CATEGORY II

NATIONAL EXPERIMENTAL AND EVALUATION PROGRAM

Construction and Monitoring of a Corrugated Galvanized Structural Plate Composite Pipe Arch in St. Johnsbury, Vermont

Project - St. Johnsbury RF F 041-4 (2)
US 5 over St. J & L.C. Railroad

Combined interim and final report

April 4, 1978

Vermont Agency of Transportation - Construction Division

TECHNICAL REPORT STANDARD TITLE PAGE

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FHWA-VT 78-C1		

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Vermont Agency of Transportation Construction Division Montpelier, Vermont 05602	11. Contract or Grant No. None
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12. Sponsoring Agency Name and Address	FINAL REPORT
Vermont Agency of Transportation Construction Division Montpelier, Vermont 05602	14. Sponsoring Agency Code

15. Supplementary Notes
Conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration

16. Abstract

This report evaluates the construction and monitors the behavior of a C.G.S.P. Composite Pipe Arch constructed on a ten degree curve. The structure appears to be performing the purpose intended. Movement has nearly stabilized in one year since construction. Future monitoring by walk-through inspections considered adequate.

17. Key Words	18. Distribution Statement
Pipes, Pipe Arch, Structural Plate, Composite Pipe Arch	No restrictions

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	24	

Form DOT F 1700.7 (8-69)

INDEX

INITIAL WORK PLAN

SUPER-SPAN

MOVEMENT CONTROL

Monitoring movement of any SUPER-SPAN is a necessity.

Before a structure can be monitored for changes, it must be measured in the first place. So, the number one rule is: Measure the basic structure dimensions, rise and span, including checking of alignment before backfilling begins. Exact tools and methods used to check movement may vary, but periodic checking is necessary during all backfilling. While this is primarily so the inspector will know the structure is not being distorted beyond acceptable limits, it is also useful in evaluating soil placement procedures and it provides a record which could prove helpful to future design decisions. It is also of great value should any problems develop later. Visual checking is good but should not be considered a substitute for directly measuring the structure.

Drawing 1005717, attached, shows suggested location and spacing of control hooks. It also shows typical size and make-up of a hook furnished as standard. Clip angles can be substituted for control hooks in some instances such as on low profile arches. However, experience indicates the larger hooks are easier to use on large, high structures. The method of measurement should be accurate to about the nearest 1/4".

On horizontal ellipses and low profile arches, vertical checking is often all that is necessary. However, if significant change is occurring, check span as well. Measurement at top of crown is most revealing on these shapes. For structures 23' span and over, hooks are provided in the thrust beam area. Heavy compaction outside the thrust beam can sometimes rotate the beam and measurements on those hooks can indicate flattening in the plates just above the beams.

Pear shapes and high profile arches tend to flatten on the sides during side

filling. Frequent span measurements are desirable here as well as the crown vertical measurements. In some instances on large pear shapes, it is necessary to string chord lines on the side plates and check mid-ordinate there. This will show immediately any flattening of sides.

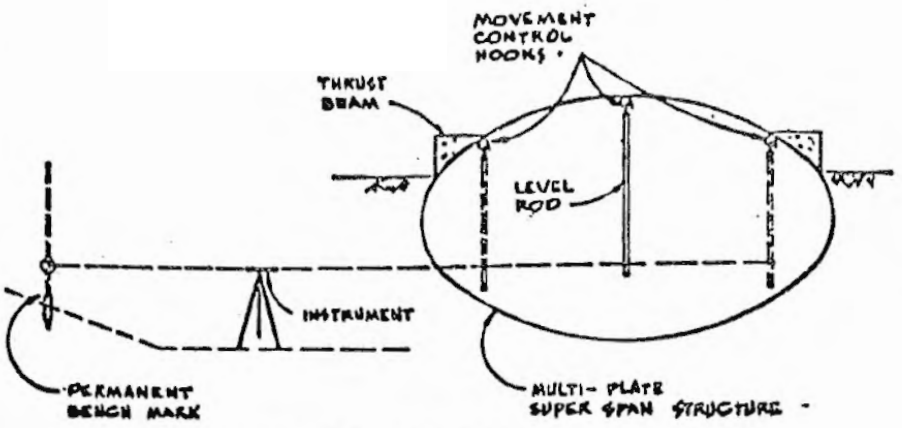
Tape measurements on spans are the easiest way to check that dimension. Vertical movement can be obtained by hanging plumb-bobs from the control hooks or by means of a surveyor's instrument and a rod or stick with hook on it. The bobs have the advantage of being nearly direct reading. The surveyor's instrument method has the advantage of being more accurate, is not subject to damage by stream flow, traffic through the structure or vandalism, and readings can be tied into a permanent bench mark for record purposes.

Frequency of measurement should vary with speed of backfilling operation as well as type of soil and size of compaction equipment used. Heavy continuous compaction will move a structure quickly. This might require measurement on every lift. Fine grained backfill may permit more live load from compaction effort to reach the structure sides and necessitates frequent checks. An extra heavy lift of fill can move the structure quickly. Readings should always be obtained at beginning and end of a shift. Measurements before and after pouring thrust beams can indicate problems from this operation. Always obtain a set of readings if the structure is to be left for any long period of time and always when the job is complete. Final measurements of all basic dimensions, including alignment shall be taken after completion of backfill.

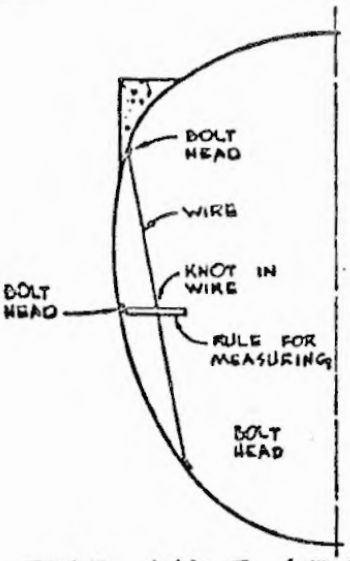
Control hooks can be removed or left in the structure at completion as desired. Most often they are left in place and can thus provide future means for easily checking movement.

Attached drawing 1005758 shows typical methods of monitoring that have worked well.

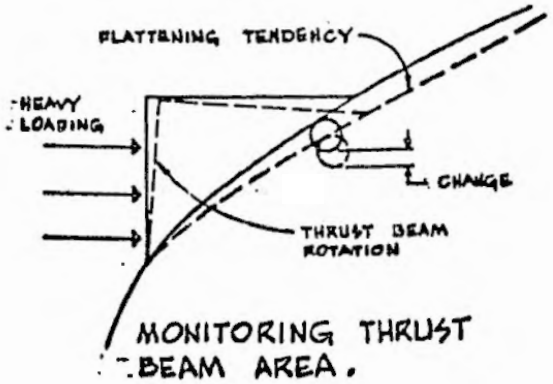
NOTE: ALWAYS MEASURE BASIC STRUCTURE DIMENSIONS BEFORE BACKFILLING AND AT COMPLETION OF JOB.



