HMS

HEAVY MOVABLE STRUCTURES, INC.

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Clearwater Beach, Florida

SESSION WORKSHOP PRESENTATIONS

"EMERGENCY REPLACEMENT OF DEFORMED, CRYSTALLIZED SCHERZER TREAD PLATES"

by PAUL M. BLAIR, P.E.
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EMERGENCY REPLACEMENT OF DEFORMED, CRYSTALLIZED SCHERZER TREAD PLATES

By:

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LOCATION: BLYNMAN BRIDGE - GLOUCESTER, MA
MA ROUTE 127 OVER BLYNMAN CANAL

OWNER: MASSACHUSETTS HIGHWAY DEPARTMENT (MHD)

FHWA's bridge inventory records indicate that of the 970 movable highway bridges on file, more than half (529) are bascule type structures.

One common type of bascule is the Scherzer rolling lift. FHWA *Bridge Inspector's Training Manual* indicates the first Scherzer was designed by William Scherzer and built in Chicago in 1895. Scherzers were patented and aggressively marketed by the Scherzer Rolling Bascule Bridge Company as Figure 1 shows.

Unfortunately, early Scherzer designs contained a flaw. The thickness of the tread plates of the segmental and track girders was insufficient. **Many Scherzers exhibit significant distress related to high line bearing stresses.** The current AASHTO *Standard Specifications for Movable Highway Bridges* states the "...line bearing between treads for segments having a diameter of 120 inches (a 5 foot radius of segmental tread) or more shall not exceed:

$$(12{,}000 + 80D)\ \frac{Fy-13{,}000}{20{,}000}$$

in which the D is the diameter of the segment in inches and F_y is the specified minimum yield....".

It is clear from the formula that allowable line bearing increases with diameter and tread plate yield strength. The length of the line upon which the line bearing applies is further defined in terms of "web thickness including the effective thickness of the side plates plus 1.6 times the least depth of tread". This indicates that actual line bearing is reduced as tread depth increases.

In rehabilitation of an existing Scherzer segmental tread plate, the radius of curvature must be maintained; therefore it is clear, with little investigation, that changing segmental tread plate thickness to correct excessive line bearing stress can be a major undertaking. Unfortunately, changing the tread plates to a higher yield strength material is not always sufficient to correct existing overstress.

This paper is an account of one such case and the innovative interim solution necessitated by circumstances which caused delay in scheduled rehabilitation of a heavily distressed **Scherzer Rolling Lift Bridge** in Massachusetts. Photo 1 is an elevation of the **Blynman Bridge**, a skewed double leaf Scherzer in Gloucester, Massachusetts. The structure was rehabilitated in 1980 by others. The method selected was in-kind replacement of treads with a high strength tread material of the same thickness (1-1/2 inches) as the existing tread. For various reasons, the material supplied and installed in

1980 was not the material originally specified and an attempt was made to increase the yield strength of the supplied fabricated treads by metallurgical case hardening methods. The hardened treads were then installed due to the need to return the structure to operation quickly. When Lichtenstein personnel first inspected the structure in 1987, the tread plate attachment bolts on the segmental and track girders had fractured heads in many areas. The treads were plastically deformed and exhibited severe longitudinal cracking in the center of the line bearing zone over the track girder webs. Over the years from 1987 to 1992, we designed and the Massachusetts Highway Department (MHD) employed a number of stopgap measures including welding, shimming and a substantial amount of worrying and burning of the midnight oil to keep the tread plates of this vital structure operative until a rehabilitation could be contracted, designed, bid and built. This contract would replace the heavily damaged treads with new higher strength and much thicker tread plates (3-1/2 inches). Finally in the winter of 1992/93, the condition of the tread plates on the track girders reached a point where the existing tread material was extremely brittle. Welding was no longer effective. A weld placed to correct a crack would immediately recrack in the heat affected zone within the very tired base metal. The decision was made by MHD to replace the two worst track girder treads as a safety measure prior to the heavy 1993 navigational usage summer season.

