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REHABILITATION OF SAGA BRIDGE

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At the Second Movable Bridge Symposium in 1988, a plan for the rehabilitation of four movable bridges in Connecticut was presented by Metro-North Commuter Railroad. This paper will discuss the rehabilitation to date of one of these structures, the SAGA Bridge Over The Saugatuck River in Westport, CT. This bridge, located along the New Haven Line about 40 miles northeast of New York City, is a four track, Scherzer rolling lift bascule bridge originally built in 1905 for the New York, New Haven and Hartford Railroad. The bridge presently carries Metro-North Commuter trains between NYC and New Haven along with Amtrak passenger trains headed to Boston and Hartford and Conrail freight trains.

The SAGA Bridge is a 458 foot long open deck structure consisting of five fixed spans in addition to the single leaf movable span. (Figure 1) Each span consists of eight girders, two below each set of track and ties. Outboard of the south fascia girder is a pedestrian walkway. The superstructure is supported on granite faced concrete piers and spread footings founded on the rock below the river bed.

The movable leaf is divided into two halves, side by side, which can be opened simultaneously or individually. The counterweight end of the leaf is supported on curved segmental girders which roll back on track girders to open the span. The steelwork supporting the leaf spans across the tops of the two sections of the bascule pier. The movable span is powered by a pair of diesel-fueled internal combustion engines located in the operator's house at track level and driven through a system of open gearing, shafts and bearings running down under the house, across the bascule pier and supporting steelwork and up into the leaf to main pinions which mesh against stationary racks. The movable span is presently opened about 100 times a year, mainly for pleasure craft during summer months.

The rehabilitation of the SAGA Bridge started back in the mid-70's, when the entire structure was originally scheduled for replacement under the Northeast Corridor