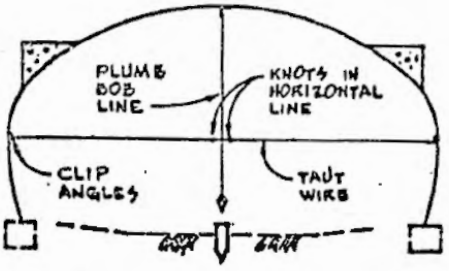
INSTRUMENT METHOD



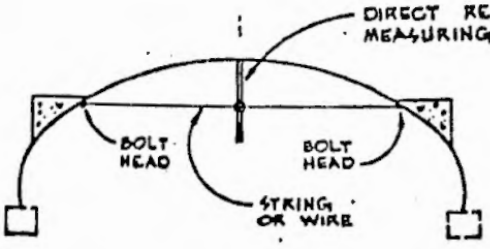
PEAR SHAPE SIDE MONITORING.



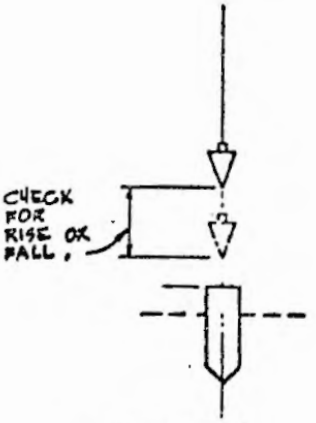
MONITORING THRUST BEAM AREA.



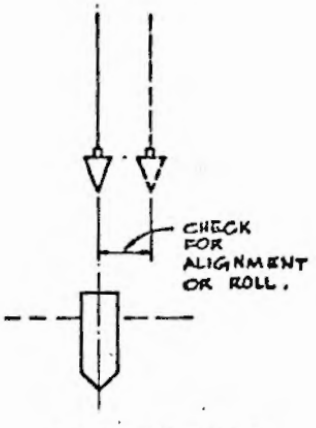
PLUMB-BOB METHOD



METHOD FOR MONITORING TOP ARCH MOVEMENT.



VERTICAL CHECK.



HORIZONTAL CHECK.

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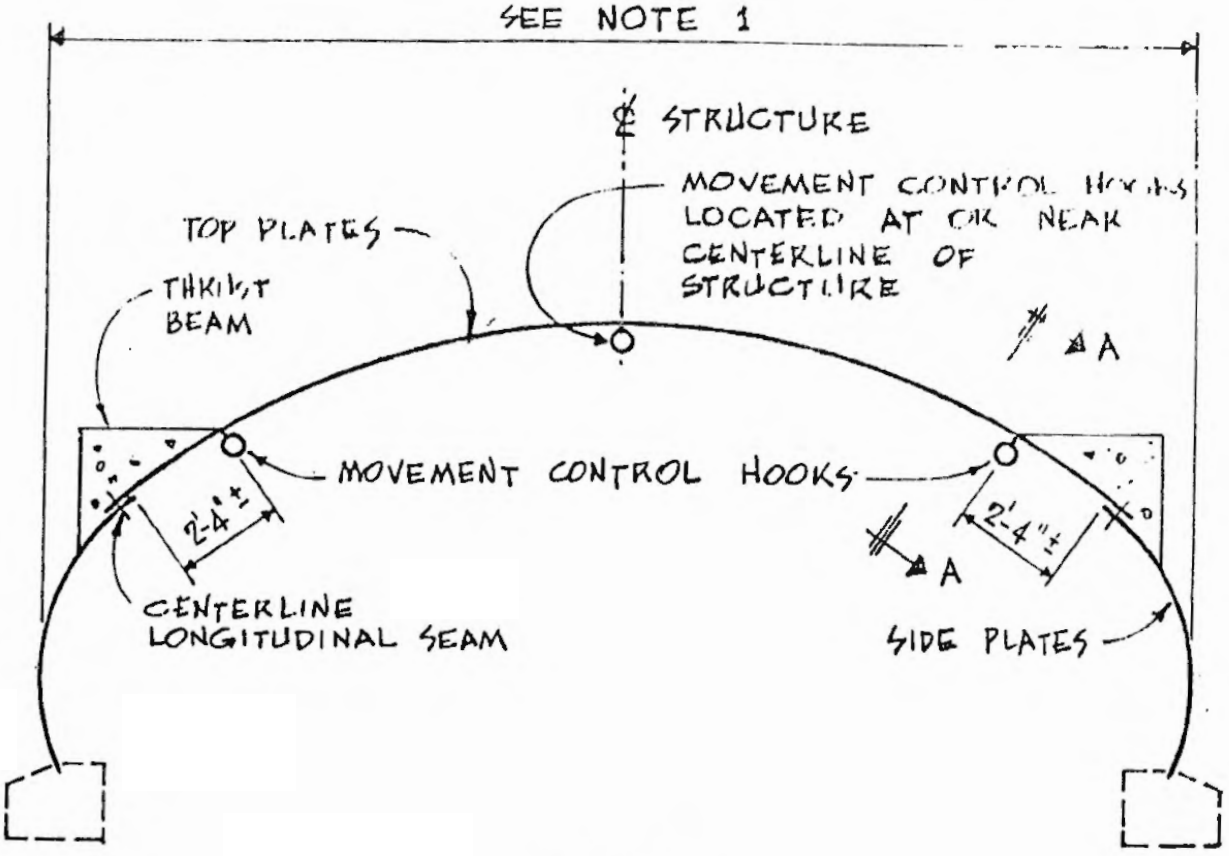
ARMCO Armco Steel Corporation
Metal Products Division
Middletown, Ohio 45042

MULTI-PLATE SUPER SPAN TYPICAL MONITORING IDEAS

NOV. 27, 1973 AS

1005758



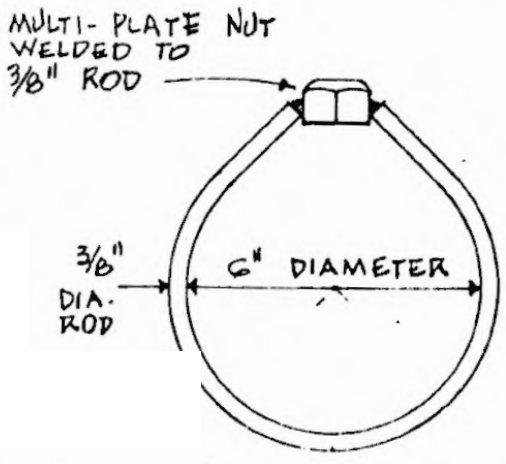
SECTION

ARCH SHAPE SHOWN, ALSO APPLIES TO HORIZ. ELLIPSE

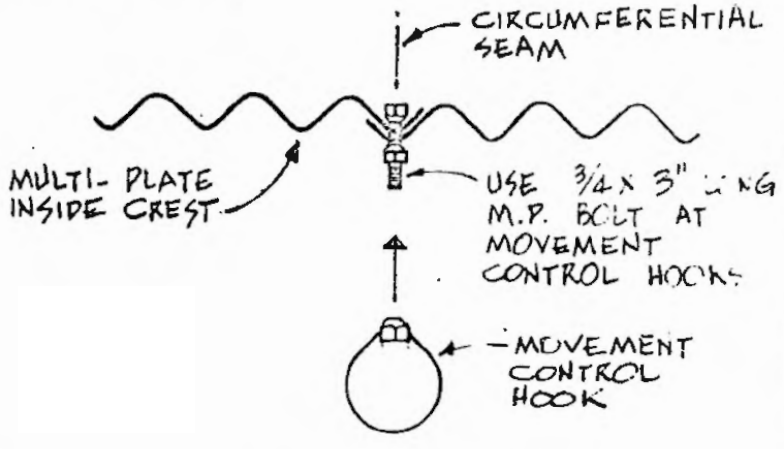
NOTES:

1). STRUCTURES WITH SPAN OF 23' OR SMALLER REQUIRE ONLY THE CENTER ROW OF MOVEMENT CONTROL HOOKS. STRUCTURES LARGER THAN 23' SPAN REQUIRE ALL 3 ROWS OF MOVEMENT CONTROL HOOKS.

