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PUTTING RESEARCH TO WORK

BRIEF

Repair of Deteriorated Bridge Substructures

Degradation of bridge substructure members in Wisconsin is a serious concern. Concrete, steel and timber members all require distinct repair methods which not only address the true cause of the deterioration, but also protect the members from future damage. Deterioration of bridge substructure members in Wisconsin has been caused by deicing chemicals, the cycle of wetting and drying, scour, erosion, improper design and many other damaging processes. Utilizing repair techniques that merely address the effect of the deterioration has proven costly and unreliable. Understanding the relationship between cost and service life of modern repair methods can help maintenance engineers make informed decisions that will maximize efficacy.

What is the problem?

Determination of efficiency of different repair methods for bridge substructure systems is needed to select an optimized method for a deteriorated member. The current repair procedures for concrete only address the effect of the deterioration but not the cause. The longevity of repairs throughout WisDOT is not currently tracked. Knowledge of estimated service life and cost of different repair methods is needed to help engineers find the most efficient maintenance strategy for deteriorated bridge substructures.

Research Objective

The objectives of this research project were to:

- Gain a better and more current understanding of the deterioration and damage of bridge substructures
- Explore both assessment and repair strategies for bridge substructures subjected to either damage or deterioration
- Develop a guidebook for assessment and repair of substructures that would be utilized by WisDOT staff
- Gather information regarding prices and service life for common repair techniques in order to make effective comparisons between rehabilitation methods

Methodology

To determine common repair practices and their success rates, the research team surveyed maintenance engineers throughout the United States. The survey, composed of nine questions, was sent to 90 maintenance engineers and generated a response rate of 30 percent. The research team also visited eight bridges throughout the Southeast and Southwest Regions of WisDOT. These bridges were documented, both for their typical deterioration and unique repair methods. Unique and successful repair techniques were also collected from the survey.

							Estimated Cost		Service Life Years	Year of Cost Estimate
	Repair Methods	Piles	Piers	Abutments	Bridge Seats	Unit	Low	High		
Cathodic Protection Systems	Galvashield CC		X			Each	$24.00	$36.00	15	2012
	Galvashield XP		X	X	X	Each	$21.00	$36.00	15	2012
	Ebonex		X			Each	$29.00	$97.00	25–30	2012
	Norcure Chloride Extraction		X	X		SF	$35.00	$50.00	25–30	2012
	Galvanode DAS	X	X		X	Each	$165.00		10–20	2012
	Galvanode ASZ+		X			SF	$22.00	$27.00	10–20	2012
Crack Repairs	Epoxy Injection		X	X		LF	$20.00	$50.00	20	2012
	Mortar		X	X		LF	$35.00		20	2012
	Jacketing	X	X			LF	$600.00	$1,200.00	20–40	2012
	Drilling and Plugging			X						
	Simple Surface Repair		X	X		SF	$45.00	$77.60	5–10	2012

Section of Concrete Repair Decision Matrix

Investigator

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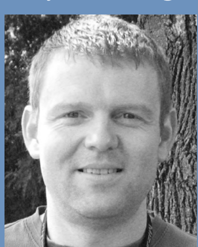
Results

The results of the research conducted are:

- Degradation of bridge substructure members in Wisconsin has been caused by deicing chemicals, the cycle of wetting and drying, scour, erosion, improper design and other damaging processes. Improper expansion joint maintenance has accounted for a large portion of deterioration throughout Wisconsin's infrastructure. It was determined from the survey that concrete surface repair is the most common repair technique, and is also viewed as the most unreliable. It was identified as the least effective repair, accounting for 40 percent of the responses.
- Pier caps and bridge seats that were directly below an expansion joint typically showed signs of spalling and reinforcement corrosion due to chloride intrusion.
- Deicing chemicals becoming embedded within snowpack on concrete columns caused a large portion of the observed deterioration.
- Concrete encasement was very successfully used to repair deteriorated columns in one observed bridge, but was much less successful for pier cap repair in another bridge.
- When chlorides are allowed to remain in the existing concrete or to continue entering the concrete, the steel reinforcement corrosion will continue to occur and results in delamination. Chloride extraction processes, cathodic protection and expansion joint maintenance are useful tools to prevent steel reinforcement corrosion.
- Section loss of steel piles which occurs at the waterline can be rectified by welding or bolting steel to the cross section. Further protection can be provided by a concrete encasement, fiberglass jackets that are form-fitted to the specific H-pile (with an advantage of not requiring dewatering), and sacrificial anodes which can be combined with any of the included repairs.
- As a means of comparing separate repairs, three decision matrices were created. Dependent upon the type of deterioration, a relevant repair may be found in either matrix.
- Riprap can be effectively used as a temporary scour repair. The implementation of gabions or grouted riprap can reduce the required riprap size while increasing the overall stability of the repair.
- Timber repairs involve repair of individual timber piles and timber sway bracing. Pile posting, pile restoration and pile shimming all incorporate a new piece of treated timber in the repair. These methods are cost effective, but will be subjected to the same deterioration. Concrete jacketing, pile augmentation and PVC wrapping are methods which leave the existing pile in its deteriorated state, but replace the section loss with concrete and usually provide a watertight seal. These three methods are more expensive, but provide a level of protection against future deterioration.
- Decision matrices were created to compare different repair methods based on their unit costs and estimated service life. A repair manual including detailed drawings and procedures of 72 different repair methods was created.

Project Manager



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Recommendations

The researchers highly recommend that WisDOT start tracking longevity of repairs throughout Wisconsin. Keeping a better record of simple concrete repairs, and making that record available through the Highway Structures Information System (HSI) would help to determine why some repairs are considered unreliable. New experimental repairs should be well documented and tracked for longevity. Since many of the concrete surface repairs have exhibited high failure rates within a few years of placement, consideration should be placed on repair life in addition to repair cost. Cathodic protection systems, which have been implemented with success in many states, have a higher initial cost, but a life cycle analysis could be conducted to determine if the extended repair life is worth the additional cost. The removal of chloride ions from the concrete could greatly increase the service life of a bridge and is worth further investigation. Approaches other than riprap for scour repair should be investigated to ensure that the highest cost savings is always achieved. Further research into the bonding of old and new concrete, and the use of bonding agents, could prove useful as a means of increasing repair reliability.

This brief summarizes Project 0092-11-08,
"Rapid Repair and Strengthening of Bridge Substructures"
Wisconsin Highway Research Program (WHRP) *http://wisdotresearch.wi.gov/whrp*