Additively Constructed Seismically Protected System for Bridge Infrastructure

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Abstract

Conventional design for bridges in seismic-prone areas relies on ductility concept by concentrating the damage at columns' ends. This approach is adequate for life safety; however, bridge columns exhibit significant damage and residual deformations resulting in expensive repairs or need for full replacement. Several seismic protective systems were developed over the last few decades to minimize the damage and enable repair after strong earthquakes like rocking systems, dampers, and seismic isolation systems. This paper proposes an innovative system that integrates several seismic protective concepts to achieve self-repair and deconstruction through additive construction. In this proposed system, protected elements such as bridge bent caps, columns and footings are additively constructed. In addition, the columns are designed to rock at interfaces between the columns and bent cap/footing and external elements are added to dissipate energy to promote resiliency.

Keywords: accelerated bridge construction, seismic, repair, deconstruction, additive construction.

1 Introduction

Bridge design concepts in seismic-prone areas have been in place to ensure life safety by concentrating the damage at plastic hinges at beam/footing column connection with sufficient ductility. However, these design concepts do not account for functional recovery. Successful functional recovery boosts the economy, requires minimum to zero recovery time (rapidity), and achieves sustainability goals.

Resilience is defined as the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. Resilience is assessed using 4R-Methodology including robustness, rapidity, redundancy, and resourcefulness, as shown in Figure 1-a. Emerging technologies such as accelerated repair, hazard protective systems (HPS), self-repairing structure, accelerated upgrade and additive construction, and machine learning based structural health prediction (ML-SHM). Hazard protective systems such as seismic isolation and low damage structures can reduce functionality losses and increase robustness as depicted in Figure 1-b. Finally, Self-repairing structures which backup structures systems that engage at higher hazard intensity can minimize functionality loss and reduce downtime (rapidity) as depicted on Figure 1-c. Finally, ML-SHM can enhance resilience by reducing impeding factors caused by mobilizing equipment, inspection crew, and in-house structural assessment that may lead to shorter