2). MOVEMENT CONTROL HOOKS ARE LOCATED AS SHOWN ABOVE AND ON 10' OR 12' CENTERS (CIRCUMFERENTIAL SEAMS) FOR THE ENTIRE LENGTH OF THE STRUCTURE.



MOVEMENT CONTROL HOOK



SECTION A-A

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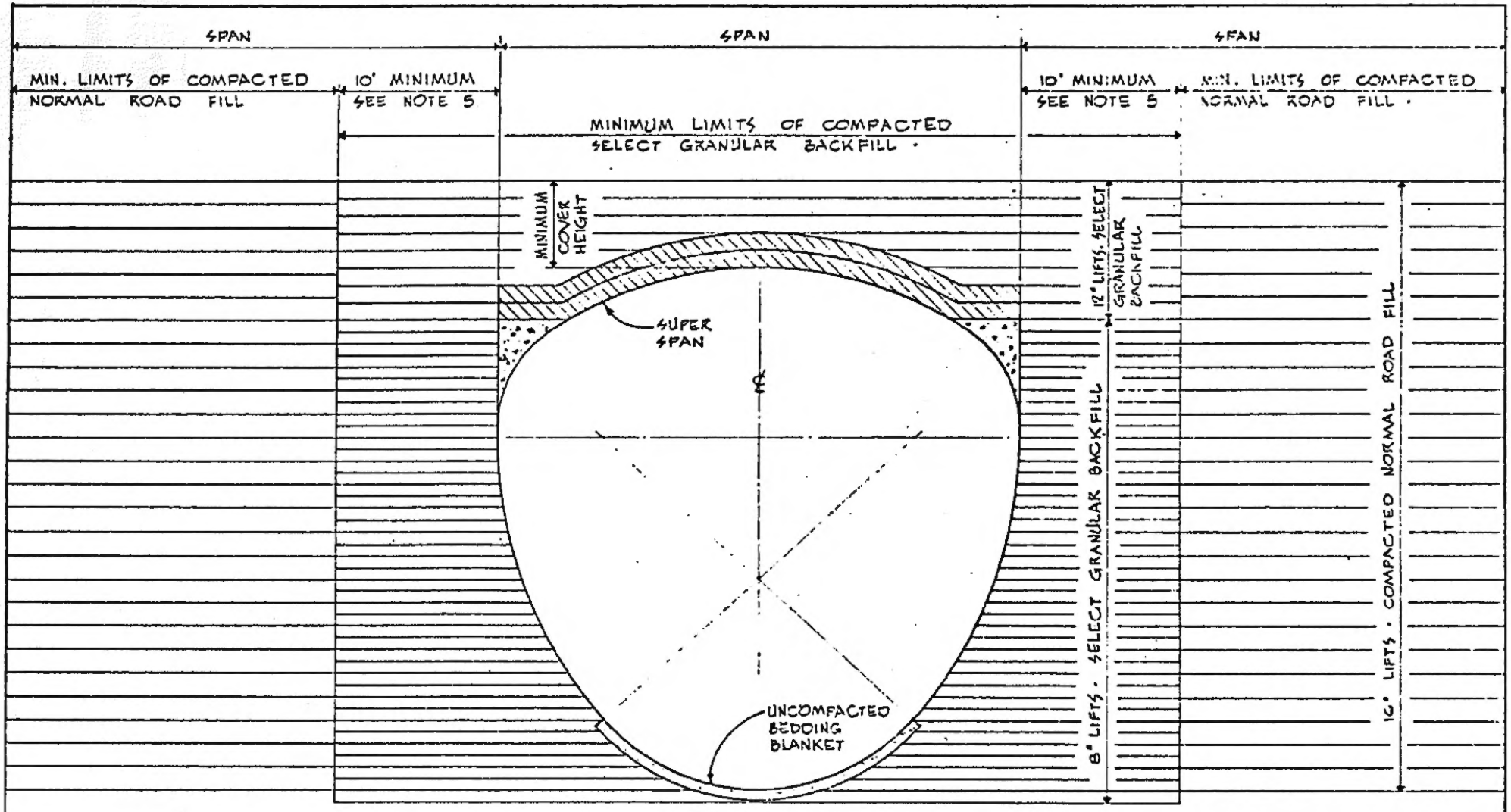
MULTI-PLATE SUPER SPAN
MOVEMENT CONTROL HOOK DETAIL

ARMCO Armco Steel Corporation
Metal Products Division
Middletown, Ohio 45042

DATE	DWG. NO.
10-19-73	1005717
REV.	

R. SCHOLLFIELD
CK.



SECTION

NOTES:

1). ALL BACKFILL, BOTH SELECT GRANULAR AND NORMAL ROAD FILL TO BE COMPACTED TO 90 PER CENT PER A.A.S.H.O. T-180.
2). COMPLETE AND CONTINUAL MONITORING OF THE SUPER SPAN SHAPE IS NECESSARY AT ALL TIMES.
3). DO NOT COMPACT THE SURFACE OF EACH LAYER OF BACKFILL AGAINST THE SIDE PLATES CLOSER THAN 2 FEET FROM THE PLATES.
4). PREVENT EXCESS DISTORTION OF SHAPE AS NECESSARY BY VARYING COMPACTION METHODS AND EQUIPMENT. "EXCESS DISTORTION" IS DEFINED AS CHANGE IN DESIGN DIMENSIONS IN EXCESS OF 2 PER CENT.
5). GREATER DISTANCE MAY BE REQUIRED. DISTANCE DEPENDS ON BEARING LOAD FOR ANY GIVEN LOADING, STRUCTURE SHAPE AND BACKFILL MATERIAL. SEE "EXCAVATION GUIDELINES SHEET".

NOTICE

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INITIAL LIFTS OVER CROWN OF STRUCTURE AS INDICATED BY SHADED AREA, ARE TO BE COMPACTED TO REQUIRED DENSITY WITH HAND OPERATED EQUIPMENT OR WITH SMALL TRACTOR (D-4 OR SMALLER) DRAWN EQUIPMENT.

