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QUALITY ISSUES OF SEISMIC RESTRAINTS FOR NON-STRUCTURAL BUILDING COMPONENTS SUBJECT TO EXTREME CONDITIONS

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ABSTRACT

Mechanical and electrical equipment that generate noise and vibration are mounted on vibration isolators. For seismic applications these isolators are designed with restraint parts that limit the movement in specific direction. To enable easy manufacturing and assembly designers prefer standard bolts, studs that are readily available in the market. These bolts form the main restraint part of the seismic isolator. They are assembled in holes that include elastomeric elements to prevent metal to metal contact. Recent dynamic (shake table) tests exposed catastrophic bolt failures. Most of the failures were found to be related to material composition. Low grade bolts could not withstand the dynamic and repeated loading characteristic of the shake table testing. High grade steel has its advantages from mechanical performance prospective but they are vulnerable to environmental conditions as are most engineering metals. One of the most critical issues is their protection against corrosion. Hot deep galvanizing is widely used in the construction industry and many specifications call for it when isolators are to be used in outdoor conditions. This coating type presents a specific problem to high grade steel. It causes hydrogen embrittlement which is undesirable and especially in dynamic loading can cause failure of the bolt and consequently failure of the isolator and the equipment itself.

Quality Issues of Seismic Restraints for Non-Structural Building

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Components Subject to Extreme Conditions

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Mechanical and electrical equipment that generate noise and vibration are mounted on vibration isolators. For seismic applications these isolators are designed with restraining parts that limit the movement in specific directions. To enable easy manufacturing and assembly designers prefer standard bolts, studs that are readily available in the market. These bolts form the main restraint part of the seismic isolator. They are assembled in holes that include elastomeric elements to prevent metal to metal contact. Recent shake table and dynamic tests exposed catastrophic bolt failures. Most of the failures were found to be related to material composition. Low grade bolts could not withstand the dynamic and repeated loading characteristic of the shake table testing. High grade steel has its advantages from mechanical performance prospective but they are vulnerable to environmental conditions as are most engineering metals. One of the most critical issues is their protection against corrosion. Hot deep galvanizing is widely used in the construction industry and many specifications call for it when isolators are to be used in outdoor conditions. This coating type presents a specific problem to high grade steel. It causes hydrogen embrittlement which is undesirable and especially in dynamic loading can cause failure of the bolt and consequently failure of the isolator and the equipment itself.

1. Introduction

Earthquake protection of non-structural building components and improving their performance is relatively new subject in the commercial industry. Considering the fact that major earthquakes are not everyday occurring events there is limited performance data available on the subject. Past earthquakes in the last decades have demonstrated the importance of these components. Hence recent building codes include requirements for non-structural building components but these codes are not able to cover all aspects. Recent changes in ASCE 7 meant that some critical equipment had to be qualified for seismic by shake table testing. These tests exposed isolator failures that were unexpected. Majority of the failures were related to the restraint bolts on the isolators and they were across the board and not limited to single manufacturer or type of isolator.

2. Seismic Restraint Mounts for Mechanical and Electrical Equipment

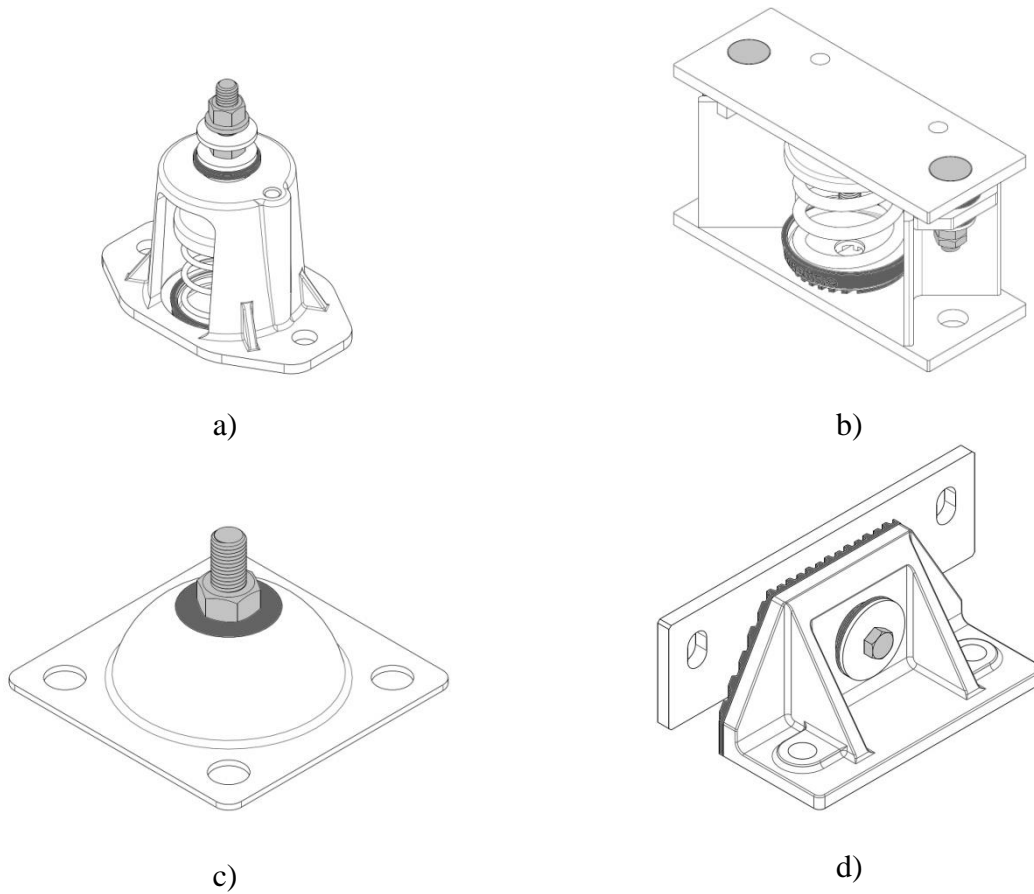
Non-structural building components account for substantial amount in terms of material and cost in modern commercial buildings. Their seismic capabilities are directly correlated with building

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performance during earthquake. Especially mechanical, electrical and plumbing (MEP) installation and equipment play key part in achieving safe and high performance buildings. Some of the MEP equipment include pumps, fans, chillers, cooling towers, air handling units and diesel generators. Besides providing comfort and basic utilities their continued operation is critical for hospitals, police station and other types of emergency buildings, in natural disaster zones.

Majority of MEP equipment generate vibration, hence the use of external or internal vibration isolators are inevitable. There are many types of isolators in commercial use but in broad terms they can be categorized in two main groups elastomeric and spring type mounts. Their adaptation for seismic use is achieved by incorporating steel housings and restraining parts. Typical seismic mounts are shown bellow in Figure 1:



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