Seismic Rehabilitation of Reinforced Concrete Bridge Substructure Using Fibre-Reinforced Polymer Composites

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INTRODUCTION

Many bridge structures throughout the world contain seismic strength deficiencies that can lead to catastrophic failures when subjected to earthquake loads. Traditional rehabilitative methods can be costly and have a significant impact on the weight and aesthetics of the structure. A recent bridge retrofit implemented the use low-profile fibre-reinforced polymer (FRP) composites on the Mission Bridge in British Columbia as shown below.

OBJECTIVES

- Provide additional shear capacity at the bottom of the pier columns within the plastic hinge regions for all piers.
- Provide additional joint shear strength for the tie beam-column connections at four of the nine existing piers located along the river.

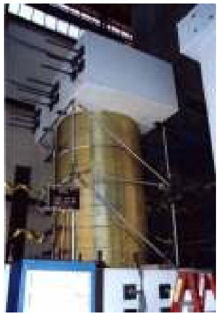
ADDITIONAL PROJECT CONSIDERATIONS

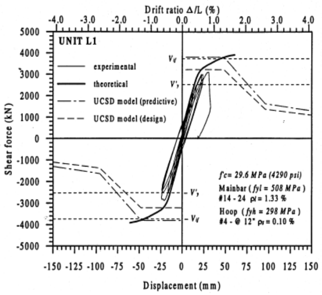
- Design and installation of the FRP composite system in accordance with the construction documents, Canadian Standards Association (CSA) S6-06 and per manufacturers' guidelines.
- FRP composites would be exposed to low temperatures as well as freeze thaw conditions, therefore the durability of these materials had to be validated.
- Composite strengthening system must maintain existing pier-column geometry while negligibly increasing effective seismic weight.

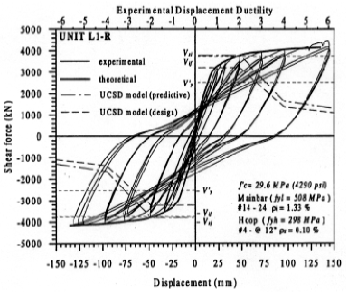
BENEFITS OF UTILIZING FIBRE-REINFORCED POLYMERS IN CONSTRUCTION

- High strength comparable to that provided by traditional steel reinforcement
- Long term and durable solution
- Low profile won't change geometry of structure
- Relatively quick and non-intrusive installation can allow for continued vehicular & pedestrian traffic during construction
- Proven track record - FRP's have been used successfully on thousands of civil infrastructure projects
- Light weight system will not effect the seismic weight of the structure
- Cost effective alternate to traditional rehabilitatuve methods

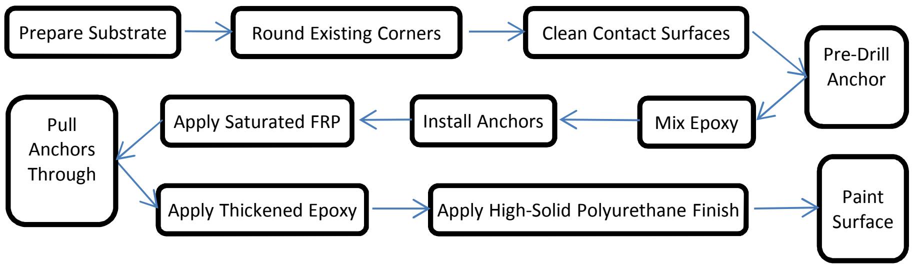
CALTRANS COLUMN TESTING







INSTALLATION PROCEDURE



PROJECT DESIGN SPECIFICS

An effective and durable carbon composite FRP was selected with multiple layers applied at each location to achieve the desired accumulated thickness and strength. The FRP wraps were applied transverse to the longitudinal axis of the columns, with a 150mm minimum overlap in the primary fibre direction (CSA S6-06). As carbon fabrics are typically manufactured in 610mm wide rolls, transverse butt splices were used to completely wrap the required column length in elevation. Special detailing was provided at the beam-column joints consisting of a bi-directional wrapping schematic with the fibres oriented at a 30°/60° angle. FRP composite anchors were detailed at all edges of the fiberwrap sheets to help develop the reinforcement into the concrete substrate.

CONCLUDING REMARKS

Over the last twenty-five years, FRP composite strengthening systems have developed into reliable alternatives to traditional structural repair materials and seismic retrofit methods for reinforced concrete bridge structures. With the low-impact, cost-effectiveness and ease of installation of these materials, the number of projects with FRP's being specified for rehabilitation, strengthening, and protection of structural elements is continually growing. The Mission Bridge seismic strengthening project provides one example of effectively utilizing fibre-reinforced composite systems on bridge structures. In this case, high seismic demands were able to be designed for and the FRP system was installed in a cost-effective and rapid rehabilitation manor. When designed, detailed and installed correctly, FRP materials can provide a long lasting, effective strengthening solution with minimal impact on the existing structure and its surroundings.

REFERENCES

- Canadian Standards Association, S6-06: Canadian Highway Bridge Design Code, 2006
- International Code Council, Acceptance Criteria 125: Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening Using Externally Bonded Fiber-Reinforced Polymer (FRP) Systems, 2010
- Priestley, M.J. Nigel, and Seible, Frieder. 1994. Column Seismic Retrofit Using Fiberglass/Epoxy Jackets.