Study on Causes of Cracks And Its Remedial Measures In Reinforced Concrete Bridge Piers And Abutment of Major Bridge

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Abstract- *Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, Causes of deterioration. The success of repair activity depends on the identification of the root cause of the deterioration of the concrete structures. The repairs can be done for the improvement of strength and durability, thus extending the life of the structure, is not difficult to achieve.*

It is the processes of restoring the structure to service level, once it had and now lost, strengthening in endowing the structure with a service level, higher than that initially planned by modifying the structure not necessarily damaged area. In this project we are concentrating on cracks developed in major bridges due to moving loads and other loads and repairing techniques used.

Keywords- Damaged structure, Causes of deterioration, strength, and durability

I. INTRODUCTION

Bridge deterioration has become a widespread problem throughout the transportation infrastructure of the world. Implementing cost-effective and reliable repairs is necessary to ensure that full-service lives can be achieved from existing bridges. Understanding the destructive mechanisms that are acting on bridge substructures throughout Wisconsin will help to ensure appropriate steps are taken not only to repair deterioration but also to prevent future material failures.

Research Motivations

Research focused on bridge superstructure repair is much more common than research regarding substructure elements. There currently exists no document which effectively analyzes the possible repair methods for bridge substructure deterioration. Significant cost savings could be realized by exploring alternate means of rehabilitation. It was discovered that the majority of concrete bridges require repair within the first 11 to 20 years of their service lives (Tilly 2011). Since such a large number of bridges will require work within the first 20 years of service life, it is imperative to analyze how repairs are being conducted. Maximizing the efficiency and reliability of repairs that are conducted on concrete substructures could result in significant cost savings throughout the service life of the structure.

Review of Past Research

Bridge substructure repair has a lack of research when compared to superstructure repair. Distributing information regarding effective repair methods is necessary to increase the reliability of repair procedures. There were a number of studies and research projects undertaken in an attempt to improve the procedures for rehabilitation. Portions of each of these studies were important for considering substructure rehabilitation, but no single source has yet been created for substructure repair. The Department of Transportation for the state of Iowa conducted research that focused on maintenance, repair and rehabilitation methods for bridges (Wipf. et. al. 2003). Significant portions of this study were dedicated to superstructure rehabilitation methods. The research that was conducted for substructure members was focused on pile repair. The specific pile repair procedures that were covered are well described and the design processes are thoroughly explained. What lacks in this study, is the analysis of when specific repair procedures are most appropriate.

Objectives of Thesis

In an attempt to complete the understanding of effective bridge substructure repair methods, there were several key objectives. One of the primary goals of this document is to bring attention to how substructure repairs are currently being utilized throughout Wisconsin. Understanding the specific conditions which are necessary to increase repair reliability and service life will create a basic knowledge for when repairs should be implemented. Another goal of the thesis is to highlight the importance of the life-cycle cost of different repair methods. Repairs should be considered in terms of their cost and estimated service life to give a clear picture of which repair will truly be the most cost effective.

II. THEORY OF CRACKS

Cracking

Cracking will occur whenever the tensile strain, to which concrete is subjected, exceeds the tensile strain capacity of the concrete. The tensile strain capacity of concrete varies with age and with the rate of application of strain.

Classification of cracks

It may be classified in terms of their effects:

- Those cracks which indicate immediate structural distress
- Those cracks which may lead in the long run to a reduction of safety, through corrosion of steel
- Cracks which lead to malfunction of the structure, as evidenced by leakage, sound transfer, damage to finishes and unsatisfactory operation of windows and doors.
- Cracks which are aesthetically unacceptable

Class I-Cracks leading to Structural Failure

Little difficulty arises in relation to this class. Those cracks that indicate that failure is near and that margin of safety are seriously reduced, may have formed in concrete, which was expected by the designer, to carry load in its un cracked condition .Such cracks are necessarily wide, and may lead to the detachment of parts of the structure.

Class II Cracks causing Corrosion

There is no unique relationship between crack width and the onset of corrosion. Part of the difficulty arises from the nature of cracks themselves. For flexural members, many cracks taper from a certain width at the surface of the concrete, the near zero width at the steel-concrete interface. However, flexural cracks that are controlled by the overall depth of the beam are not of the tapered shape, and it is likely that cracks due to temperature and shrinkage are nearer to being parallel sided. It has been assumed for many years that, since wider cracks would give easier access to aggressive substances, corrosion could be controlled by controlling crack widths and that permissible widths should be a function of how aggressive the environment was many complicated formulas for the calculation of crack widths in flexural members have been devised with the object of controlling corrosion. But extensive tests on beams in which the cracks are normal to the axis of the bars show evidence of any relationship between corrosion damage and crack width.
When cracks run along a bar, much more of the bar is in an exposed position, and it might be expected that there would be a closer relationship between crack width and corrosion in this situation. There is a little evidence however, that cracks whether transverse to the bars or running along the bars, pose any create risk of increased corrosion, if they are less than 0.3mm in width.

