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# Repair of concrete bridges

Alok Sarkar

In repairing deteriorated concrete bridges, the primary objective is to restore the structure to its original shape and condition by using a material that will ensure structural integrity, durability, and composite behaviour, while matching the existing concrete in colour and appearance. The repair material should be at least as strong and durable as the existing concrete. Physical and chemical properties such as modulus of elasticity and coefficient of expansion should be similar to the existing concrete. It is essential that the repair material should not shrink; otherwise shrinkage cracks will develop. Selection of proper repair material plays an important role (for example, epoxy resins are more difficult to apply than cement based materials). The cost factor has to be considered carefully before specifying any particular repair material.

## Inspection

Inspection is an integral part of maintenance. The structure should be inspected on a regular basis, not after the failure of the bridge. A bridge inspector must possess the following qualifications.

1. Must be a licensed structural engineer.
2. Should have knowledge in structural behaviour and design of bridges.

3. Should be aware of the changing behaviour of materials with age, its fatigue, chemical properties.
4. Must be familiar with construction practices and proper execution.

## Inspection process

1. Review available plans and specifications and previous inspection records.
2. Prepare a set of bridge plans and sketches of framing plan, deck plan, pier, abutment details, joint details, bearings, etc. These are helpful in taking notes of deteriorated structural and other components.

## Inspection procedures

1. Plan a general course of action i.e. from where to start the inspection process? From the middle or end? What to do during inclement weather? How to work below the deck? Checking of leaking joints, etc. Take photographs and notes of damaged or deteriorated bridge components.
2. To recommend immediate precaution if necessary, and determine the safe load carrying capacity of the structure till its repairs are over.

Needless to say that the observations made during inspection are very critical as it lays the foundation of the entire maintenance programme. If inspection or maintenance is neglected, the consequences may be hard to cure.

## Surface preparation

Obtaining a good bond between the repair material and the original concrete is extremely important in any concrete repair. After the unsound concrete is identified, the edges of the repair area are to be saw cut. Removal is performed by jack hammers or hydrojetting. The hammer's size or the water jet's pressure should be adjusted according to the volume, size and sensitivity of damage. Water jet techniques are better than jack hammers due to fast and efficient removal, elimination of unpleasant noise and dust. Water jet technology provides a rough clean surface with no hairline cracks. Much of the corrosion of reinforcing steel is removed without damaging the reinforcement. Better bond at the interface of base concrete and repair material can be achieved with water jet technique.

## Applying the repair material

### Hand applied mortar

For small or overhead areas where forming and casting are not feasible, hand applied mortar is commonly used. After removing the deteriorated concrete, preparing the surface, and applying the bonding coat (cement mortar or epoxy compound or similar product), the repair material is trowelled on in layers. It is very important to cure the material properly after placement to reduce differential shrinkage.

### Cast concrete

In deck slabs, where the spalls extend below the top reinforcement, the area is built up with conventional concrete. On vertical and overhead surfaces, forms are normally necessary if concrete is to be cast. Forms are first attached to the sound concrete surrounding the spall either by expansion bolts or any other suitable anchoring devices. Cast in concrete is then deposited from the top by gravity or by pressure grouting. Normally, superplasticisers are admixed for the production of free flowing concrete in hot weather. It is also used as a water reducing agent leading to high early strength.

## Pneumatically applied concrete mortar

For overhead repairs, there is no better repair method than sprayed concrete (shotcrete). This method is also very useful for vertical repairs. Shotcrete needs no

bonding compound. A latex modified shotcrete is used in inaccessible areas because it needs no forms and has a high bond strength. The repair surfaces should be wetted just before applying the shotcrete, but shotcrete should not be applied where there is standing water. Application of dry shotcrete requires a great deal of skill. It should be applied about 3 feet from the surface, and the rebound loss should not be more than 20%.

## Crack repair

Cracks in concrete are caused by many factors, e.g., shrinkage, excessive thermal stresses, improper placement or compaction, uneven foundation settlements, overstressing, inadequate reinforcement, improper detailing and corrosion of reinforcement. For crack repair, epoxy grouts are generally used because of their excellent bonding qualities. Cracks ranging in width from 1 to 6 mm can be successfully filled with epoxy grouts of varying viscosity. Cracks wider than 6 mm can be filled with either a cement grout or an epoxy grout. A modified lignosulphonate based admixture should be added to cement grout for improved workability without an increase in water content. This allows easier placement leading to denser concrete and superior finish.

