# Numerical modeling of a resilient hinge (RH) for accelerated bridge constructions

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## Abstract

The present paper focuses on the advanced numerical modeling of a novel resilient hinge (RH), with emphasis on the connection between the foundation and the bridge pier. The design philosophy of dynamic resistant structures (such as bridges) requires the imposed energy to be dissipated in the hinges of the structure and let the remain elements with no damages. The investigated Resilient Hinge (RH) was proposed by Mitoulis et al. in 2016 and is further developed in this paper through parametric numerical simulations utilizing the 3D FE software Abaqus. The RH is a novel substructure that mitigates the imposed energy through the yielding of easily replaceable steel bars, thus offering rapid restoration times. It is designed to have re-centering capabilities because several steel bars remain primarily elastic, so they return to their initial position. The investigated variables are the type of material, the roughness of the contact surface, the diameter of the bars and the type of connection between the different parts of the RH. Stress analysis of the obtained results occurred in a way to quantify the problem and discover the weak regions of the RH. Finally, detailed design suggestions for the RH are provided.

**Keywords:** materials and equipment; conceptual design and realization; bridge pier mechanism; seismic device; self-centering pier mechanism;

## 1. Introduction

Bridges lay among structures of high importance not only because their construction is costly but since they must remain functional in emergency situations such as floods, earthquakes, winds and accident.

Three are the basic concepts of designing the structures that aim at their shielding against seismic vibration. These are the conventional design capacity, seismic isolation and low damage design [3]. The most recent seismic design approach aims to minimize the possible damages to the construction. This philosophy is called internationally as D.A.D. (Damage Avoidance Design) and has been developed for structures made of reinforced concrete [6], steel [7] and wood [8]. It differs from the others because it does not require a specific mechanism (creation of a plastic hinge or increase the construction's eigen period) to activate. Generally, the idea behind this philosophy is to reduce the damages by connecting special replaceable joints or mechanisms that can receive small or large inelastic deformations without causing failures to structures. In addition, in this way the construction can be restored to its original position without the need for human intervention. Finally, the main goal of the present design philosophy is to ensure that the construction will remain functional after the end of the earthquake,

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