Examples of Repairs to Concrete in Bridges

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• THE STATE of New York is divided into ten highway districts that supervise all construction work and do the maintenance work on all highways and bridges belonging to the State system. These districts also do all surveying, preparation of road plans, and design culverts with spans of less than 20 ft.

Each district has a maintenance engineer who has one or more maintenance organizations in each county, each having its own buildings and equipment in charge of a highway maintenance engineer. The maintenance crews are equipped to do ordinary maintenance work and snow removal but are not equipped to do major structural repair work. Such work is done by contract, using construction rather than maintenance money. Contract plans for doing the work are prepared by the Bureau of Bridges, Albany.

A great many of the older bridges ranging in age from 25 to almost 100 years old were originally built by cities, towns, and counties or by private concerns as toll bridges. Over the past 30 years, the State has incorporated them into the State highway system and now maintains them. When taken over, many were in bad condition due to poor maintenance and age. Some have been replaced by new bridges. Others have been repaired and sometimes widened.

Thirty or forty years ago, it was thought in bridge design that concrete got stronger with age and that there would never be a maintenance problem. As a result concrete was used with great confidence, assured that it was an everlasting construction material. Even when steel was used in bridges, it was encased in concrete, certain that it would never have to be painted and that it would be forever protected from rust. No attempt was made to protect the concrete itself from water or weathering except during its curing period.

Now it has been discovered that this confidence was misplaced. Hundreds of structures containing unsightly patches of deteriorated concrete now exist. In many cases, the concrete is less than five years old.

Because these bridges have already been built, there is now the problem of keeping them in service by repairing them as well as possible, and while repairing them, trying to protect them from future damage. Luckily, the damage effect is usually local and does not affect the strength of the main members of the structure to a dangerous degree. There have been no spectacular failures of concrete structures but only local failures like holes in slabs, deterioration of curbs, pieces falling off of beams and arch ribs, exposing the reinforcing steel.

The cost of rehabilitating some of the older bridges often exceeds the original cost of the bridge but traffic can usually be maintained while repairing the bridge and still at only about one-fifth the cost of a new bridge.

The concrete slabs are about the most common and fundamental part of most structures. From about 1930 to 1955, most bridges built by New York State had a separate concrete wearing surface laid on top of the slab. This wearing surface was made of rich concrete, reinforced with one layer of wire mesh. To keep it from bonding to the slab below either asphalt or a membrane waterproofing separated it from the main slab. The purpose of the wearing surface was to make a better riding surface by better screeding and also it was thought it could be removed and replaced when necessary. Many of the older bridges had a concrete slab covered by a sand cushion and then paved with brick or wood blocks.

In the early years of its use, this concrete wearing surface stood up well in most cases. However, in late years due to heavier loads and the extensive use of de-icing chemicals for snow removal, many of the wearing surfaces on the newer bridges have cracked and spalled, requiring repairs and resurfacing.

Since 1955, a $2\frac{1}{2}$-in asphalt wearing surface laid in two courses has been used on most of the bridges. Before placing this asphalt concrete wearing surface, the slab below it is waterproofed first with a silicone and then with a waterproofing bituminous material such as "Sika Seal."

The experience with asphalt wearing surfaces has not been completely satisfactory. Asphaltic concrete is not necessarily waterproofing for the slab under it and it seems to be porous and hold water that can aggravate the salt action on the slab below. A way to seal the asphalt wearing surface so that water cannot permeate it is desirable. At present, monolithic slabs are being considered. These have no wearing surfaces but are protected from salt action by sealing compounds such as silicones, linseed oil, asphalts, epoxies, and bakelites. Now, perhaps with the improvement of screeding methods, it is hoped monolithic slabs that will have good riding qualities can be obtained.

As previously mentioned, there are two main problems or objectives in the bridge repair work:

1. To restore the structural strength and appearance of the concrete.
2. To protect all concrete, both new and old, from future damage due to weathering and de-icing chemicals.

There is an article in "Better Roads" July 1961 issue by John F. McGovern of the Massachusetts Department of Public Works entitled "Water Is the Number One Enemy in Maintenance of Structures." In this article, McGovern calls attention to the fact that water destroys concrete, rusts out steel, and rots timber.

When water has salt in it, its ability to damage steel and concrete is multiplied many times. Therefore, logic dictates that an attempt be made to waterproof steel, concrete, and timber when they are used.

