Repairing Steel & Concrete Structures Using Smart Materials Including Fiber Reinforced Polymers & Shape Memory Alloys

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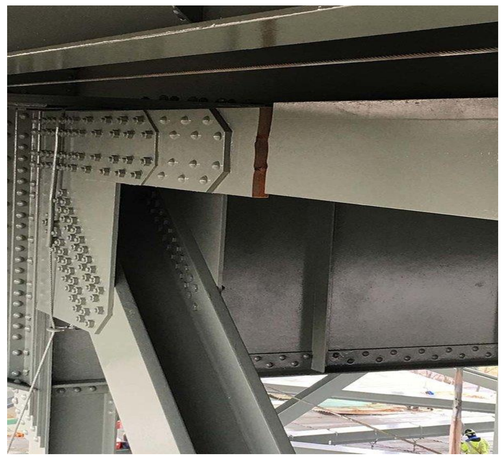
Repair of Metallic Structural Elements with FRP & SMA

Background

- The U.S. has over 600,000 bridges, ~40% are 50 years or older.
- When metallic structures fatigue, they crack.
- Finding a consistent repair method can dramatically increase the lifespan.
- Current surface preparation methods are not environmentally friendly.
- Being able to repair metallic members rather than replace is key.

Methodology

- Notch various sample types to induce a crack.
- Prepare the surface with non-traditional methods that are available in the field.
- Use different CFRP bond lengths to minimize material usage.
- Test which epoxy works best with different application techniques.
- Apply displacement transducers and strain gauges before testing in tension.



Perspective Outcomes

Steel

- Lab results have shown that the fatigue-life of repaired member can increase up to 26 times compared to an unrepaired element for stress-induced fatigue.
- Develop an “easy-to-install” method using FRP’s without welding or permanently altering the structure that will be affordable and efficient to use in the field.

Concrete

- Full scale circular concrete columns will have an increased capacity following SMA confinement rehabilitation.
- Shape memory alloys can be introduced as a more economic and easily constructible solution compared to FRP sheets.

What’s Next

- The rehabilitation cost of a severely cracked bridge can exceed 25 million.
- Experiment with various surface preparation methods.
- Prepare samples of different thicknesses, steel types, and crack sizes.
- Test samples and analyze data sets to determine effectiveness of this solution.

Acknowledgements

- A special thanks to the entire structural lab for the mentorship and guidance.
- This study was funded by the University of Houston Summer Undergraduate Research Fellowship (SURF)

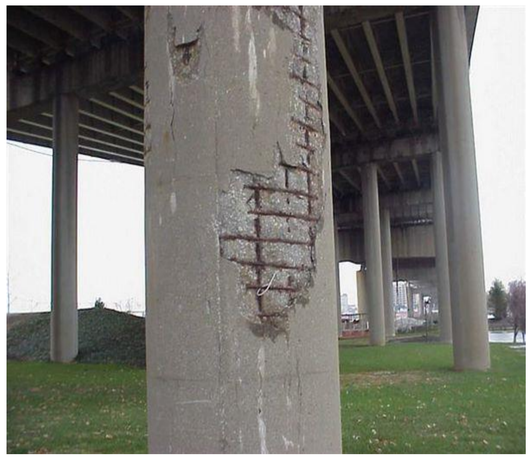
Rehabilitation of Reinforced Concrete Columns with SMA

Background

- A 2017 estimate puts U.S. bridge rehabilitation needs at $123 billion.
- Traditionally, columns are repaired by using fiber reinforced polymer (FRP) sheets.
- FRP sheets need to be combined with an epoxy to bond with concrete.
- Replace FRP with Shape Memory Alloy to rehabilitate large scale circular columns.
- Test confinement configurations to understand strength effects on the member.

Methodology

- Simulate wrapping configurations on small scale columns.
- Experiment various methods to fasten SMA strips that would be effective in the field.
- Determine an effective length for bond and increase in capacity.
- Analyze the temperature effects that heating methods have on concrete.
- Use 2,500,000lb load capacity MTS machine to test effects of confinement.



What’s Next

- Continue developing a more cost effective solution for circular RC columns.
- Determine consistent method to secure and engage SMA strips.
- Test multiple configurations on small scale RC columns and analyze data.
- Cast large scale RC columns, simulate failure, and test rehabilitation methods.

References

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- Dawood, M et al. (2015) Development of self-stressing NiTiNb shape memory alloy (SMA) / fiber reinforced polymer (FRP) patch. Smart Materials and Structures, 24(6)