM, various structural systems (including frame and shear-wall systems), and height-to-width ratios. This study developed twenty-three models compliant with the Chinese seismic codes, featuring different height-to-width ratios and structural systems, and performed comprehensive numerical analyses using ETABS on these models in three aspects: seismic isolation efficiency (e.g., in reducing internal forces and accelerations), safety (e.g., against collapse), and cost. The following main conclusions were drawn: 1) For such 2TSLB structures, generally, compared with base-isolated structures, inter-layer isolated structures exhibit superior safety performance (in terms of resisting collapse during earthquakes, qualified by metrics of the maximum earthquake acceleration that the structure can endure before failure) and lower construction costs. Nonetheless, the isolation efficiency (quantified by metrics such as largest maximum story shear force) of inter-layer isolated structure is relatively lower. 2) In the altered height-to-width ratio of the structure (from 4.16 to 2.38) and the structural system (from a shear-wall structure to a frame structure), these above conclusions remained consistent, thereby demonstrating the broad applicability of the findings. Subsequently, by combining these conclusions with practical experience, a decision process flow chart for seismic-isolated 2TSLB design was summarized. The conclusion of this study answers the questions raised by objectives, optimizes the structural design process, assists structural engineers quickly find the appropriate seismic isolation schemes, and provides additional theoretical basis for the application of isolation technology in complex structures such as 2TFSLB. It should be noted that this study is based on numerical analysis, and the findings could be further validated by experimental tests.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

The occurrence of earthquakes inflicts significant damage upon human beings, including the structural collapse of buildings, the destruction of infrastructure such as roads, water supply systems, power grids, and gas pipelines. Moreover, earthquakes have the potential to trigger soil liquefaction, landslides, debris flows and other disasters that directly or indirectly lead to loss of life.

1.1.1 The Basic Concept of Traditional Earthquake-resistant Designs

With the advancement of science and technology, a comprehensive set of traditional earthquake-resistant design methodologies for building structures has been developed, utilizing the stiffness, strength, and ductility of the structure to effectively resist seismic forces.

The purpose of this is to achieve the design objectives (MOHURD & AQSIQ, 2010) such that the building can withstand frequently occurred earthquake without damage, can be repaired for normal use when subjected to an earthquake at basic fortification intensity, and will not collapse during rare earthquakes exceeding the basic fortification intensity in the region. Nevertheless, on the one hand, the random nature of earthquakes often causes structures to suffer earthquakes that exceeds the local seismic fortification intensity. On the other hand, certain specialized structures require that the internal functions of the building remain operable and precision instruments within it remain undamaged after an earthquake, such as hospitals, nuclear power plants and other critical infrastructure. This necessitates an enhanced seismic performance of the structure, which leads to the concept of seismic isolation (SI) technology.

1.1.2 Basic Concepts of Seismic Isolation (SI)

The principle of seismic isolation (SI) involves inserting a layer of seismic isolation between the superstructure and foundation or within specific parts of the