For integral waterproofing, dense concretes with air-entrainment materials and other additives are being used; for surface waterproofing, paints, asphalts, resins, bakelites, coal tars, silicones and trade name products such as Sika Seal, Dum-Dum, Gunite, Penetryn, and Guard Cote are employed.

Only about five years ago, New York State Bureau of Bridges started using air entrainment in structural concrete. There are no examples of repair to air-entrained concrete yet; however, the amount of air entrainment anticipated has not always been attained. Only time will tell how well these protective efforts work and during that time interval, better materials for protecting concrete may be invented. It is hoped the structures can be protected indefinitely.

GLENS FALLS BRIDGE OVER HUDSON RIVER

This bridge (Figs. 1 and 2) was built in 1915 by the City of Glens Falls and was taken over by the State of New York about 5 years ago as part of the State highway system.

It consists of a series of concrete fixed arches, open spandrel type with all piers and abutments resting on rock. It is the third bridge at this site, the first one being built shortly after 1800. There is a rocky gorge under the bridge and a power dam above the bridge. Water is usually going over the dam and this causes a mist that often covers the bridge, forming ice in cold weather. Thus, a great deal of salting is done in cold weather to make the bridge passable for cars and pedestrians. The river water also contains a lot of chemicals from the paper mills above the bridge.

The bridge has two arch ribs 13 ft wide of varying thickness carrying transverse spandrel walls at ten 6-in. centers and on top of the spandrel walls, there is a 12-in. thick concrete slab supporting the roadway. These ribs were built by the Melan system which employed the reinforcing to act as centering for the arch from which the forms were hung. On top of the 12-in. slab there was a layer of fill concrete shaped to give a parabolic crown to the roadway, then covered by a layer of sand which carried paving bricks that were later covered with a few inches of asphalt concrete.

The heavy concrete railings and sidewalks were carried on fascia brackets supported from the transverse spandrel walls mentioned. On the upstream side, these brackets have deteriorated so badly that a section of the railing fell into the river. The de-icing chemicals and chemicals in the river water being sprayed over the bridge in the form of mist had done the damage, and even the 12-in. supporting slab was badly deteriorated. The bridge is now being repaired by contract.

All concrete is being removed down to the supporting slab including all road material, pylons, and concrete railing. New concrete brackets are being built to support the sidewalks and widened roadway. A span will be constructed between transverse spandrel walls with a new reinforced slab using the old slab only as forms, and all new concrete will be bonded to existing concrete with epoxies after all decayed concrete is removed.

Decayed and spalled places on arch ribs, spandrel walls, piers, and abutments will be repaired with gunite bonded to the old concrete with epoxies and wire mesh. After all concrete repair work is done, all exposed surfaces will be waterproofed with Penetryn waterproofing.

The new railing will be of aluminum and will be open with tubular-shaped railing and cast aluminum posts. Curbs are 10 in. high and then stepped back 6 in. and then another curb of 8 in., making the sidewalks 18 in. above the gutter. Curb faces will be protected with corrosion-resisting steel plates. The bridge will be widened from 30 to 40 ft between curbs. Two lanes of traffic will be maintained while the work is going on.

