Quantifying damage in the steel shims of seismic isolation rubber bearings due to support rotation

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Abstract

Seismic isolation is an effective technique for mitigating the earthquake movements on important infrastructures such as bridges and hospitals. Rubber bearings are one of the most common seismic isolation devices used for the protection of critical infrastructure assets. Isolators are critical elements of an isolated structure, and as such, they should experience limited, if any, damage during earthquake shaking. Damage associated with yielding of the reinforcing steel shims in seismic isolation rubber bearings has received limited attention in the literature. This study investigates the effect of the steel reinforcement characteristics on the behavior of rubber bearings under combined axial load, shear displacement, and rotation. The potential damage of the steel shims and the rubber bearings under design-level lateral loads is investigated using a damage index, r_{pl}, and a damage factor, Ω, respectively, with emphasis placed on the thickness of steel shims.

Keywords: rubber bearing; seismic isolator; steel shims; shim thickness; damage index; damage factor; vulnerability; residual deflections; rotation; nonlinearity.

1 Introduction

Seismic Isolation rubber bearings are composed of alternating layers of rubber and steel. They are used for the seismic isolation of critical infrastructure assets such as bridges [1,2]. They have low horizontal stiffness and high vertical stiffness, so that they can provide effective horizontal isolation while supporting the weight of the structure without excessive vertical deflections [3,4]. This high compressive stiffness is achieved by the presence of the steel shims, which constrain the lateral bulging of the rubber. This constraining effect in the rubber generates tensile stresses in the shims that, if they become large enough, could cause failure through yielding or fracture.

Research on the effect of the thickness of steel shims and the response of isolators after the shims yield is scarce. Kelly and Takhirov [5] investigated the influence of the steel shim thickness on the performance of bearings, but residual rotations and vertical deflections as a result of yielding of the

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