ARMCO MULTI-PLATE SUPER SPAN TYPICAL BACKFILL PLAN

PEAR SHAPE

ARMCO Armco Steel Corporation

BACKFILL REQUIREMENTS FOR SUPER-SPAN

MATERIAL

A granular type of material shall be used around and over the structure. This select structural backfill material shall conform to one of the following classifications of Soil from A.A.S.H.O. Specification M-145, Table 2: A-1, A-3, A-2-4 or A-2-5.

Group Classification	A-1		A-3	A-2	
	A-1-a	A-1-b		A-2-4	A-2-5
Sieve Analysis, Percent Passing:					
No. 10 (2.00 mm)	50 Max.	--	--	--	--
No. 40 (0.425 mm)	30 Max.	50 Max.	51 Min.	--	--
No. 200 (0.075 mm)	15 Max.	25 Max.	10 Max.	35 Max.	35 Max.
Characteristics of Fraction Passing No. 40 (0.425 mm)					
Liquid Limit	--		--	40 Max.	41 Min.
Plasticity Index	6 Max.		N.P.	10 Max.	10 Max.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand	

The extent of the structural backfill required is a function of several variables. Design of these limits is an individual job item and shall be in accord with the latest Design Practice issued by Headquarters Engineering.

PLACEMENT

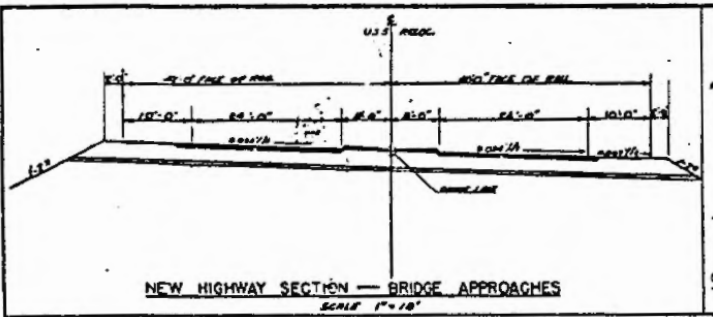
1. Backfill material shall be placed in horizontal, uniform layers not exceeding 8" in thickness, before compaction, and shall be brought up uniformly on both sides of the structure. Each layer of backfill shall be compacted to a relative compaction of not less than 90%, per A.A.S.H.O. Test Method No. T-180.

2. Compaction equipment or methods that produce horizontal or vertical earth pressures which cause excessive distortion or damage to structures shall not be used.

MANUFACTURER'S INSPECTION

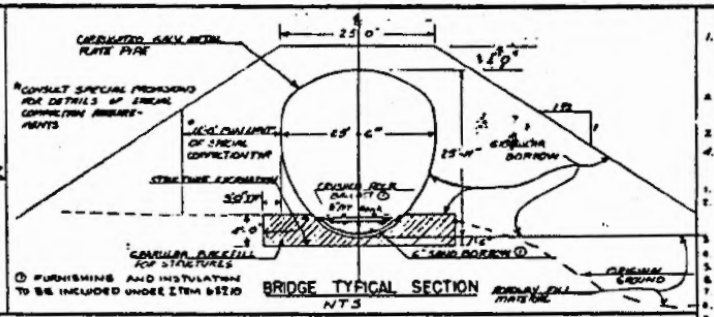
The manufacturer shall provide inspection of all backfilling. Said inspector must approve all backfill materials and the placement and compaction thereof, and shall have full authority to stop such work. The engineer (or owner, or contractor) shall provide field density tests of the compacted backfill and suitable survey control on the structure to check structure movement, as directed by the manufacturer's inspector.

October 11, 1973



NEW HIGHWAY SECTION — BRIDGE APPROACHES

SCALE 1"=10'



