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Effectiveness of Earthquake Retrofitting of Masonry Dome using Base Isolation Technique

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Abstract-

Study of retrofitting of masonry dome for earthquake resistance using base isolation technique is presented. A flexible layer of elastomeric bearings is provided at the circumferential bottom of the dome as well as the wall at the top of which dome rests. The finite element software ANSYS® is used for the effectiveness of earthquake retrofitting of masonry dome and effect of base isolation technique numerically. Comparison of the conventional dome without retrofitting is also done with the same manner. Significant reduction in principle von Mises stresses is observed as compare to conventional dome, which reflects the effectiveness of the retrofitting using base isolation technique. STAAD Pro. Software is also used to validate the results of von Mises stresses.

Index Terms- retrofitting, earthquake, base isolation, masonry dome, base isolation.

INTRODUCTION:

Fundamental vibration frequencies of masonry structures vary in the frequencies at maximum earthquake ground motions. It causes earthquake ground vibration amplification in structures, along with severe stresses resulting in calamitous collapse. Most of the historical structures like dome were during period where reinforced concrete was not used, were constructed on the expertise builders or masons without considering seismic loading, Thereby, affect disastrously for the duration of earthquakes. It is very essential to prevent these types of historical monuments for proper seismic resisting recital.

It is very important to protect these structures from earthquake ground motions using base isolation as far as it's architectural and aesthetics characteristics are concern. Flexible base isolation layer provision is the most expedient way of supporting these structures from earthquake damage. Fundamental time period can be prolonged by providing base isolation material between the dome and its supports. In this manner it is possible to scatter the energy at base isolation level in order to prevent damage to the superstructure. The successful use of earthquake base isolation has been reported in the literature [1-3]. Also, several existing buildings, bridges and tanks are seismically retrofitted by base isolation worldwide [4]. Finite element method (FEM) based numerical investigation of a masonry dome retrofitted by the base isolation is presented in this case study with a mean to demonstrate effectiveness of the retrofitting system.

RETROFITTING SYSTEM USING BASE ISOLATION TECHNIQUE:

The ancient historical structures are built with construction of stone or brick using as a load bearing structures. Thereby, load path is passed through masonry walls to the ground or soil. Base isolators can be interpose by supporting masonry walls as well as temporary support. Small diameter holes are drilled in the wall and a needle-beam mounted over the seismic base-isolators at pre-designed spacing is constructed progressively as shown in Figure 1 [4]. Then the temporary supports in the form of underpinning are removed to transfer the load through needle-beam and the base- isolators. The entrance details, utility services passing through the isolation level such as gas lines, water supply lines, sever lines etc. need to be worked out such that during earthquake event they should not fail and the isolation should not get locked. Also, a separation gap/moat is required to be provided for accommodating increased displacements owing for flexibility. Notably, restrainers are provided to bind the maximum isolation displacement during rarely larger magnitude earthquake to evade unseating.

Seismic isolation technique maintains the aesthetics and prominent features intact compare to conventional retrofitting techniques, it helps in such preservation of these historical monuments. Evaluation of the dynamic properties of the existing structure to be retrofitted is done through the ambient or forced vibration tests, which is essential in the design of base isolation systems. Numerical simulation can be used to attain maximum efficiency for the alternative of isolation technique type.

MASONRY DOME AND ELASTOMERIC BEARINGS FOR BASE ISOLATION

Figure 2 shows details of the historical masonry dome of 0.15 m thickness to be retrofitted by base isolation. The isolators are installed between the peripheral reinforced concrete needle-beam and the supporting masonry wall. The two main categories of isolation systems are elastomeric bearings and sliding systems. In the present case study, high-damping rubber bearings (HDRB) are used. The components of HDRB include alternate layers of steel and rubber plates as shown in Figure 3(a) [4]. Thus, high damping capacity of the order of 10 percent, horizontal flexibility and high vertical stiffness is achieved. These devices can be manufactured easily and are quite resistant to environmental effects. Building codes specify an equivalent linear viscous model for the force-deformation behavior of the HDRB as shown in Figure 3(b). The restoring force developed in the HDRB under the earthquake excitation is

$$F_b = K_b u_b + C_b u_b \qquad (1)$$

Where is the bearing displacement; and are the lateral stiffness and viscous damping of the HDRB, respectivel y. The equivalent stiffness and viscous damping of the HDRB designed to provide the desired isolation time period ( ) and the damping ratio ( ) are

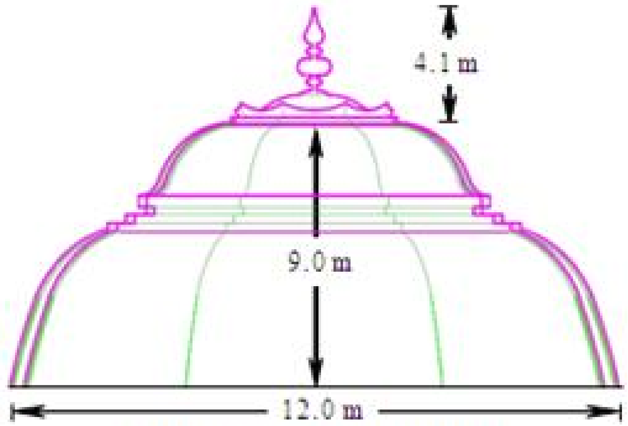

Figure2. Masonry dome dimensions.

Figure3. (a) HDRB and (b) its force-deformation behavior

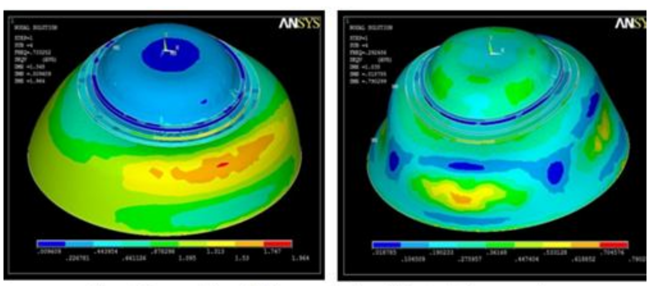

Figure4. Stresses induced in (a) conventional and (b) retrofitted masonry dome.

CONCLUSIONS

The effectiveness of earthquake base isolation to retrofit historical masonry dome is investigated by numerical simulation. Construction procedures to be followed during such a retrofit project are also delineated. The following conclusions are drawn from this study.

1. The sequence of construction while retrofitting of the masonry dome by base isolation demonstrates its practical viability.
2. Retrofitting achieved by base isolation of the masonry dome reduces the stresses induced by about 59 percent as compared to the conventional counterpart;
3. Retrofitting done by base isolation almost preserves the original aesthetic and architectural value of the historical monumental structures;

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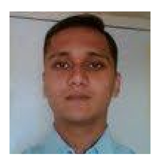

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