Some cracks, which are parallel to a bar, may have been caused by the corrosion of that bar. These cracks will widen as corrosion proceeds, and will eventually lead to spalling and exposure of the corroded bar. A crack of any width, which is judged to be brought about by corrosion, is an indication of a deteriorating structure, and therefore no minimum width, below which the crack is not significant, can be set. A crack that indicates the corrosion of the bar is actually showing that the corrosion will continue, unless positive measures are taken. Merely filling the crack will not achieve the result.

Class III-cracks affecting Function

The cracks in this class, which have the most serious consequences are those that allow liquid- retailing structures to leak, or that occur in roofs or other structures, intended to be waterproof. BS 8007 prescribes limiting crack widths and details methods of predicting the widths. The maximum design surface crack width, for direct tension and flexure or restrained temperature and moisture effects are: Severe or very severe exposure-0.2mm

There are only limited test data available on what constitutes the limiting crack, for preventing leakage. Flow through a parallel-sided smooth crack, can be calculated in terms of head, crack width, crack length and fluid viscosity. The difficulty with concrete is that the cracks are not smooth or parallel-sided.

Class IV-cracks affecting appearance

For class 4cracks,it has been suggested that crack widths up to 0.3mm in width are acceptable aesthetically, but there are no good guidelines. Various attempts have been made to establish what constitutes an acceptable crack on an aesthetic basis, but in the end, there is no rational basis for aesthetic decisions. The aesthetic objection to cracks may be summarized as:

- Cracks cause alarm about the safety of the structure
- Cracks lower the visual acceptance of the structure

(a) by modifying surface textures and damaging the visual effect intended by the designer and
(b) by giving an appearance of cheapness or bad building.

III. MATEIALS FOR REPAIR

Special concrete and mortar

High Aluminates Cement Concrete
Shrinkage Compensated Concrete
Polymer Cement concrete
Polymer Impregnsed Concrete
Epoxy Concrete
Latex modified concrete

Necessity of adding concrete chemicals

To improve the performance of concrete
To have the early strength gain as early as possible
To accelerated the setting time of concrete
To make the structure waterproof

special elements for accelerated strength

In repairs of certain structures, particularly roadways and bridges, it may be desired that early strength gain should be rapid as possible. The engineer may, as a first approach, consider using admixtures, so that ordinary types of Portland cement can be used. The chief chemical admixture

Now used for this purpose is Super plasticizer of one type or another. Formerly, high doses of calcium chloride were advocated, but this producer has been rejected on the basis of corrosion, problems associated with calcium chloride were advocated, but this procedure has been rejected on the basis of corrosion, problems associated with calcium chloride use. The time of setting of Portland cement concrete and its strength gain may be shortened by the use of calcium aluminates cement, because of problems associated with the conversion under hot humid conditions, of the calcium aluminates hydrates from one from to another, and the resultant strength losses, other types of cements have been preferred.

Regulated set cement is a modified Portland cement, which contains a substantial amount of calcium fluro-aluminate. This cement contains a substantial amount of fluorite as a substitute for limestone. The burning process is not without problems, due to the release of small amount of fluoro compounds.

Expansive cement

Expansive cement, when mixed with water, forms a paste that, after setting, tends to increase in volume to a significantly greater degree than Portland cement paste. This expansion may be used to compensate for the volume decrease due to shrinkage, or to induce tensile stress in reinforcement.
Types of Expansive cements:

Type K:

An expansive cement containing anhydrous tetra calcium alumino-sulphate, which is burnt simultaneously with a Portland cement composition, or burnt separately, when it is to be interground with Portland cement clinker or blended with Portland cement, calcium sulphate and free lime.

Type M:

It is a mixture of Portland cement, calcium-aluminate cement and calcium sulphate

Type S:

It is a Portland cement, containing a large compound of tricalcium-aluminate content and modified by an excess of calcium sulphate, above the usual optimum content.

In all cases, the specific surfaces or fineness of expansive cement has a major influence on its expansion characteristics.
The increase in specific surface accelerates very early formation of ettingite in the plastic mix, and as a result, with the increase in the specific surface for a given sulphate content, the amount of expansion decreases with increasing surface area.

