SEISMIC PROTECTION OF BRIDGES THROUGH GEOTECHNICAL SEISMIC ISOLATION: FROM SOIL–STRUCTURE INTERACTION TO INNOVATIVE STRUCTURAL SYSTEMS.

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Extended Abstract

Geotechnical Seismic Isolation (GSI) has emerged over the last decade as a technique to reduce the seismic vulnerability of structures. Unlike conventional protection strategies, GSI does not directly modify the structural characteristics of the system to be protected. Instead, it acts on the interface between the foundation and the surrounding soil by introducing one or more layers of engineered material. Since its protective concept relies on modifying soil–structure interaction (SSI), GSI requires a multidisciplinary approach integrating geology, civil engineering, and materials science to design solutions that are both effective and economically viable.

In this presentation, the innovative application of this concept to integral abutment bridges is introduced for the first time using a prehole method. The mechanical behavior of the pile with a prehole seismic isolation system was investigated through pseudo-static low-cycle tests and numerical analyses on scaled specimens with various filling materials.

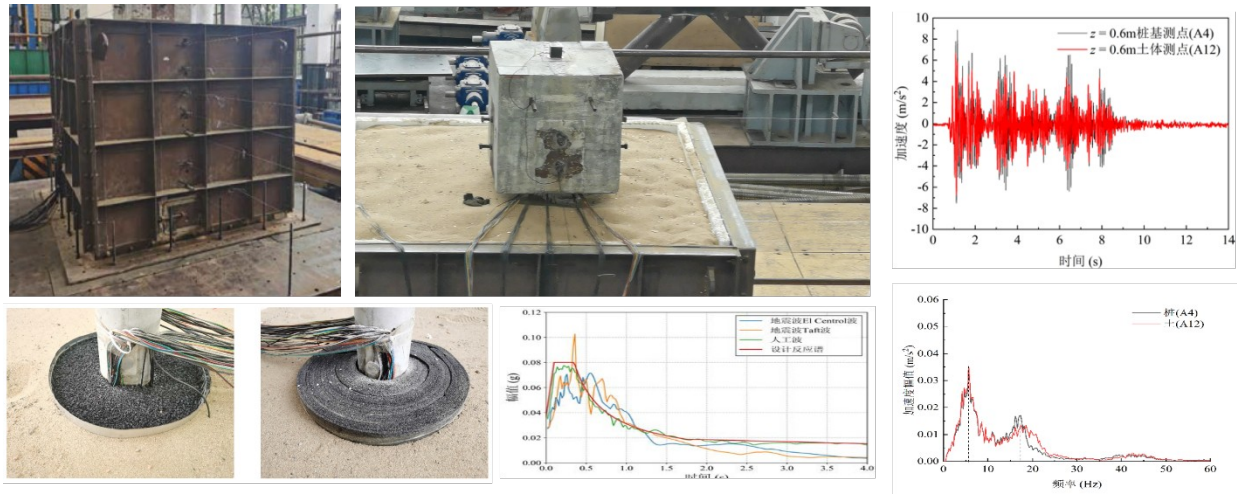
Building on this background, a novel integral abutment bridge type was proposed and investigated experimentally and numerically within a European-funded project. The study aims to (a) develop new scaling procedures for the physical modeling of integral abutment bridges (IABs), (b) experimentally investigate the potential benefits of adding compressible inclusions (CIs) between the abutment and the backfill, and (c) explore the influence of different connection types between the abutment and the pile foundation.

Furthermore, a two-stage multiscale approach is proposed to study the nonlinear seismic SSI of structures protected by a GSI system based on a rubber–soil mixture layer (GSI-RSM). In the first stage, the Distinct Element Method (DEM) is employed

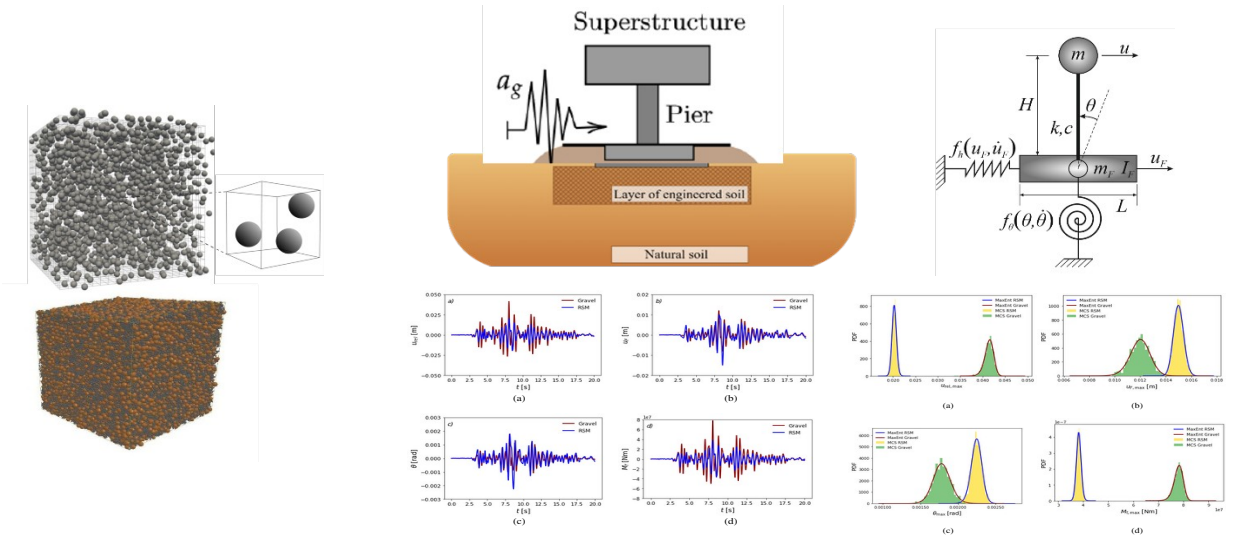
to determine the soil–foundation interaction mechanism while accounting for soil variability. In the second stage, the structural response is investigated using a lumped approach based on the Preisach formalism combined with an energy balance method.

Finally, this study presents an innovative combination of GSI technology with post-tensioned (PT) rocking piers, comparing the seismic performance of three configurations: a rigid base (RB), natural soil (NS), and GSI.

Together, these findings provide engineers with validated innovative structural systems, probabilistic tools, and efficient analysis methods for designing bridges that are not only durable but also predictably more resilient against future seismic events, thereby helping realize the full potential of damage-resistant bridge designs.



a)



b)

Figure 1 - a) Shacking table tests on pile-isolation system; b) two-stage multiscale approach for nonlinear seismic SSI of bridges protected by a GSI system.

Keywords: *Seismic response of bridges; geotechnical seismic isolation; shaking table tests; nonlinear soil-structure interaction*