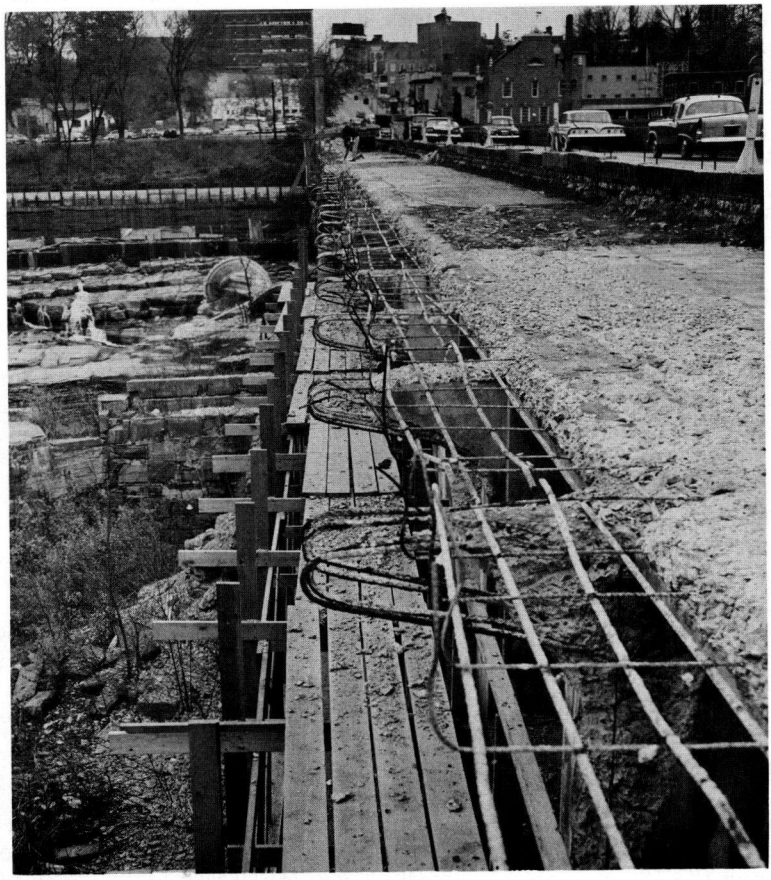

Figure 1. Glens Falls Bridge over Hudson River showing deck and sidewalk brackets after deteriorated concrete has been removed.

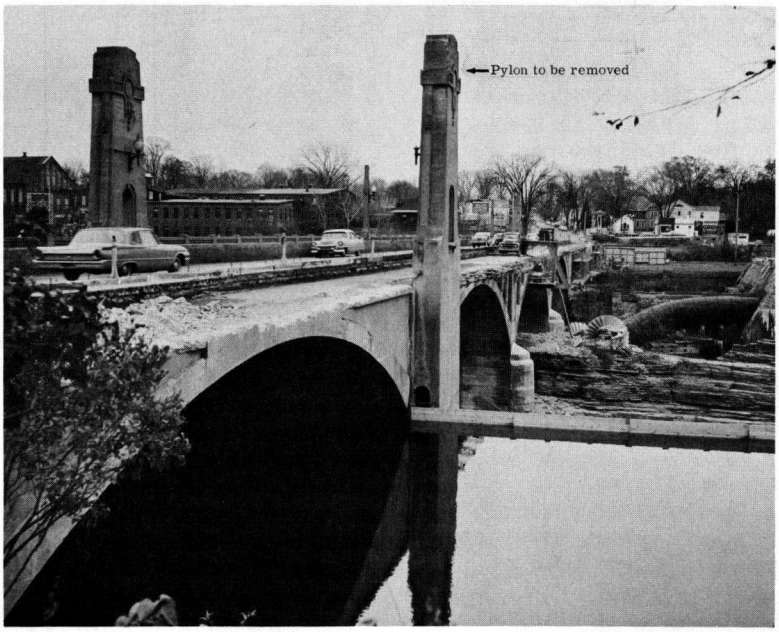

Figure 2. Glens Falls Bridge over Hudson River.

In 1960, a traffic count showed that the bridge carried a maximum of 1,200 cars per hr and 20,000 cars maximum in a 24-hr period. Bad traffic conditions have existed there for years because it is almost in the center of town and has bad approaches to it. Repair work will cost well over $400,000.

WATERFORD BRIDGE

The original bridge was built in 1804 by Theodore Burr. It was the first bridge across the Hudson River between Waterford and New York City. It consisted of four timber arch spans with an average length of 200 ft each. It had two 15-ft roadways separated by the middle truss. It lasted 105 years until it burned in 1909. It even carried streetcars for several years before it burned.

When it burned, Boller & Hodges, well-known engineers of the early 1900's, designed new steel trusses that were placed on the original piers which were built in 1804. This new bridge has a 5½-in. concrete roadway slab and 4-in. sidewalk slab of concrete.

In 1960, the original piers began to show signs of extensive deterioration as they were only masonry shells resting on the rock bottom of the river and filled in with loose field stone. Straps of wrought iron tied the walls together (Fig. 3).

The piers were encased in sheet piling up to 2 ft above the pool elevation, and the space between the piers and piling were filled in with 36 in. of tremie concrete. (Fig. 4). Above the piling, the stone was encased with a shell of reinforced concrete 30 in. thick on the average. All of this work was done during a very cold winter, the contractor working on 30 in. of ice, which made a fine platform to work from.