BRIDGE TYPICAL SECTION

NTS

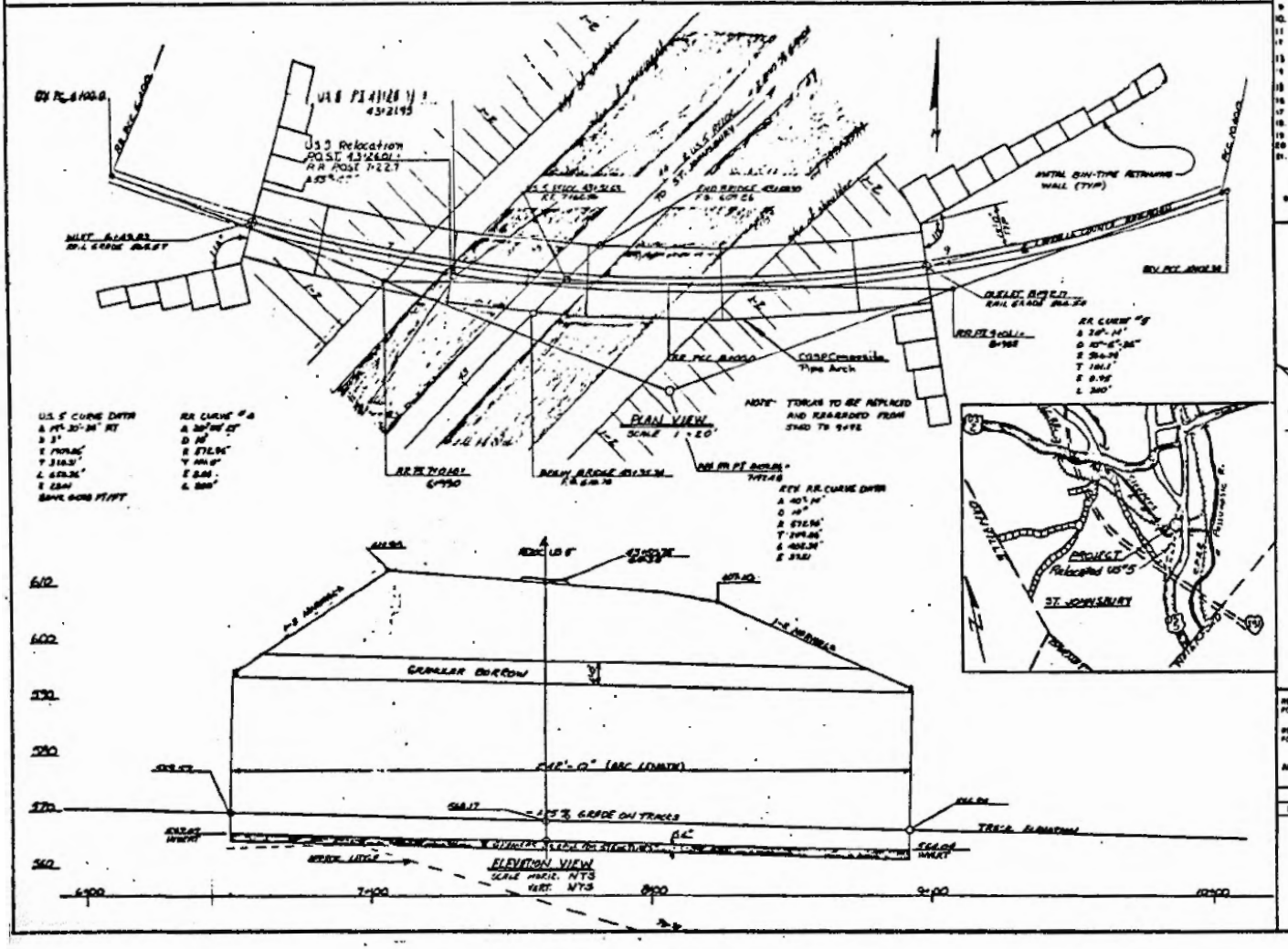
NOTES

1. ALL MATERIALS AND LABOR INVOLVED IN THE REMOVAL OF THE RAILROAD TIES AND RAILROAD BED TO SUBGRADE AND THE PLACING OF ONE FOOT OF NEW BALLAST BETWEEN RAILROAD TRACKS STA 5+70 AND 9+92 AND ALL MATERIALS AND LABOR INVOLVED IN ANY P.R. BEFORE SHALL BE MEASURED UNDER ITEM 633.10 MAINTENANCE OF TRAFFIC FOR BRIDGE PROJECTS (MODIFIED).
2. IT IS INTENDED THAT THE STRUCTURE BE CONSTRUCTED IN SEQUENTIAL UNITS WITH A MAXIMUM LENGTH OF 50 FT AND TO FIT THE CLEARANCES SHOWN.
3. CENTER LINE OF PIPE SHALL BE ADJUSTED 9 INCHES TO THE LEFT OF THE P.I. 10° CURVE AT THE INTERSECTION OF MAIN SEC.
4. SEE BRIDGE SHEET 10-A FOR INDEX OF SHEETS

NEW STRUCTURE

1. RECOMMENDED TYPE OF STRUCTURE CORRUGATED GALV. STRUCTURAL PLATE CARBONIZED PIPE ARCH RAILROAD UNDERPASS
2. RECOMMENDED OVERALL STRUCTURE LENGTH 64'-0" FEET
   CLEAR SPAN LENGTH(S) NORMAL TO STREAM 23'-6"
   SPAN LENGTH(S) CENTER TO CENTER OF BEARINGS N/A
3. ARE THERE OBJECTIONS TO A PIER IN THE STREAM? YES ___ NO N/A
4. DOES STREAM REACH ITS MAXIMUM HIGH WATER ELEVATION RAPIDLY? N/A IS ORDINARY RISE RAPID? ___
5. NATURE OF NATURAL STREAMBED: N/A
6. EST. SCOUR DEPTH N/A COMMENT ON: DRIFT ___ ICE ___
7. DRAINAGE AREA IN ACRES N/A CHARACTER OF TERRAIN ___
8. VELOCITY OF STREAM AT DESIGN STAGE N/A DESIGN DISCHARGE Q 50 = ___
9. IS ALL WATER INTENDED TO PASS THROUGH NEW STRUCTURE? N/A AREA FULL OPENING ___
10. ORDINARY HIGH WATER ELEVATION AT NEW STRUCTURE N/A
11. DESIGN HIGH WATER ELEVATION AT NEW STRUCTURE N/A (SOURCE OF INFORMATION) ___
12. VERTICAL CLEARANCE ABOVE [illegible] ___ FT. IN AREA ___ FT. IN SPAN
13. CHECK DISCHARGE = 1.5 X DESIGN DISCHARGE N/A CHECK DISCHARGE WATER SURFACE ELEV. ___
14. ALLOWABLE WATER SURFACE ELEVATION N/A FREEBOARD ___
15. IS DESIGN BEING AFFECTED BY DOWNSTREAM CONDITIONS? N/A IF YES - DESCRIBE ___
16. ARE SIDEWALKS REQUIRED? YES IF SO ON WHAT SIDE? LEFT CLEAR WIDTH 4'-0"
17. TRAFFIC TO BE MAINTAINED UNDER ITEM NO N/A ONE OR TWO WAYS ___ ESTIMATED COST ___
18. PROVISIONS TO BE MADE FOR PUBLIC UTILITIES NO
19. ESTIMATED ALLOWABLE LOAD FOR BIN WALLS 4 K.S.F. DESIGN MAX FOOTING PRESSURE ___
20. PILING DESIGN LOAD N/A ESTIMATED LENGTH N/A TYPE N/A
21. DESIGN SPECIFICATIONS:

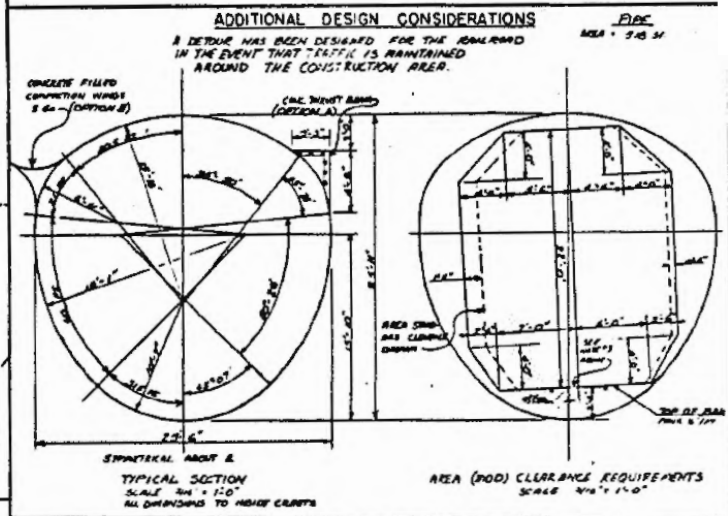
DESIGN LOAD	ALLOWABLE STRESSES			
	STRUCTURAL STEEL:		REINFORCING STEEL:	CONCRETE:
A.A.S.H.O. M 183-44	TENSION		TENSION 24 KSI	f'_c 3.5 KSI
* SEE HIGHWAY STANDARD	COMPRESSION		COMPRESSION 20 KSI	f_c 1.4 f'_c KSI



① FURNISHING AND INSTALLATION TO BE INCLUDED UNDER ITEM 652.10

ADDITIONAL DESIGN CONSIDERATIONS

A DETOUR HAS BEEN DESIGNED FOR THE RAILROAD IN THE EVENT THAT TRAFFIC IS MAINTAINED AROUND THE CONSTRUCTION AREA.



