REPAIR OF BRIDGE PRESTRESSED CONCRETE GIRDER SUBJECTED TO OVER-HEIGHT VEHICLE IMPACT

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Abstract

This study investigates the repair of prestressed bridge girders subjected to vehicle impacts through the utilization of externally bonded CFRP and strand splicing techniques. The girders experienced significant damage, with **a 50% loss of strands after the impact event**. Through meticulous repair processes, a remarkable **35% increase in flexural strength** was achieved, accompanied by the restoration of 20% of the lost cross-sectional area. Equally noteworthy was the restoration of the effective prestress to 0.85fpu. These findings underscore the effectiveness of this repair approach in not only mitigating damage but also substantially enhancing the structural performance and longevity of impacted prestressed bridge girders.

Background

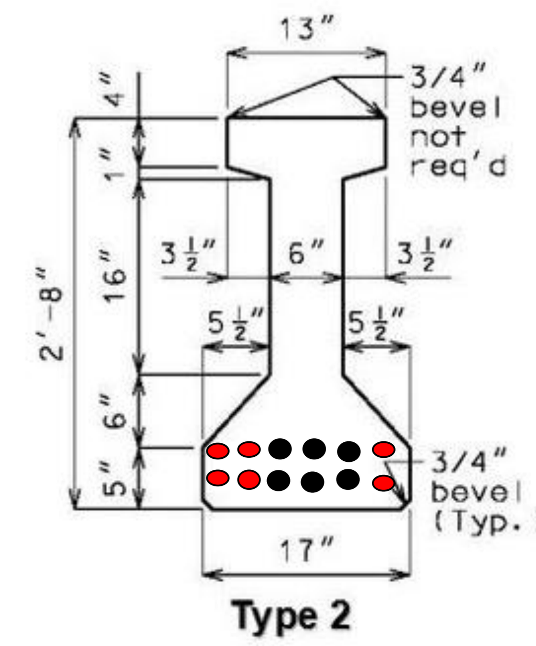
- Prestressed concrete girders are commonly used in bridge construction due to their high strength-to-weight ratio, durability, and cost-effectiveness.
- However, when subjected to the extreme forces generated by over-height vehicle collisions, they can experience significant damage.
- As per the Federal Highway Administration, collision damage resulting from the impact of a vehicle or vessel represents the **3rd major factor** contributing to bridge failures or collapses. (Agrawal 2012)
- Agrawal 2012 reported that approximately 200 collisions with bridges occur annually in the state of New York.
- Semi-tractor trailers are the most common type of vehicle involved in these types of accidents (Agrawal 2011). These collisions often lead to cracks, spalling, and delamination of concrete, as well as damage to prestressing tendons.
- Extremely expensive consequences, average girder replacement costs about **8000 USD/ft (Jones et al 2015)**.
- According to Radlinska et al 2012, the expenses associated with repairs amount to 50% of the expenditures required for a complete replacement