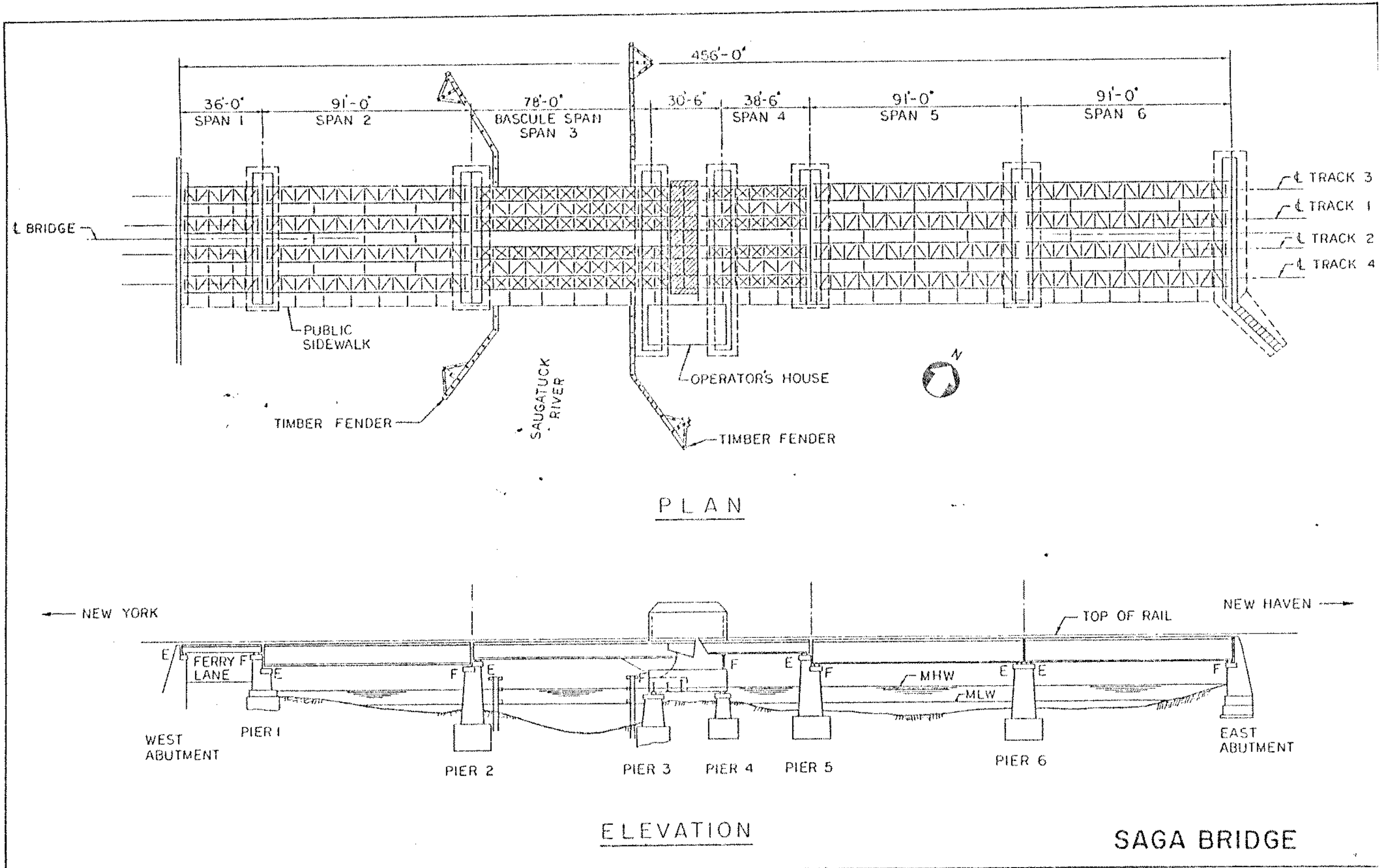

Figure 1 - Gener[illegible]lan and Elevation

Improvement Program (NECIP). However, due to a lack of funds, rehabilitation of the structure was necessitated. In 1978, an in-depth inspection and analysis of the structure was undertaken to determine the repairs needed. This inspection revealed serious deterioration to the structural elements within the tidal zone. The mortar had been washed out from between the granite block facing of the river piers, with a number of blocks shifted out of position. At the bascule pier, the lower portion of the steelwork supporting the movable span and operator's house was severely corroded and holed through after 75 years of being washed by the tide twice a day. In addition, the fillet between the legs of the curved bottom flange angles of the segmental girders of the bascule span were found to be cracked and the leaf itself uneven due to differential settlement.

This inspection led to an extensive rehabilitation program which included replacing or repairing corroded portions of structural steel members, encasing the tidal portion of the pier stems in concrete and enclosing the bascule pier to make a waterproof pit for the exposed steelwork and counterweight. To bring the bridge up to current standards, it was proposed to replace the diesel engine and controls with state-of-the-art electrical equipment, to replace much of the operating machinery and to provide new locks, brakes, limit switches, expansion bearings, mitre rails and track and ties. Unfortunately, in 1981, with design plans and specifications 90% complete, the Northeast Corridor work was stopped and the rehabilitation project put on hold.

In 1983, the Metro-North Commuter Railroad was created and given the responsibility of rehabilitating the bridge. Due to limited funding, the rehabilitation was scaled down and divided into three phases to stretch out the repair work. These phases were initially:

Phase I - Movable span repairs to include the bascule and rest piers.

Phase II - Substructure repairs to the remaining piers and abutments

Phase III - Fixed span repairs to include the operator's house, pedestrian walkway and timber fenders.

Structural repairs included new curved flange angles and stiffeners for the segmental girders, shimming of the track plates to re-level the bascule leaf, replacement or repair of all corroded steelwork (girders, bracing, columns) within the tidal zone atop the bascule pier, replacement of expansion bearings, stiffener and rivet replacement, counterweight box repairs and realignment of the racks and heel locks. Substructure repairs consisted of resetting of granite blocks, sealing cracks and repointing joints between blocks and then fastening the blocks to the concrete core of the pier with rock anchors. Rehabilitation of the operating equipment was limited to refurbishing the mechanical elements, rebushing bearings and replacement of heel lock motors and limit switches. Tie and rail replacement was left to Metro-North maintenance forces. These repairs are intended to provide enough rehabilitation to extend the operating life for a finite period of time.

Because this is an active commuter rail line, the repairs were scheduled to be done closing only two of the four tracks at a time. This was possible because of the split leaf. Work with the span closed and inoperable was limited by the Coast Guard to the months of November through April as not to disrupt marine navigation.

Contract Plans for Phase I were put out to bid in Spring 1986. Actual construction starting in November 1987 with the south half of the leaf. The leaf section was tied back in the open position and front half of the track shimmed and the corresponding section of curved angle for the segmental girder replaced. At this time, the operating machinery was removed and taken to a machine shop for refurbishing. Gearing was cleaned up while bearings were rebushed and journal ends of shafts repolished. Once the machinery was reinstalled and realigned, the leaf was lowered so that the back half of the track and curve angle could be worked on. Also during this time, the counterweight box was emptied of all cast iron blocks to facilitate repairs to the box. The blocks were cleaned, reinstalled and grouted into place.