IV. REPAIRS REHABILITATION AND RETROFITTING OF BRIDGE STRUCTURE

Purpose of bridge repair

Using a metaphor, the road network which serves for the national socio-economic activities such as logistics, travels and communications, is compared to the vascular network in a human-body. To maintain a healthy human body, people may check their physical condition daily, and may have some advices from their doctors periodically and then keep their body condition in well, and sometimes people may receive medical treatment or surgery. It is same manner for road infrastructure for logistics. Therefore, the road infrastructure is essential for Cambodia economy.

ABUTMENT REPAIRS

Abutment Face Repair

The concrete in abutments may deteriorate from the effects of water, sea salt, and debris impact. This condition requires that repairs be made to prevent continued deterioration, particularly increased spalling due to moisture reaching the rebar and causing corrosion. The procedure is often used to re-face old rubble masonry or concrete made from large stone. See Figure 4.4. The following steps in the rehabilitation procedure are normally required:

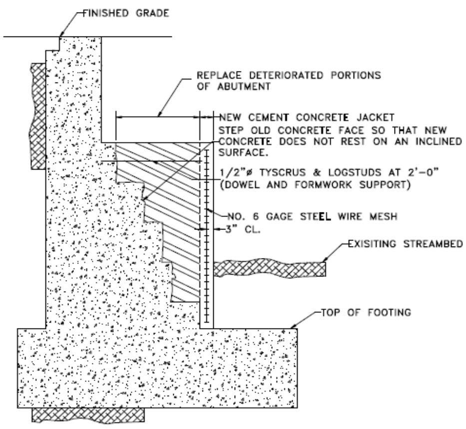

Figure 4.4 Repair of Abutment Face

A. Recommended Method

1. Establish traffic control, if necessary.
2. Remove deteriorated concrete and laitances by chipping and blast cleaning.
3. Drill and set the tie screws and log studs to support the form work.
4. Set reinforcing steel and forms.
5. Apply epoxy-bonding agent to the concrete surface just before placing the concrete.
6. Place the concrete, cure, remove the forms.
7. Install erosion control material.

Backwall Repairs

Abutment backwall damage caused by pressure from approach pavements can be avoided by installing relief joints, as described under Bridge Deck Maintenance & Repair. To repair a cracked backwall, the following procedure can be used. This method is used to repair the abutment backwalls for the full width of the structure between abutment parapets, and to a depth sufficiently below the bridge seat elevation to permit the installation of dowels or the proper lapping of reinforcing bars. See Figure 4.5

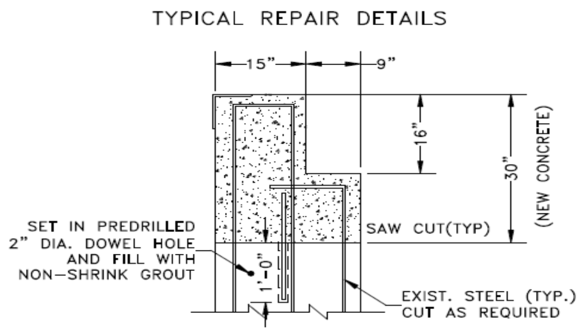

Figure 4.5 Abutment Back wall Repair

A. Recommended Method

1. Temporarily tack weld the abutment side of the steel armored joints, sliding plate expansion joint, or toothed expansion joint to the deck side of the joint assembly.
2. Cut and excavate the approach slab or pavement to allow access to the backwall.
3. Remove deteriorated concrete or masonry and/or reinforcing bars from the backwall.
4. Place replacement reinforcing bars by tying them into existing bars in the abutment or by grouting dowel bars into the abutment.
5. Place forms for concrete.
6. Place and cure concrete. Ensure concrete is placed beneath existing joints.
7. Remove forms and temporary tack welds on joints or dams.
8. Backfill and compact sub-grade under the approach slab or pavement.
9. Patch the approach slab or pavement.

PIER REPAIRS

Repair of Deteriorated Concrete

Repair to concrete piers is accomplished by removing deteriorated or damaged concrete and placing new concrete. This method is used to restore the integrity of concrete piers that have spalls, cracks, voids, etc. The first step in the repair of any type of deterioration in concrete is complete removal of all unsound concrete. No satisfactory repairs can be made until there is clean and sound concrete to which the new concrete can be bonded. The edge of a cut out area should be undercut for deep patches to help retain the new material.

Effective bonding of the new to the old concrete is usually accomplished with a bonding material and is particularly important when deep cracks require a large volume of concrete to be replaced. A grout can also be used when the form for the concrete is so inaccessible that an epoxy material cannot be applied effectively. The exposed area can be sloshed liberally with grout just prior to placing the concrete. Shotcrete may also be used in filling the crack after it is properly prepared. See Figure 4.8.