RECOMMENDED FOR APPROVAL: W.M. Smith, BRIDGE ENGINEER, 2-20-75 DATE

RECOMMENDED FOR APPROVAL: Lawrence Jones, ASSISTANT CHIEF ENGINEER, 2-21-75 DATE

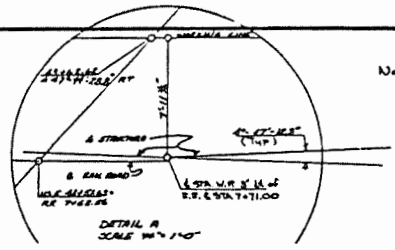
APPROVED BY: R.O. Munroe, CHIEF ENGINEER, 2-21-75 DATE

NO.	REVISIONS DESCRIPTION	BY & DATE

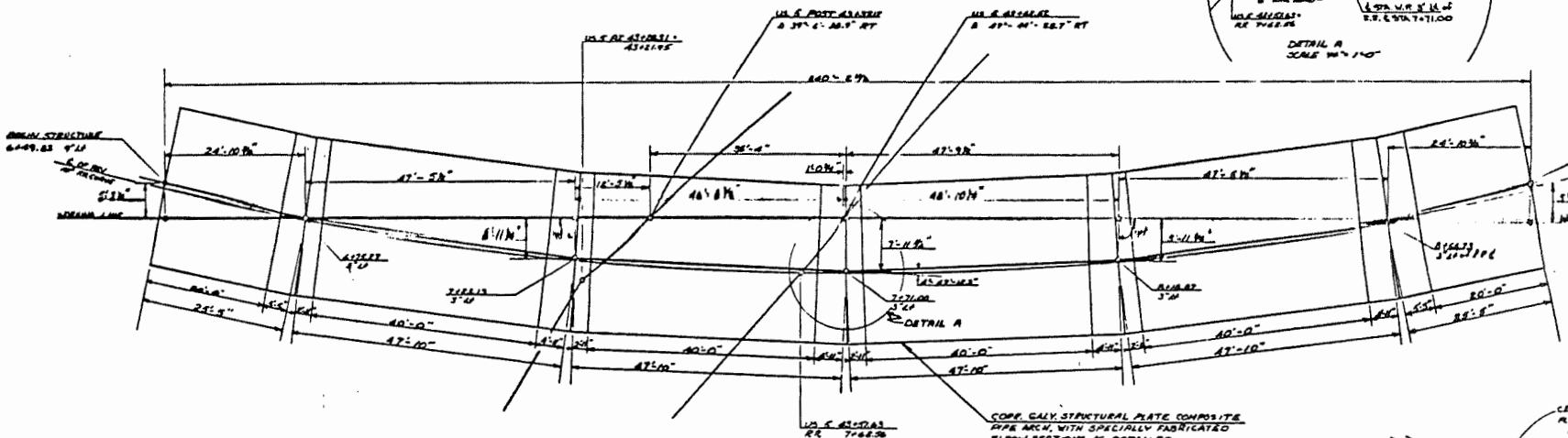
STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

TOWN OF ST JOHNSBURY	Bridge No. ___ Log Sta. ___
HIGHWAY NO US 5 RELOCATION	Sheet Sta. 43-31
US 5 OVER LAMOILLE COUNTY RAILROAD	
PRELIMINARY INFORMATION	
Designed by W. STODDARD	Drawn by W. STODDARD
Checked by J. BURNETT date 2-20-75	Bridge Design Supervisor R.S. HAUPT date 2-20-75
PROJECT ST. JOHNSBURY	PROJECT NO. R FF 041-1(2)
Bridge Sheet No BR 100	Sheet 26 of 136

NOTE: THE PLAN VIEW SHOWN IS AN APPROVED SEGMENTAL LAYOUT WITH SHOP FABRICATED ELBOWS, AND LAYOUT GEOMETERY FOR THE COMPOSITE PIPE ARCH WHICH WILL MEET THE ALIGNMENT AND CLEARANCE REQUIREMENTS NECCESARY FOR THE RAILROAD. THE FABRICATOR AT HIS OPTION MAY SUBMIT FOR REVIEW AND APPROVAL ANY ALTERNATE SCHEME PROVIDING IT CONFORMS WITH THE DETAILS SHOWN ON THESE PLANS AND THE PROVISIONS SET FORTH IN THE CONTRACT.

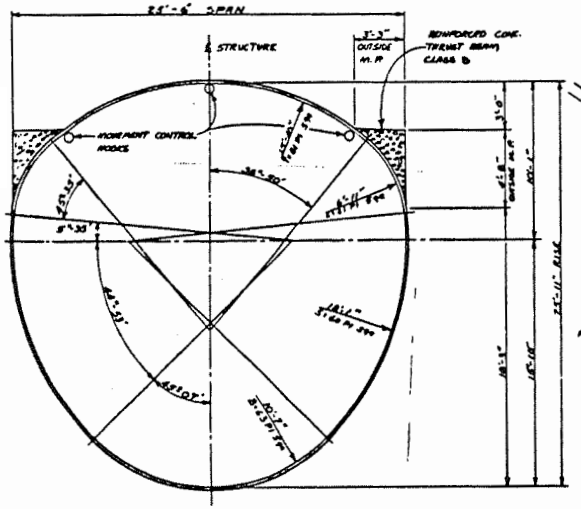


Note: (Applicable to both option 'A' and 'B')
All concrete shall be placed in accordance with section 601.10 "Placing Concrete" (including vibrating) with a maximum slump of 4 inches.



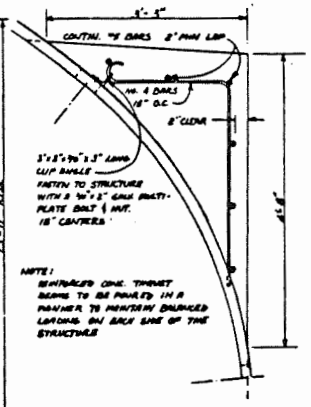
PLAN VIEW
SCALE 1" = 10'-0"

Note: Under option 'B' the entire compaction wing assembly, on both side shall be erected complete in place prior to placement of any concrete. The 7/8" holes in the top plate of the compaction wings are provided to insure complete filling of the void with concrete. It is intended that concrete placed in the compaction wings be pumped into the voided section.

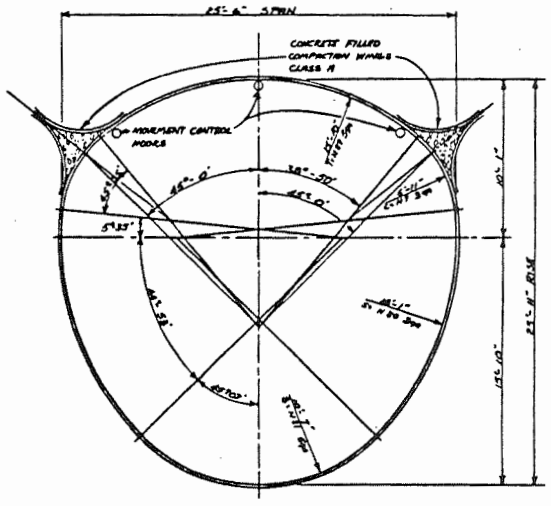


SECTION THRU BARREL OPTION "A"
SCALE 1/4" = 1'-0"
ALL DIMENSIONS TO INSIDE CARRIES

(OPTION 'A' CONFORMS WITH THE REQUIREMENTS OF U.S. PATENT NO. 3508406)

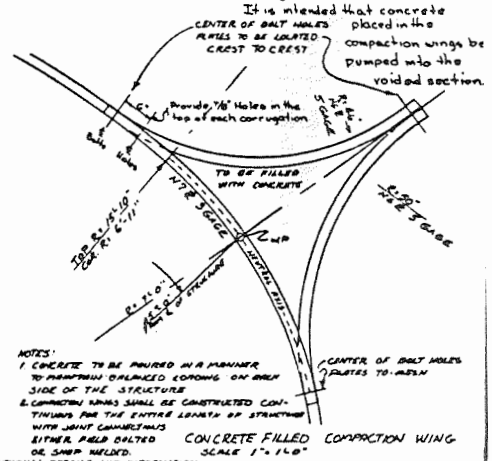


THRUST BEAM DETAILS
SCALE 1" = 1'-0"



