PhD Final Defense – Donghyuk Jung

Performance of Shape Memory Alloy Rehabilitated Bridge Columns under Sequential Earthquakes

Advisor: Professor Bassem Andrawes

Date: Monday October 1st, 2:00 pm

Location: Newmark Civil Engineering Building Room 3218

Abstract

While civil infrastructure systems have played a pivotal role in the provision of essential services and facilities for human life and public society, weaknesses of the systems to natural and man-made hazards has emerged as a major public concern. As a way to improve the resilience and sustainability of the current and future infrastructure systems, utilization of new, smart materials such as shape memory alloy (SMA) in civil engineering application has been drawing keen attention of industry and academia.

Among many, active confinement technique using SMA's shape memory effect (SME) demonstrated a great potential in retrofitting and/or repairing seismically deficient RC bridge columns. In order to gain recognition as an effective seismic retrofit/repair strategy and systemize its application, however, it is necessary to thoroughly study the unique behavior of this new material and its impact on the performance of the structural system under diverse circumstances.

In this research, three main objectives are established. First, a series of shake table test is carried out to investigate dynamic responses of SMA retrofitted/repaired RC columns. Two reduced scale (1/6th) RC cantilever columns retrofitted or repaired with SMA spirals at the plastic hinge zones are tested under bidirectional seismic excitations at varying levels of intensity. The dynamic testing is expected to show the realistic seismic behavior of the SMA confined RC columns which were not able to be captured in the previous quasi-static cyclic loading tests. Second, this research also numerically studies the seismic performance of a SMA retrofitted multiple frame bridge when subjected to sequences of main shock-aftershock ground motions. Beyond exploring the responses of the columns at the component level, the impact of retrofitting a single or multiple columns with different levels of confinement pressure on the overall performance of the bridge is studied including interactions with other bridge components such as abutments or expansion joints. Furthermore, the seismic damage status and post-earthquake functionality of the SMA retrofitted bridge after multiple earthquake events are assessed. Lastly, an advanced evaluation method which effectively combines numerical and experimental approaches, named material testing incorporated (MTI) simulation is newly developed. In addition to seismic loading, this new method experimentally derives the realistic material behavior of SMAs at varying situations affected by chemical and/or thermal changes, and incorporates the measured data into the numerical analysis to predict the structure's overall response.