The problem with replacing only the track girder treads was that the severe plastic flow and wear of the treads made replacement of the irregularly shaped treads with new duplicate treads challenging. There were no straight lines on the treads and a mismatch between new track girder treads and existing segmental treads or lugs and lug pockets could potentially have caused severe operational problems. The method selected to duplicate the two existing track girder tread plates exactly was to make a laminated in-situ mold. The construction of the mold consisted of placing one layer of epoxy resin followed by one layer of urethane and then a final layer of woven fiberglass matting reinforced urethane on the existing tread.

Due to the fact that work was done in the winter it was necessary to construct an enclosure to provide an environment conducive to placing and curing of the dimensionally stable mold laminations as shown in photos 2, 3 and 4. The molds were done as two segments, one of the forward half of the tread with the bridge open and the other of the rear with the bridge closed. The molds were carefully referenced to a meticulously laid out centerline and levelled with a special frame as shown in photo 5 to provide a horizontal reference plane.

The two half molds for each tread were taken to a pattern shop, reinforced, and a similarly laminated tread plate mock-up was constructed using the molds. The mock-up was then an exact replication of the existing tread contour. The tread mock-ups were then assembled and backed with a wood frame shown in photo 6. The duplicate tread was also carefully marked with the transferred centerline and horizontal reference plane. This model was then used to set the parameters for the complex sculptured surface geometry. A CIMLING Cad System was utilized to digitize the tread surface through IGES translation.

When the model was fully set, it was placed on the bed of a RAMBAUDI turn spindle Rammatic 800 mirror image CNC with FIDIA controls for digitizing coordinates of all critical points on the tread. The lug teeth were duplicated exactly, but the rolling surface was smoothed slightly to eliminate some of the existing irregularities which increased rolling resistance. Once the digital setup was completed, a blank of T1 steel was inserted and milled to produce a half section of new tread as shown in photo 7. The corresponding half section of existing tread was removed, the new tread was taken to the bridge and positioned on the existing flange angles of the track girder. An air driven end mill was used in a small hand held air drill to mark the exact location of existing holes using the existing holes in the flanges angles as a template. The T1 plate was then taken back to the shop and drilled. This procedure was necessary due to the fact that plastic flow had pushed the bolt heads at the surface of the existing treads out of alignment, making direct measurement impossible until after removal of the existing tread. The half section was then returned and bolted in place as shown in photo 8. Due to the marking procedure the bolt-up went smoothly with no alignment problems. The span was then rolled to the open position and a similar procedure employed to replace the toe segment of tread as shown in photo 9.

The fit of the two new half segments was so precise after assembly that it was difficult to feel the joint with a fingernail. This procedure was employed in this instance as a stopgap measure to maintain safe operating conditions until a full rehabilitation could be accomplished. We believe it may have some usefulness for other applications where exact match to an existing complex shape is desired and there is room to place molds. The time schedule and construction costs for this work are attached as Appendix 1.

APPENDIX I

1. Site Construction Time Estimate:

   For mold impressions and fabrication:
   4 - 16 hour shifts = maximum 64 hours

   For tread plate removal and replacement:
   6 to 8 - 16 hour shifts = maximum 128 hours

   Actual Site Construction Time for Both Treads:

   For mold impression and fabrication:
   2 - 8 hour shifts = 16 hours

   For tread plate removal and replacement:
   7 - 12 hour shifts = 84 hours

   Total construction duration was 11 weeks with construction completed one week before the Memorial Day Weekend, the traditional kick-off weekend for summer boating at Gloucester Harbor on Cape Ann.

2. Construction costs for both treads together were estimated to be $140,000. The contractor completed the work on a time and materials basis with total construction costs approximately 35% below the Engineer's Estimate. The detailed Engineer's Construction Cost Estimate is attached to this Appendix.

