**Defense Announcement**

Multiaxial Fatigue Life Extension of Steel Elements Using Shape-Memory Alloy/Carbon Fiber-Reinforced Polymer (SMA/CFRP) Patch

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**Location:** Zoom **Meeting ID:** 95504644491; **Password:** email ojrussian-aranda@uh.edu
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Fatigue cracking is a primary factor hindering the performance of steel bridges. Without alternative load-paths, fatigue failure of a member can lead to sudden and catastrophic collapse of the entire structure. There are currently more than 170,000 steel bridges containing fatigue-sensitive details in service throughout the United States. The prevalence of such bridges can be attributed in part to initial design mistakes, but also to the ineffectiveness of existing repair methods. For this reason, increased efforts have targeted the development of novel technologies to address the fatigue problem. Of particular interest is the repair and strengthening of sensitive details using bonded attachments.

This dissertation presents a detailed documentation of the experimental and numerical investigation of the behavior, performance, and implementation of a self-stressing (thermally activated) shape-memory alloy (SMA) / carbon fiber-reinforced polymer (CFRP) patch for the repair of cracked steel elements. The SMA/CFRP patch provides crack bridging effects through its stiffness contribution to the sensitive detail, and crack closure through compressive stress fields generated by activation of the nickel-titanium-niobium SMA wires.

An experimental program that included fatigue tests across various surface preparation methods, repair techniques, and loading conditions was conducted. A suite of material, recovery force, and pullout tests supported the program. Surface characterization tests informed the evaluation of the grit blasting and power tool cleaning surface preparation methods. Experimental results suggested that the fatigue life extension provided by the SMA/CFRP patch is greater when grit blasting is adopted. Furthermore, they suggest that these benefits exceed those associated with a stop-drilled hole (SDH) method. Fatigue life extension provided by the SMA/CFRP patch under distortional fatigue loads was demonstrated.

A numerical program was undertaken to augment the experimental findings. This included the development of finite-element models used to calibrate interfacial modeling parameters, and to predict the fatigue behavior of repaired specimens of different configurations and under various loading conditions. Numerical results suggest that even a modest increase in the prestressing level can result in significant elongation of distortional fatigue life.