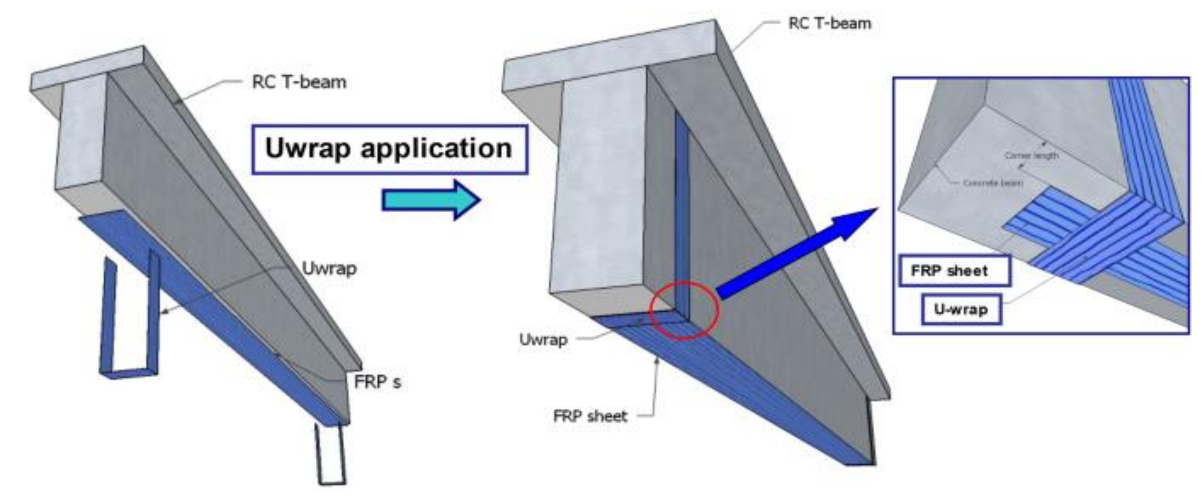
Objectives

- Determine the residual carrying capacity of the damaged bridge girders, which will allow stakeholders (DOT engineers) to prioritize girders that need repairs.
- Determine the best repair technique to recover the as-built strength of the damaged girders.
- Develop analytical and numerical models to allow bridge engineers to determine the residual strength of damaged girders.

Experimental Approach

- Impact resulted in 50% loss of prestressing strands

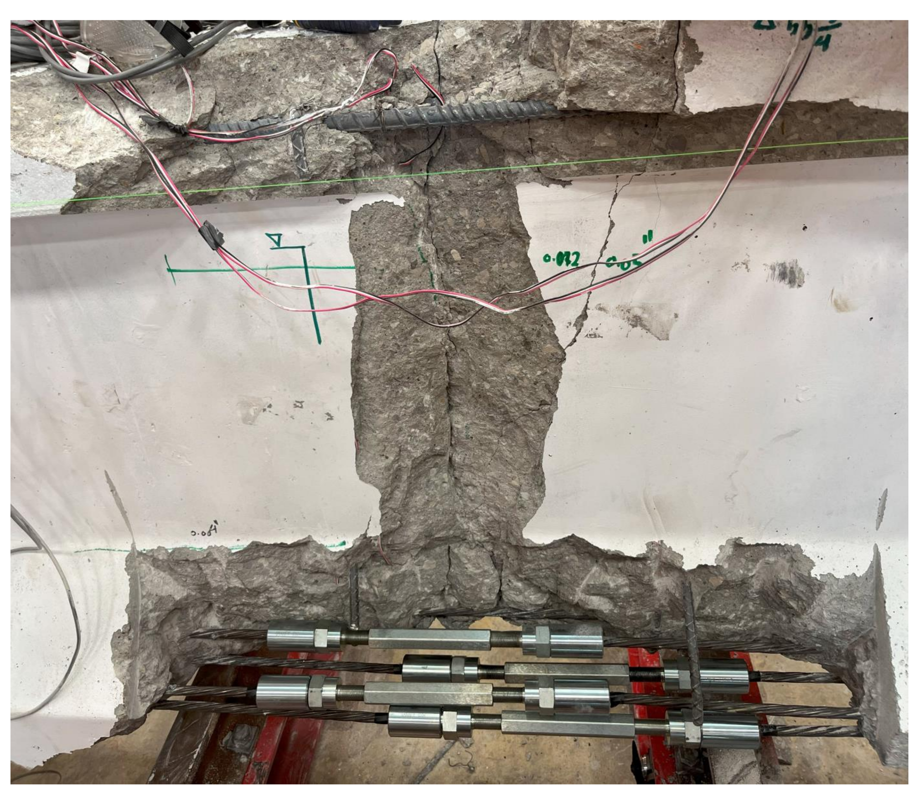




- The hybrid repair method has been demonstrated to optimize the extent of damage that can be effectively addressed.

