Structural Design of Office Building with Resilience and Redundancy using Viscoelastic Dampers

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1 Abstract

4-story steel-frame office building was designed having approximately a rectangular plan of 50 m × 40 m (span 9.6m, 5 spans × 4 spans) in Osaka, Japan. Here, there is a risk of large-scaled earthquakes (subduction-zone earthquake and local earthquake which occurs directly underneath), and high earthquake resistance performance and flexibility as office building were required. Therefore, we designed rigid-framed structures without a brace inside the building and provided seismic elements in only outside frames. One pair of K-type buckling restraint braces and one viscoelastic damper with K-type steel braces are set up for each outside frame on each floor considering the eccentricity of this building. This viscoelastic damper controls the seismic response by the damping due to the response velocity and restrains the residual deformation of each story by its elastic component. In addition, the viscoelastic damper functions as a fail-safe by its hardening under the large deformation, preventing collapse under large-scaled earthquake exceeding assumptions. We show the advantage of this type of building in terms of resilience and redundancy with structural analysis results.

Keywords: office building; steel structure; seismic-response controlled structure; viscoelastic dampers; high damping rubber; buckling restraint braces; redundancy; resilience; optimum design.

2 Introduction

In Japan, an earthquake-prone country, buildings are required to be earthquake redundant [1]. In such a situation, we designed a 4-story steel-framed office building with a penthouse in Osaka, Japan. In Osaka, there is the risk of large-scaled earthquakes (subduction-zone earthquake and local earthquake which occurs directly underneath), and high earthquake resistance performance and flexibility as office building were required. However, at the same time, we were requested by the client to design so that the construction could be done within a limited construction budget and on a short period of time.

We have also proposed that the seismic force set by the Japanese Building Code be increased (for example, multiplied by 1.25). However, we could not immediately make design changes to stop the increase in seismic force if the bid amount did not fall within the planned construction budget at the time of bid proposal. Therefore, we designed structurally to keep the seismic force set by the Japanese Building Standard Code at the minimum level, and added seismic-response controlled materials to that frame as additional components.

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