BLYNMAN CANAL BRIDGE
COST ESTIMATE
FOR REPLACEMENT OF TWO EXISTING TRACK GIRDER TREAD PLATES

DESCRIPTION			COST
MATERIALS:			
	STEEL PLATES FOR NEW TREAD PLATES ASTM A-514 GRADE Q		$3,760.00
	REPLACEMENT FASTENERS FOR NEW TREAD PLATES		$425.00
	SHIM STOCK, ASTM A588		$408.00
	GROUT MATERIALS		$1,768.00
	TENTED SHELTERS:	LUMBER	$544.00
		CANVAS	$612.00
		FASTENERS	$204.00
SUB-TOTAL (MATERIALS)			$7,721.00
SUB-CONTRACT:			
	PREPARATION OF IN-SITU IMPRESSIONS/MOLDS, DETAILED DRAWINGS		$11,100.00
	HEAT TREATMENT, MACH. & FINAL HEAT TREATMENT OF TREAD PLATES		$29,800.00
SUB-TOTAL (SUB-CONTRACT WORK)			$40,900.00
EQUIPMENT RENTAL COSTS:			
	IMPRESSION/MOLD RELATED FIELD WORK:	HEAT STRIPS (LOT)	$272.00
		SPACE HEATERS (2)	$136.00
		GENERATORS (2)	$340.00
		LIGHTS	$68.00
		MISCELLANEOUS	$68.00
		FUEL	$204.00
	FOR TREAD PLATE REPLACEMENT:	CRANE	$2,176.00
		COMPRESSORS (2)	$1,904.00
		WELDING MACHINES (2)	$952.00
		STEAM CLEANERS (2)	$816.00
		POWER GENERATORS (2)	$1,632.00
		FUEL	$240.00
SUB-TOTAL (EQUIPMENT RENTAL COSTS)			$8,808.00

COST ESTIMATE (Continued)

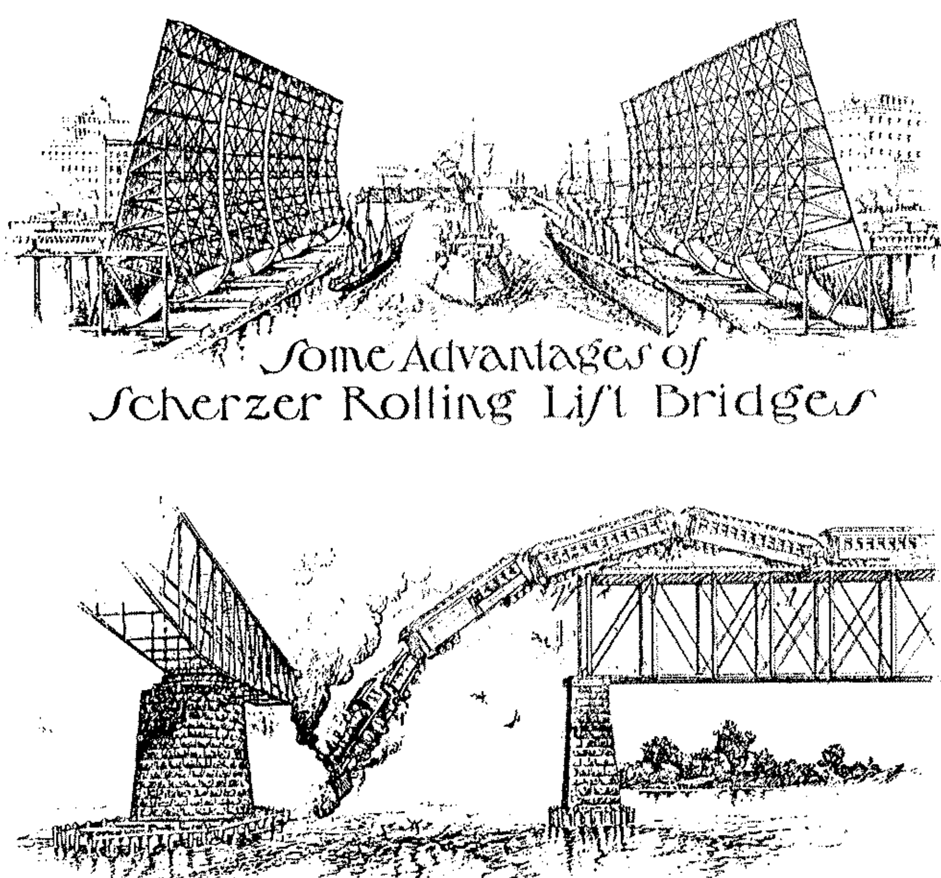
DESCRIPTION	COST
FIELD LABOR:	
ASSIST IMPRESSION/MOLD SUBCONTRACTOR WITH HEATED, TENTED SHELTERS & RELATED HEAT AND LIGHT REQUIREMENTS:	
154 MAN HOURS @ $45.00/HOUR	$6,930.00
TO INSTALL REPLACEMENT TREAD PLATES IN TWO LOCATIONS:	
865 MANHOURS @ $50.00/HOUR	$43,250.00
SUB-TOTAL (FIELD LABOR)	$50,180.00
PROJECT SUB TOTAL	$107,609.00
CONTRACTORS OVERHEAD AND PROFIT (1.3 x PROJECT SUB-TOTAL)	$139,891.70
SAY	$140,000.00