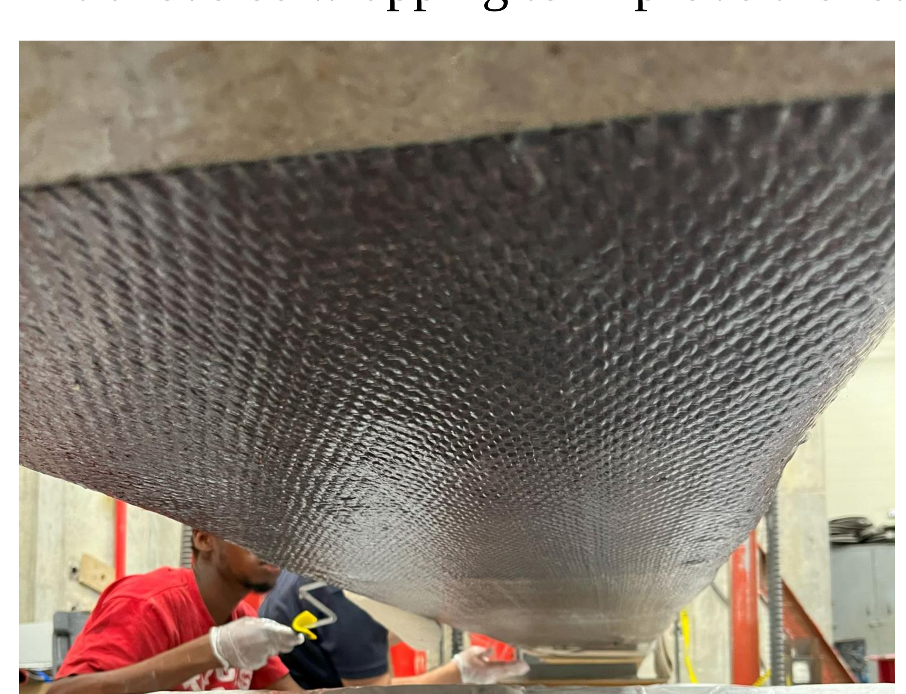
Strand splicing

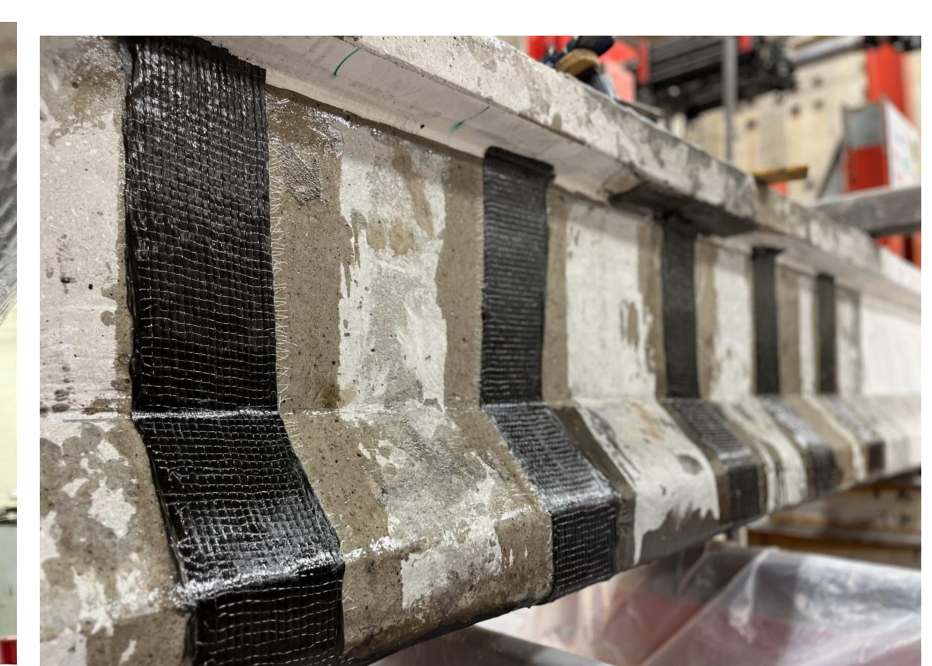
- Zobel and Jirsa (1998) recommend against repairing a number of strands exceeding 10–15% of the total strands within a single girder.
- Jarret et al 2014 **limited strand splicing to 15%** out of 25% of damaged strands