## Concrete deck slab maintenance and repair

Concrete deck slabs are constantly pounded by traffic, and are directly exposed to weather. Consequently they deteriorate faster than other parts of the bridge. Before rehabilitating a deck slab, a detailed inspection is essential. On a scaled plan of the deck slab all visible cracks, spalls are recorded schematically. Spall over 30 to 40% of the total deck area imply that the entire deck slab may need replacement. An inspector uses a hammer to find out concrete delamination and hollowness of concrete deck. Half cell potentiometer is used to determine the condition of reinforcing steel. By wetting the concrete at the location of the test, an electrical current is established between the exposed reinforcing steel and the half cell unit. A potential reading on the voltmeter indicates corrosion of reinforcing steel.

## Typical deck repairs

### Shallow repairs

Where the depth of concrete deterioration is less than 20 mm and reinforcing steel is not exposed, a shallow repair is called for. The defective concrete is saw cut 18-20 mm deep into rectangular or square shape. Then, concrete is removed either by a pneumatic hammer or hydrojetting.

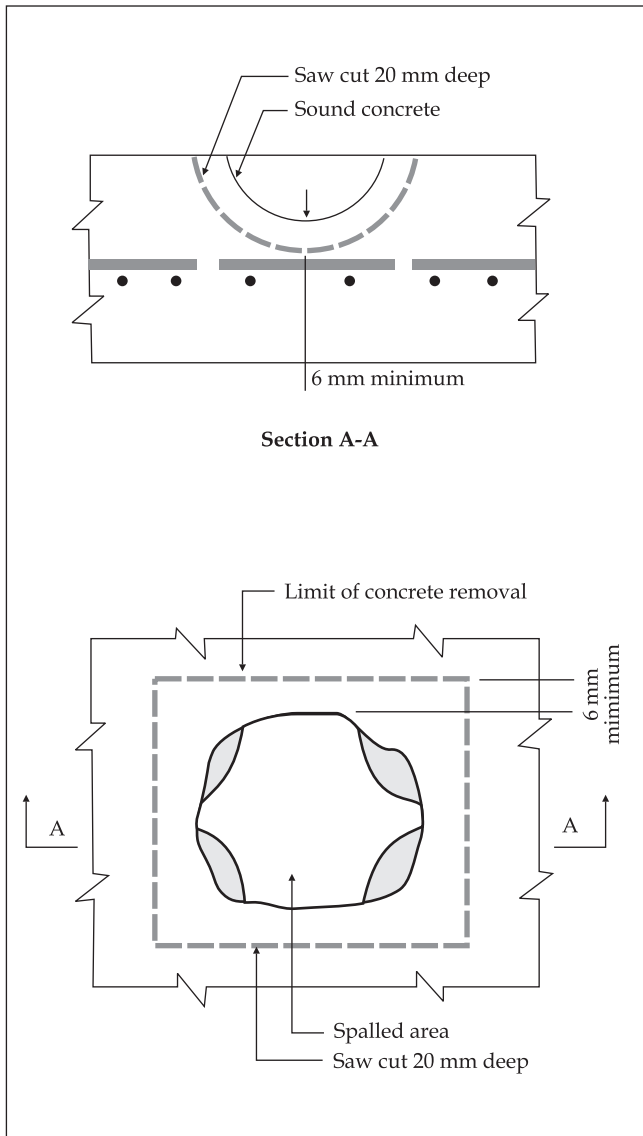


Figure 1. Shallow repair of deck slab

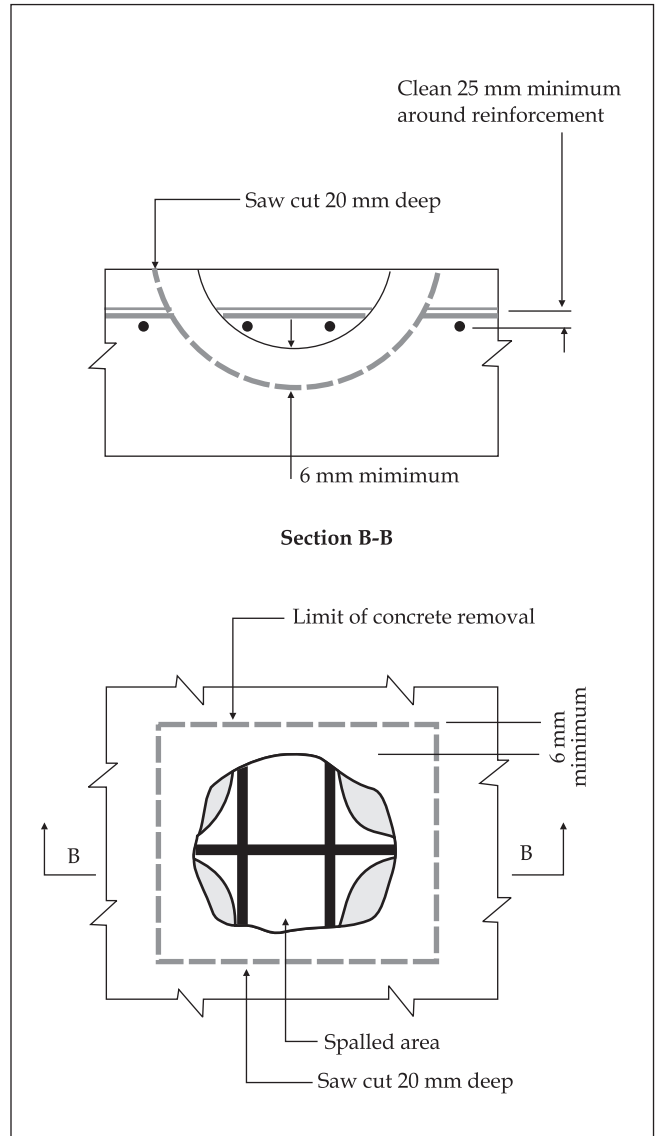


Figure 2. Deep repair of deck slab

The surface is cleaned thoroughly, and a non-shrink, quick setting polymer modified cementitious mortar is applied and cured. Figure 1 depicts a typical repair detail.

### Deep repairs

Defective concrete deeper than the top mat of steel reinforcement requires deep repair. The deteriorated concrete is removed as for a shallow repair, but the top reinforcing mat is completely exposed as shown in Figure 2. Subsequently, these bars are thoroughly cleaned by sandblasting or hydrojetting. If there is section loss, supplemental bars are added. First, concrete substrate is cleaned with high pressure water or air jet,

then an epoxy bonding coat is applied to the surfaces on the reinforcing mat, and at the bottom of the rebars. Before the coat is hardened, the concrete is placed, screeded and cured.

