EVALUATION OF EARTHQUAKE DAMAGE MITIGATION METHODS FOR MUSEUM OBJECTS

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Act—In this paper, procedures are discussed for the evaluation of some of the earthquake damage mitigation methods in use or under development at the J. Paul Getty Museum. Generic models for various categories of objects have been formulated and analytical techniques have been devised that allow the assessment of the susceptibility of objects to rocking, overturning, sliding, and stress failure when subjected to earthquake-induced forces. Failure criteria are discussed and examples of categories of mechanical methods for reducing transmitted forces are given. Experimental verification of some of the analytical formulations has been carried out on object models using sine, swept sine, and simulated earthquake accelerogram inputs to laboratory-scale shake tables. The concepts and procedures described are generally applicable to other museums and cultural heritage repositories.

1 Introduction

The possibility of damage to fragile objects on display in museums during an earthquake is significant even if the building structure itself remains intact. Violent shaking and tilting of rigid structures can lead to object overturn, fracture resulting from dynamic loading stresses, or sliding and collision of the object with neighboring objects or walls. The damage resistance of objects depends on many factors including earthquake characteristics, building response, object materials properties and structures and support method. Although resistance to damage can be improved by modifications either to the object or to its support, altering the support is the preferred method.

Development of techniques for mounting objects in museums located in areas of seismic activity has not received much organized attention by the conservation community. This lack of activity may have been due to the relatively low priority given the problem because of the infrequency of earthquake occurrence. Another possible reason is the wide variation in object characteristics that need to be addressed in the design of a mounting system and in the absence of useable guides that relate these characteristics to the failure mechanisms that are applicable during an earthquake.

Methods for protecting the contents of buildings from earthquake damage have been described [1–3] but these are essentially qualitative and do not take into consideration the special needs that exist for the protection of museum objects. These include minimum intervention with the object itself and with its appearance.

Several years ago, the staff of the J. Paul Getty Museum (JPGM) in California recognized these problems and initiated design studies of mounting systems that would assure survival of objects in the event of an earthquake on the nearby Malibu fault. The systems that were developed ranged from a sophisticated base isolation system for a marble Kouros [4] to simple, unobtrusive tie-down clamps. However, a need existed both for a quantitative evaluation of the performance of the combined object-support systems when subjected to an earthquake, and for engineering guidelines that could be applied to the design of the mounts for the other objects in the collection.

In this paper, we report on the development of a procedure for evaluation of the response of individual art objects to earthquake excitation. To accomplish this, it was found expedient to generalize and use generic object classifications because of the large variety of objects and support systems that required analysis. The generic systems considered included the six most often encountered object/support systems and three types of base isolation systems. Analytical studies were carried out to model the systems and to determine significant system parameters. A number of experimental tests were performed to determine the validity of the analytical models by subjecting physical models to simulated but realistic earthquake conditions. The Representa-

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