The concrete slabs of the bridge floor and the sidewalks were in good shape even-though 51 years old. They probably had 40 years of salt-free life, which explains their good condition.

When the weather got warm, all new concrete above water was painted with two coatings of a waterproofing material called Penetryn. The first coat is colorless and was sprayed on; the second coat was put on with rollers and has a color about the same as concrete. The cost for the two coats was about $0.25 per sq ft. It has given the

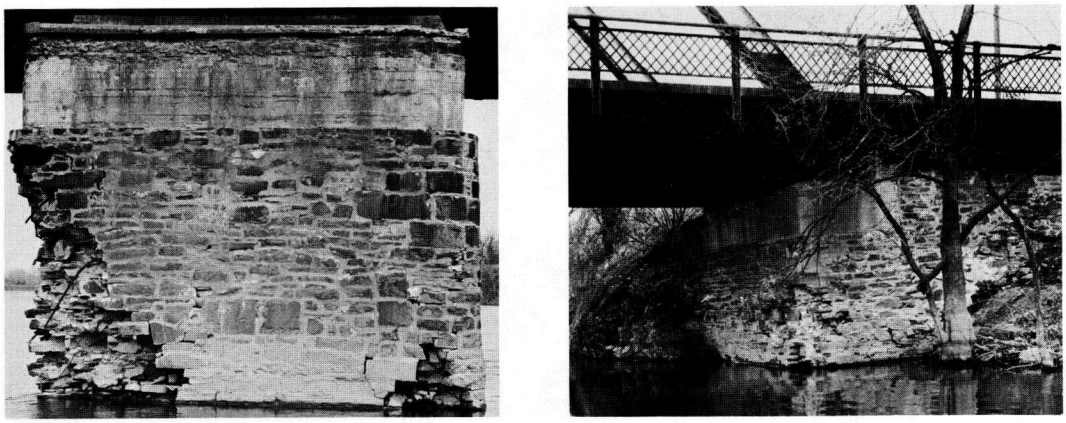

Figure 3. Pier at Waterford, N. Y., for Hudson River Bridge.

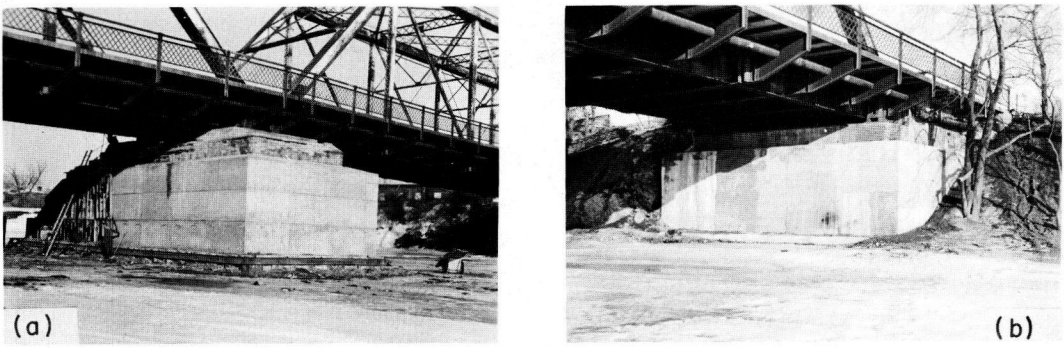

Figure 4. Waterford, N. Y., bridge pier being repaired: (a) waterproofing not yet added; (b) 26-in. ice on Hudson River used as working platform by contractor.

concrete a nice appearance and it is expected to protect the concrete from water and salt damage for a long time to come. The material has been used for quite a few years on buildings where the concrete needed repairing and waterproofing. The material on the jobs looked at seemed to be lasting well and gave all the concrete the same color.

WESTERN GATEWAY BRIDGE OVER MOHAWK RIVER AT SCHENECTADY, N. Y.

This bridge was built in 1926 by the State of New York. It consists of several rather long and flat fixed concrete arches, open spandrel type. The roadway is supported by a 12-in. concrete slab spanning between transverse spandrel walls on the arch ribs. The main span over the Barge Canal is a 210-ft, three-hinged steel girder arch with a rise of about 20 ft and it is encased in gunite concrete. It also carries a 12-in. base slab carried on floor beams supported on steel columns to arch ribs. It has a 40-ft roadway and two 6-ft sidewalks. It carries as many as 2,500 vehicles per hr and over 20,000 vehicles in a 24-hr period. It is over 3,000 ft long and has a kink in it where it changes direction.