### Deck overlays

Decks undergo severe punishment due to heavy traffic, temperature extremes and water damage. The deck overlays can be of different types. Latex modified concrete (LMC) overlay is very popular, and is widely accepted. When concrete is mixed with styrene butadiene latex, a mix is obtained that is highly efficient and durable as an overlay. The thickness normally specified for an LMC overlay is 35 - 40 mm. Before the LMC overlay is

applied, concrete spalls are usually repaired. To prepare the surface for an overlay, a thickness of 6 mm is scarified to remove all oil, grease and solvents. Then the surface is blast cleaned with air and water jets and thoroughly made wet for an hour or more prior to placement of the overlay. The LMC should be mixed at the site in a continuous mobile mixer that can accurately measure and calibrate the mix components and add them at the correct mixing times.

After installing bulkheads to set the grade and profile, the LMC is placed and distributed to the correct levels with shovels, brooms and brushes. Then a vibrating screed type finishing machine is used to strike off the excess material and fill in the low spots. LMC should not be placed at temperatures below 9°C or above 30°C. When a tight uniform surface has been achieved it should be texturised before a plastic film forms. As soon as the weight can be tolerated, it should be covered with a layer of saturated burlap and layer of polyethylene sheet for

24 hours to prevent moisture evaporation. After this, the covers should be removed and the surface should be allowed to air dry for 72 hours. LMC should not be placed in the rain. Material damages caused by sudden rain should be removed.

### References

1. \_\_\_\_\_ *Guide for repair of concrete bridge super structures*, ACI 546.1 R-80, 1980, American Concrete Institute, USA.
2. Khosrov, Babsi and Hawkins, Neil M., Evaluation of bridge deck protective strategies, *Concrete International*, December 1988.
3. Harms, S.D., The innovative use of reactive resins for bridge repair, *Proceedings of the first international bridge conference*, Pittsburgh, 1984.



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