Mr. Paul Blair, P.E. is a Senior Associate of A. G. Lichtenstein & Associates, Inc. of Fairlawn, New Jersey. He is Branch Office Manager of the Massachusetts Office and has over 23 years of experience in the inspection, evaluation, design and construction of fixed and movable bridges, including new and rehabilitation projects. Mr. Blair is in responsible charge of many projects performing "on-call" inspection, maintenance repairs and rehabilitation of fixed and movable highway bridges. He is a member of ASCE and HMS.

We at Lichtenstein would like to thank Mr. Eric Johnson and the staff at Everett Pattern & Manufacturing, Inc. in Middleton, Massachusetts for their assistance in developing this procedure and for their craftsmanship and dedication in completing the detailed work involved in a timely manner. We also wish to congratulate the leadership and staff at the Massachusetts Highway Department for having the intestinal fortitude and foresight to implement this innovative solution to a complex and thorny problem.

DATE: 7 - 29 - 94	BRIDGE IDENTIFICATION: BLYNMAN CANAL BRIDGE G-5-2
PROJECT: 1585	FEATURE CARRIED: ROUTE 127
	FEATURE CROSSED: BLYNMAN CANAL AT ANNISQUAM RIVER
	LOCATION: GLOUCESTER, MASSACHUSETTS

FIGURE NO. 1



DESCRIPTION:

CATALOGUE ADVERTISEMENT OF THE SCHERZER ROLLING BASCULE BRIDGE COMPANY, CHICAGO, IL.