Repair work became necessary due to deterioration of two 13-ft end slabs at the ends of the steel arch span. Water had entered the expansion joints and deteriorated the concrete supporting slab so extensively that the reinforcing bars were hanging in the air freely with loose ends, and holes were appearing through roadway near curbs. Curbs and sidewalk concrete were in bad shape and there were a lot of spalled places on

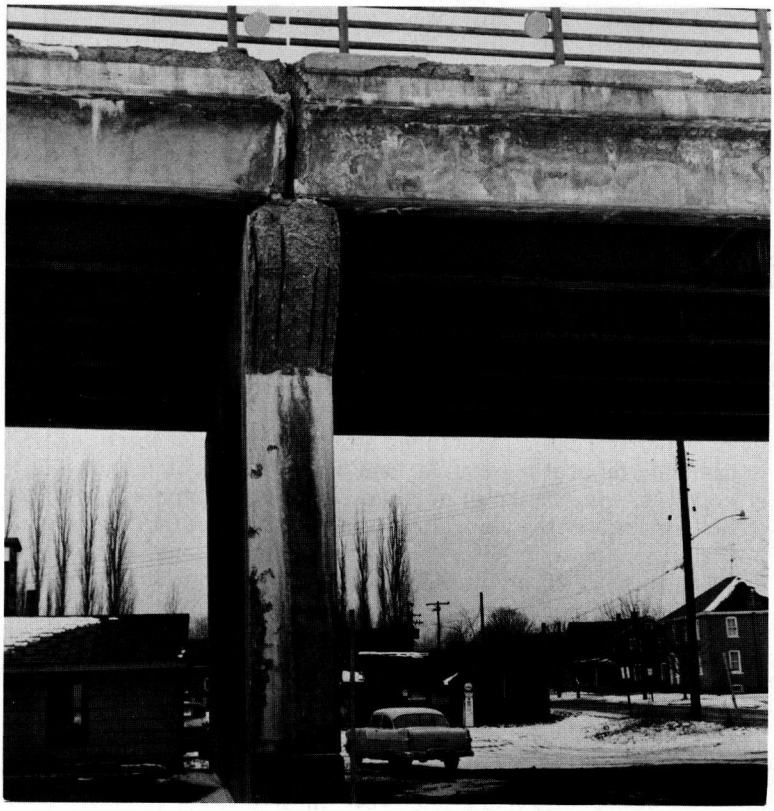

Figure 5. Bridge over N. Y. Central RR at Lyons Village, N. Y., to be repaired by removing deteriorated concrete, cleaning by steam and sandblasting, and coating with epoxy before rebuilding to original lines.

pylons and retaining walls. The railings are of heavy precast concrete lattice type and were in fairly good shape except where vehicles had hit them.

On top of the 12-in. main carrying slab was a fill concrete varying from 4 to 8 in. thick separated from the slab by a membrane. This was a lean concrete added to put a parabolic crown on the roadway and which originally was covered with an asphalt plank wearing surface. These planks had been removed long ago and replaced by an asphalt concrete. The fill concrete had broken up and provided a poor base for the asphalt concrete above it. All of this material had to be removed down to the main slab.

All work was done with traffic going over the bridge, maintaining at least two lanes of traffic at all times. A new asphalt wearing surface of approximately 6 in. of asphalt concrete was placed after the old concrete and asphalt was removed down to the main slab. The two end panel slabs were completely replaced with new concrete, using existing reinforcing bars which were in good shape and left in place. The new concrete had $7\frac{1}{2}$ percent air entrainment. New granite curbs 10 in. high were installed for the whole bridge and approaches. Deteriorated concrete was removed from sidewalks by sawing and jack hammers and replaced with new concrete with $7\frac{1}{2}$ percent air entrainment and $\frac{3}{4}$-in. maximum size aggregate. It was then bonded to the old concrete by epoxy-bonding compound. Spalled places in railings, pylons, etc., were repaired using a stiff mortar over epoxy-bonding compound. The total cost of the work done was about $250,000.