Work on the south leaf was completed by the end of April, twice the time originally estimated and the contractor was prevented from starting work on the north half of the leaf because he could no longer block the waterway to navigation for the year. Some of this delay could be attributed to extra work due to a sharp increase in deterioration and subsequent needed repairs since the bridge had been inspected in 1978.

Approximately 1000 rivets had to be removed and replaced over the course of the work. The rivets had to be punched out because the specifications specified that no burning would be allowed. This proved to be a very time-consuming operation until the contractor proposed using a magnesium electrode to burn out the rivets. The very thin flame of the torch was able to burn out the center of the rivet without damaging the steel of the structural member. This speeded up the task of rivet removal significantly.

All the burning of existing steel and its old lead paint covering increased the hazard of lead poisoning to the steelworkers. As the job progressed, safety measures were instituted to reduce this risk.

During this time, design plans and specifications were prepared for Phase II-Substructure Repairs. The bascule and rest pier repair was removed from Phase I so that now all substructure work would be done in a similar fashion under one contract. However, over the years without repairs being made, the tides had now begun to erode the concrete core of the pier behind the block facing, causing large voids to form behind the blockwork. This significantly increased the amount of work to be done.

This phase was bid in winter of 1989 with work starting on SAGA that fall. During the autumn months, the shifted granite blocks were pushed back into place as best as possible and Sika 212 grout was injected into the core to fill the voids. The cracks were then sealed and joints between blocks repointed with Master Builders "Brutem 512," a two-part epoxy. Work halted over the winter, and when resumed in the spring of 1990, rock anchor holes were drilled into the piers and the 12 foot long rock anchor rods installed and tensioned to 10,000 pounds using the "Rawl Chem Stud" system. Work on this phase was successfully completed by July 1990.

Over the winter of 1989, by mutual consent, the Phase I contractor was allowed to terminate his contract. His unfinished work on the north half of the leaf was then added to the plans for Phase III, which involved all remaining repair work on the structure. This work included structural repairs to the fixed spans, replacement of deteriorated timber wales and piles of the fender system, improvements to the operator's house, new lighting systems and electrical hook-ups, bridge balancing and painting of the entire structural steelwork. Painting specifications call for a water blast or mechanical cleaning to remove all loose paint and dirt and then a single coat of epoxy-mastic paint followed by a finish coat of urethane paint. The lower elevations of the steelwork in the tidal zone atop the bascule pier will receive a special marine paint covering for added protection.

Plans and specifications for Phase III were advertised for bid in the summer of 1990. Because of navigation requirements and other rehabilitation work scheduled for other bridges along the rail line, actual work at SAGA Bridge is not anticipated to start until January, 1992. It is my hope that I may announce the completion of the rehabilitation of the SAGA Bridge at the Fourth Movable Bridge Symposium in November 1992.

In conclusion, it is interesting to look at how the cost of rehabilitation has changed since the first set of repair plans were developed. The cost to extensively rehabilitate the entire structure back in 1981 was estimated at $5.8 million exclusive of new track and ties. These plans never went as far as the bid phase.

The engineers estimate for Phase I repairs in 1983, which consisted of the minimum needed repairs to the movable span and supporting piers, was $1.9 million and the low bid was $2.6 million. The final actual cost for this phase paid to the contractor, which in the end only involved repairs to half the leaf, was $1.3 million.

Phase II substructure repairs was estimated in 1988 to be $1.4 million. The job was bid at $1.3 million, and when complete in 1990, a total of $1.1 million was paid based on final actual quantities.

Phase III, which now includes all work not accomplished during the first two phases, is estimated to be $3.1 million.

Totaling up the cost actually paid in Phases I and II plus the estimate for Phase III comes to about $5.5 million. Adding another $0.5 million in engineering fee to redesign the repairs, some twice, gives an overall cost of $6.0 million. Discounting inflation, this is slightly higher than the $5.8 million estimated in 1981 for a much more extensive rehabilitation program. While some of this cost can be attributed to more stringent EPA requirements for paint removal and disposal, at best, one can conclude that by the unavoidable postponement of 6 to 8 years to make repairs to the structure, less repairs were done for the same amount of money.