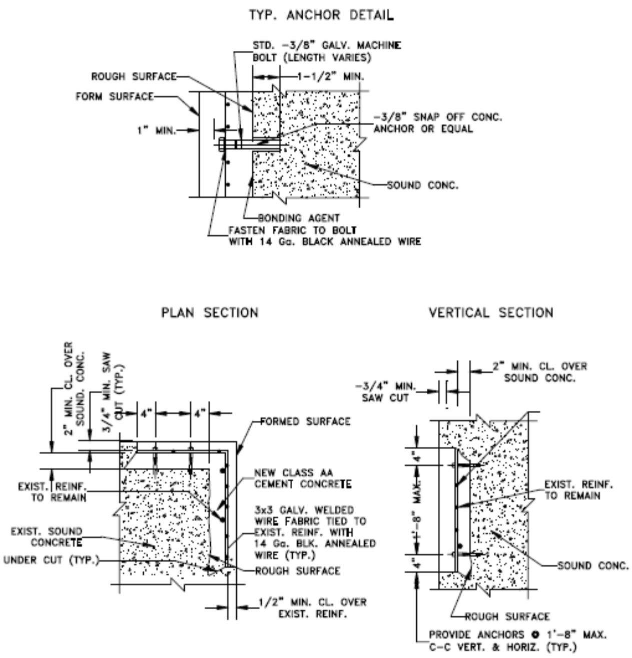

Figure 4.8 Repair of Deteriorated Concrete Pier

A. Recommended Method

1. Saw-cut the boundaries of the deteriorated concrete to be removed to a depth of 3/4 inch.
2. Remove deteriorated concrete by chipping with light power tools.
3. Blast clean exposed reinforcing bars of all rust and foreign materials. Replace deteriorated bar sections as required.
4. Place reinforcing mesh as necessary.
5. Blast clean the existing concrete to be patched to remove loose concrete chips and laitances.
6. Place forms, coat existing concrete surfaces with epoxy bonding agent, and place concrete.
7. Remove forms and finish surfaces after the concrete has cured.

V. MAINTENANCE AND REPAIRS STRATEGIES

Maintenance Engineering is defined as the work done to keep the civil Engineering structures and work in conditions so as to enable them to carry out the functions for which they are constructed.

It is preventive in nature. Activities include inspection and works, necessary to fulfill the intended function, or to sustain original standard of service.

Scope of maintenance

- Petty repairs, replacements and structural repairs of buildings, white and color washing, distempering and painting at prescribed intervals
- Repair and renewal of furniture
- Operation, periodical maintenance, repairs renewals of machinery and equipment for electric etc
- Repair of roads, culverts and resurfacing the roads

Facts of Maintenance

Aims of Maintenance work classified as

- The avoidance of accidents, which may harm people or plant
- The continued operation of a facility
- The protection of the capital investment in the asset

Maintenance work is classified as

- Preventive maintenance
- Remedial maintenance
- Routine maintenance
- Special maintenance

Maintenance work is classified as
The maintenance work done before the defects occurred in the structure is called preventive structure
Remedial maintenance
It is the maintenance done after the defects in the structure. It involves the following basic steps.

- Finding the deterioration
- Determining the clause
- Evaluating the strength of the existing structures
- Evaluating the need of the structures
- Selecting and implanting the repair procedure

Routine maintenance

It is the service maintenance attended to the structure periodically. It is depends upon specifications and materials of structure, purpose, intensity and condition of use.

Special maintenance

It is the work done under special condition and requires sanction and performed to rectify heavy damage.

VI. CONCLUSION

Based on the study of cracks and it repairs of piers and abutment, the following conclusions are drawn:

1. The concrete in abutments may deteriorate from the effects of water, sea salt, and debris impact, Application of epoxy-bonding agent to the concrete surface just before placing the concrete for abutments repairs.
2. Abutment back wall damage caused by pressure from approach pavements can be avoided by installing relief joints, Temporarily tack weld the abutment side of the steel armored joints, sliding plate expansion joint, or toothed expansion joint to the deck side of the joint assembly.
3. Repair to concrete piers is accomplished by removing deteriorated or damaged concrete and placing new concrete, A grout can also be used when the form for the concrete is so inaccessible that an epoxy material cannot be applied effectively.
4. The most effective method of repairing Vee Cracks in piers is epoxy injection. In order to get maximum penetration of the epoxy filler, the first injection is made at the bottom of the crack.
5. Repairs of cracked hammerhead piers can be accomplished by externally post tensioning both sides of the hammerhead cap.

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