Externally bonded CFRP

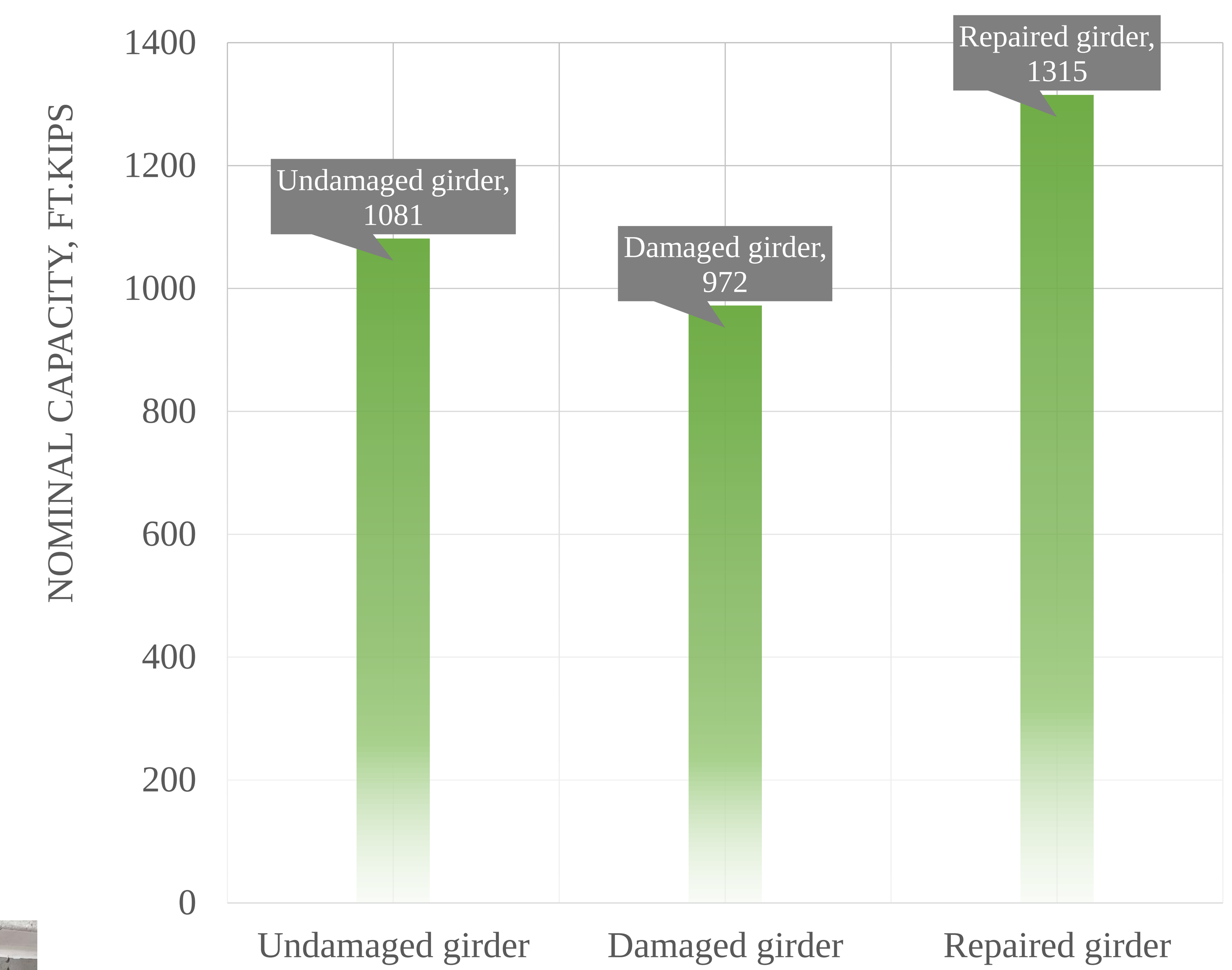
- Application of CFRP strips or fabric through adhesive bonding to prestressed-concrete girders has been proven to effectively restore or enhance the girder's flexural capacity (Schiebel et al. 2001; Tumialan et al. 2001; Klaiber et al. 2003; Green et al. 2004; Reed and Peterman 2004, 2005; Wipf et al. 2004; Reed et al. 2007.
- 0.08in thick CFRP was externally bonded to the concrete substrate as well as transverse wrapping to improve the load carrying capacity of damaged girder





Longitudinal and transverse CFRP wraps

Analytical results



Discussion and conclusion

- This study indicates a significant improvement in structural performance, including a remarkable 35% increase in flexural strength.
- Restoration of 20% of the lost cross-sectional area, and the effective prestress level at 0.85fpu.
- These findings demonstrate the effectiveness of repair strategies in not only mitigating the damage but also enhancing the overall strength and functionality of impacted prestressed bridge girders.

Ongoing/ Future work

- Four-point flexural testing of repaired girder to assess it's capacity
- Develop numerical and analytical models that enable bridge engineers to assess the remaining structural strength of girders that have been subjected to damage.

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