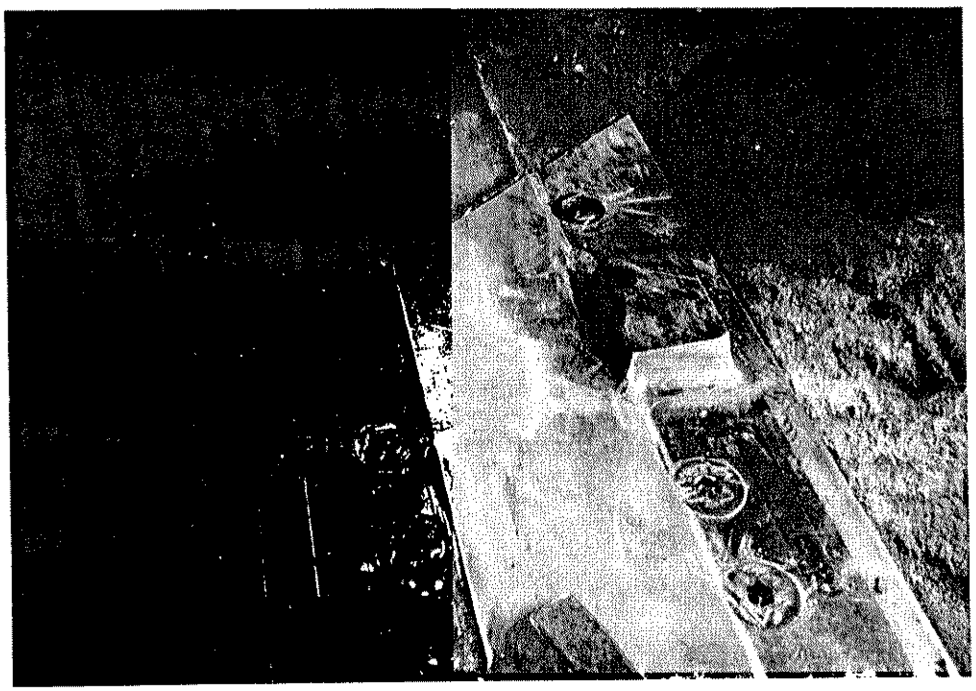
PHOTO NO. 1

DESCRIPTION:

SOUTH ELEVATION, BLYNMAN CANAL BRIDGE

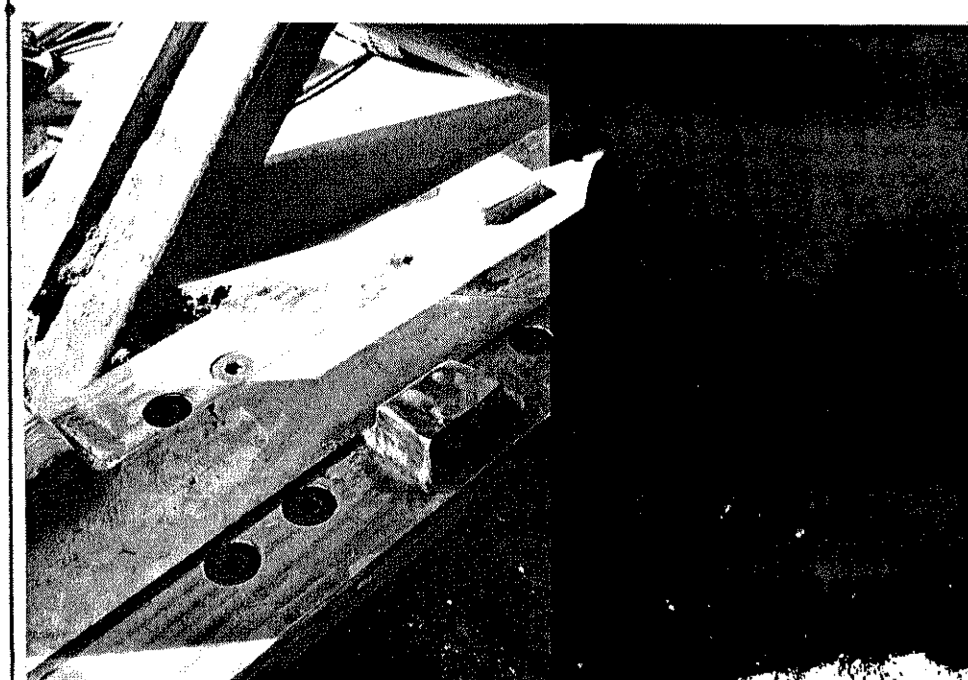
BRIDGE IDENTIFICATION:	BLYNMAN CANAL BRIDGE G-5-2
FEATURE CARRIED:	ROUTE 127
FEATURE CROSSED:	BLYNMAN CANAL AT ANNISQUAM RIVER
LOCATION:	GLOUCESTER, MASSACHUSETTS
DATE:	7 - 29 - 94
PROJECT:	1585

PHOTO NO. 8



DESCRIPTION:
MACHINED HALF SECTION OF NORTHEAST TREAD PLATE, HEEL END, WITH HOLES, FASTENED TO TRACK GIRDER

PHOTO NO. 9



DESCRIPTION:
FIT OF THE TWO HALF SECTIONS OF THE NORTHEAST TREAD PLATE, TOE SECTION IN THE FOREGROUND