学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　PARK Ji Hyun

学　位　論　文　題　名

Study on the characteristics and response control effects of a seismic mass damper system utilizing scrap tire pads
(スクラップタイヤパッドを利用した地震用マスダンパーシステムの特性と応答制御効果に関する研究)

As environmental problems have emerged, attempts have been made to use waste as a building material. Recent studies have proposed and investigated vibration control techniques, including seismic isolation and tuned mass damper systems for earthquakes using waste or used tires. Amid these flows, more recently, a seismic mass damper (SMD) system using scrap tire pads (STPs) for building structures has been proposed. The STP unit can be made by cutting the tread part of radial tires and laminating multilayers. In the SMD system, an adequate number of STPs are placed in the vibration control story at the top of the mainframe of a superstructure to exert a mass damper effect during an earthquake. It is expected that STPs act as the necessary spring, damper, and bearing functions for the SMD system. The system is expected to mitigate the peak responses of a building structure during an earthquake, resulting in a reduction of the damage to humans, structures, and non-structural members. The reuse of tires for STPs contributes to the solution of environmental problems such as excessive waste generation. Although past studies proposed various systems including base-isolated structures using waste or used tires and investigated the characteristics through experiments, no studies on the SMD systems using STPs have been conducted. No dynamic loading tests on STPs were conducted except for free vibration tests, thus the dynamic behavior of STPs for various parameters including the loading amplitude and speed, and surface pressure effects has not been clarified yet. In addition, the vibration control effects of the SMD system utilizing STPs subjected to seismic motions have not been examined.

This dissertation aimed to grasp the availability of the SMD system using STPs for seismic response reduction of buildings. The following specific objectives were examined for this goal: (1) to investigate the mechanical behavior of STPs under horizontal and vertical loadings through experiments; (2) to assess the performance of STPs concerning horizontal stiffness and damping characteristics; (3) to numerically evaluate the control effects of the SMD using STPs by earthquake response analyses. In this research, loading tests using STP unit specimens were conducted to understand the mechanical characteristics of STPs. Additionally, to evaluate the effectiveness of the SMD system, seismic response simulation was performed under various input motions using the mechanical properties obtained from the experiments.

This dissertation is structured into six chapters as follows.

Chapter I is the introductory chapter. This chapter clarifies the background, research gaps, objectives, and methodology of the present study.
Chapter II provides an overall description of the SMD system using STPs. The concept and advantages of the SMD system are explained, and an estimated number of tires needed to apply the SMD system to a building is given.
Chapter III experimentally investigated the mechanical properties of STPs. In the experiments, four STP unit specimens were prepared from tires with different mileage and manufacturer. Loading tests were conducted using the STP specimens. The test results showed a dependency on the loading conditions such as the loading cycle, frequency, amplitude, and surface pressure. All the STP specimens showed similar tendencies in their dependence on these parameters, although there were small differences depending on the status and manufacturer of the tires. Also, the results demonstrated that each STP specimen had a certain energy dissipation performance.
Chapter IV presents a seismic response analysis of a simplified linear model to examine the availability of STPs as a main element of the SMD system. A numerical two-degrees-of-freedom system model was used to simulate the response of buildings with the SMD system. The results of the analysis showed the effectiveness of the SMD system using STPs.
Chapter V evaluated the performance of the SMD system by numerical analyses using non-linear multi-story models. The analysis models were prepared by referring to two building models, a six-story reinforced concrete building and a 10-story steel reinforced concrete building, which take into account soil-structure interactions. An earthquake response simulation was conducted for the building models with and without the SMD system. Analysis results showed that the maximum response acceleration of the superstructure for the controlled model was reduced compared to the uncontrolled model. Also, results revealed that the earthquake response can be effectively reduced by setting the lateral stiffness and damping coefficient for the mass damper story to be smaller than those corresponding to the elastic natural period, in consideration of decreasing the equivalent stiffness of the mainframe due to the progress of damage and plasticity.
Chapter VI is the conclusion of this entire research. Based on the results and considerations of this study, it was concluded that the use of STPs for the SMD system could have a positive effect. The horizontal dynamic loadings under constant vertical pressure and quasi-static vertical loadings were performed on the four STP specimens to determine the basic mechanical characteristics. A seismic response analysis was conducted with and without the SMD. The results demonstrated that incorporating the proposed system using STPs can achieve a response reduction effect. This chapter also lists some recommendations for future studies.