SECTION THRU BARREL OPTION "B"
SCALE 1/4" = 1'-0"
ALL DIMENSIONS TO INSIDE CARRIES

(OPTION "B" IS AN APPROVED EQUIVALENT TO THE REQUIREMENTS OF U.S. PATENT NO. 3508406)



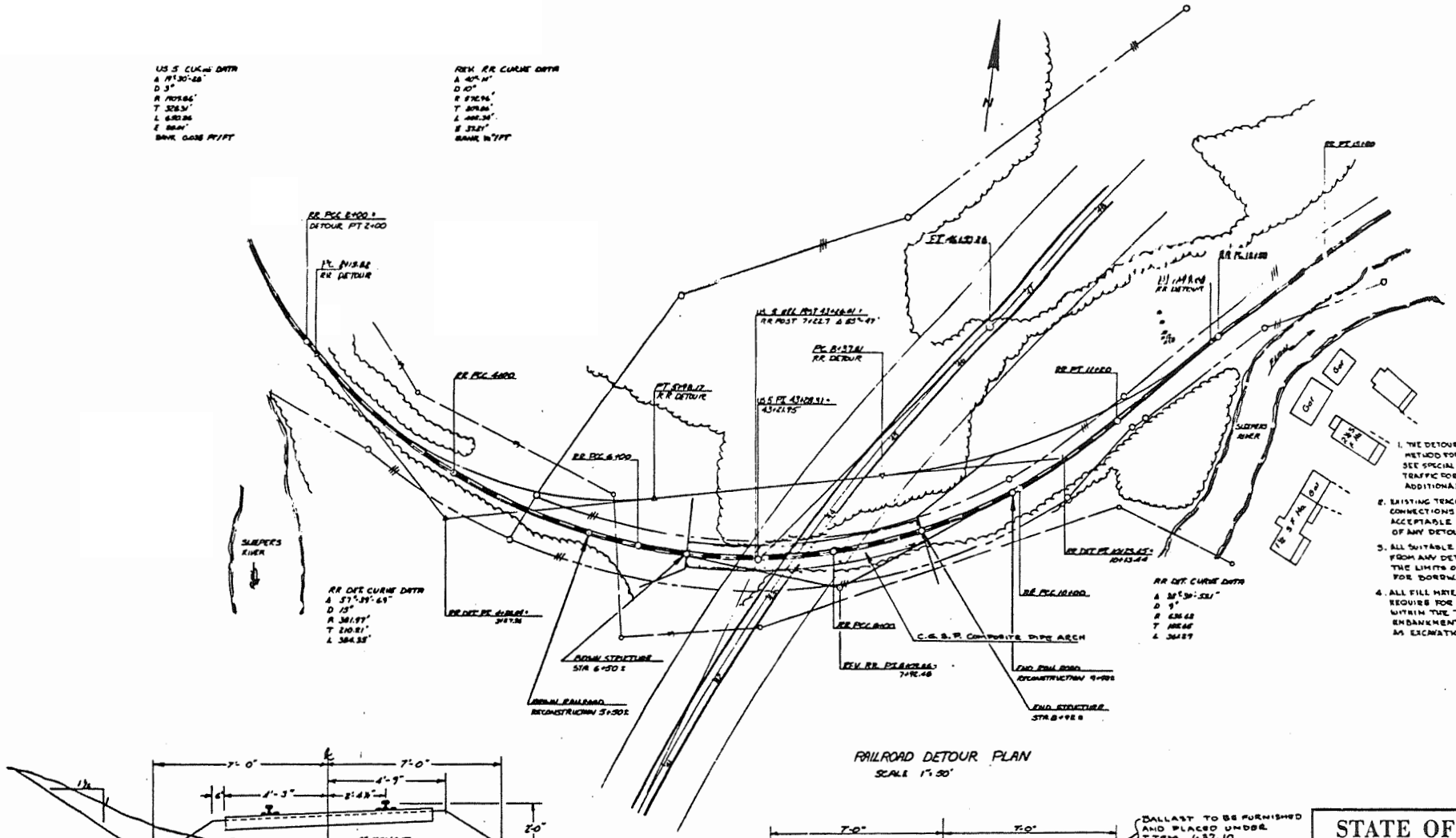
NOTES:
1. CONCRETE TO BE POURED IN A MANNER TO MAINTAIN BALANCED LOADING ON EACH SIDE OF THE STRUCTURE
2. COMPACTION WINGS SHALL BE CONSTRUCTED CONTINUOUS FOR THE ENTIRE LENGTH OF STRUCTURE WITH JOINT CIRCUMFERENTIAL EITHER FIELD BOLTED OR SHOP WELDED.
3. ADDITIONAL DETAILS AND INFORMATION SHALL BE INCLUDED IN THE FABRICATORS SHOP DRAWINGS.

CONCRETE FILLED COMPACTION WING
SCALE 1" = 1'-0"

T = TOP PLATES
C = CORNER PLATES
S = SIDE PLATES
B = BOTTOM PLATES

STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

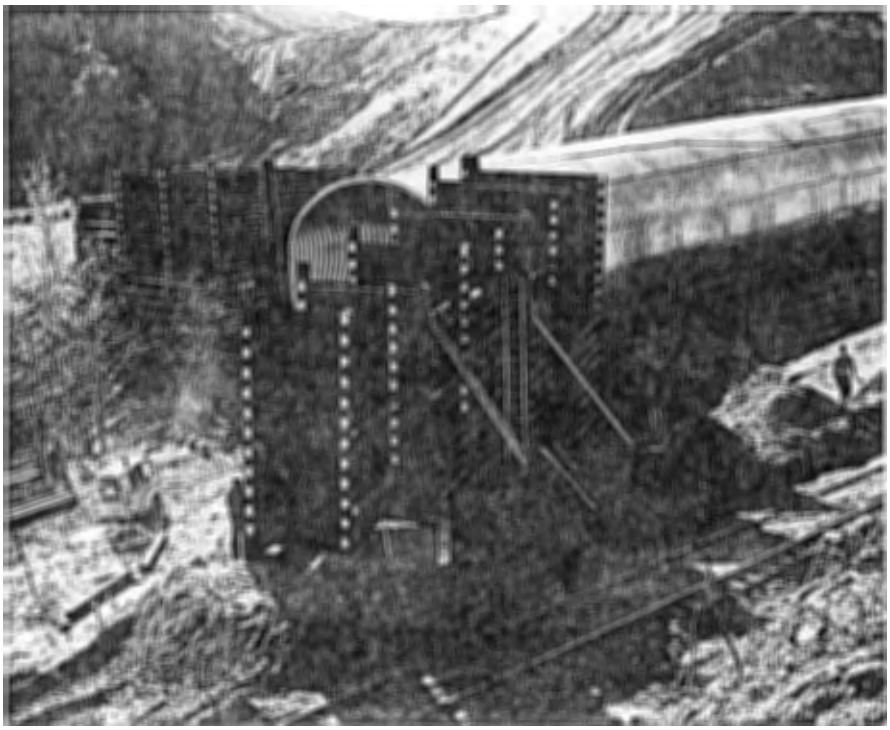
TOWN OF ST JOHNSBURY	Bridge No.
HIGHWAY NO. US 5 RELOCATION	Log Sta.
	Surv. Sta. 43+51
US 5 OVER LAMOIL COUNTY RAIL ROAD	
LAY OUT & FABRICATION DETAILS	
Designed by W STODDARD	Drawn by W STODDARD
Checked by W FELTON date 4/76	Bridge Design Supervisor R.S. HAUPT date 7/19/77
PROJECT ST. JOHNSBURY	PROJECT NO. RFF 041-4(62)
Bridge Sheet No. DR 10b	Sheet 32 of 136



STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

TOWN OF ST JOHNSBURY	Bridge No.
HIGHWAY NO. U.S. 5 RELOC.	Log No. Sum. Sta. 43+51
U.S. 5 OVER LAMOILLE COUNTY RAIL ROAD	
RAILROAD DETOUR	
Designed by W. STODDARD	Drawn by W. STODDARD
Checked by J.F. BURNETT date 4-29-75	Bridge Design Supervisor R.S. HAJIFT date JAN 75
PROJECT ST JOHNSBURY	PROJECT NO. RFF 041-1(2)
Bridge Sheet No. BR 101	Sheet 33 of 136

Plate Assembly

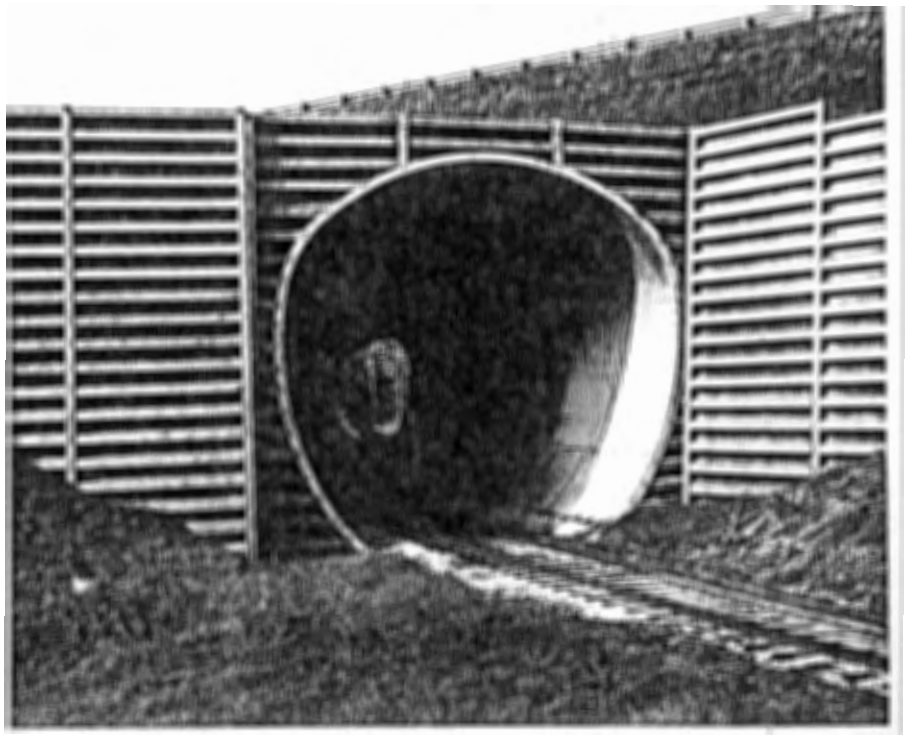


Bin Type Retaining Wall

Binwall Backfilled

Concrete Thrust Beam

Backfilling



Structure Completed

INITIAL REPORT

PROJECT

State of Vermont, Department of Highways
R FF 041-4(2)
Relocation U. S. Route 5 over
Lamoille County Railroad
St. Johnsbury, Vermont

PHYSICAL CHARACTERISTICS

Armco SUPER-SPAN Pear Shape #81P21-60-66
Span 25'6", Rise 26'2", Length 242'
Plate Gage: Top .218"
Corner .218"
Side .249"
Bottom .218"
Top Plate Make-up:
24 @ 10'
1 @ 12'
24 circumferential seams in top section of structure

SHAPE MONITORING DEVICES

Located on each circumferential seam of the top section were three movement control rings.

The ring closest to the top centerline was located on an existing circumferential bolt 3 7/8" north of the theoretical top centerline. This ring was used in monitoring the rise measurement.

Each of the side movement control rings were located on an existing circumferential bolt located approximately 2'4" above the top/corner seam. These rings were used to monitor the effects of the weight of the concrete thrust beams on the crown plates. The side rings were also used to keep the inspector aware of any excessive backfilling efforts that might have caused the thrust beams to rotate, thus flattening and/or peaking the crown section of the structure.

On each side circumferential seam and on each side of the structure, a taut wire was stretched from the corner/side seam to the side/bottom seam. This wire established a chord across the side plates. At about mid-way of the side plate arc, an aluminum angle iron was attached to a bolt head in such a manner that the angle iron probe extended from the side plate to beyond and perpendicular to the chord wire. To this mid ordinate probe a 3/4" bright red tape was attached at the point where the wire intersected the probe. The tape was a visual aid and indicated zero movement at the beginning of the backfill operation.

SHAPE MONITORING

All during the operation of backfilling the Armco SUPER-SPAN structure, constant visual checks were made through the inside, looking for flattening plates, movement of mid ordinate probes and any other action taking place at the instant.

Actual measurements were taken to determine the rise at eleven instances between backfill elevation zero and 31 feet (5 feet over crown). It was desirable to maintain all movement within 2% of the design rise (26'2").

At least once every A.M. and P.M., the wires across the side plates were checked for tautness and the extent that the wire had moved across the 3/4" tape mark on the probe.

On four occasions, measurements were taken from the side rings to the bolt head in the valley next right of the circumferential seam at the side/bottom seam. This measurement was taken only to establish relative movement and not necessarily be a specific distance. Measurements were taken at zero backfill, just before the thrust beams were poured, just after the thrust beams were poured, and at backfill 5' over the crown.

SUMMARY

As anticipated, the rise of the structure increased during the installation of the backfill. This increase 0.24' was well within the desired tolerance with the resulting rise within .03' (3/8") of design. The structure maintained a very uniform shape throughout the backfilling process.

Relative measurements of the side rings indicated very normal action.

The side plate monitoring indicated that the flattening that occurred was less than 3/4" change in the mid ordinate.

With five feet of cover compacted over the crown of the structure, all types of construction equipment successfully crossed without noticeable stress or flexing of the top plates.

From all observations made, this structure is in excellent geometrical shape throughout and has been installed in the recommended manner.

Backfill was a granular borrow type of excellent quality, and was installed in the prescribed 6" lifts. To insure constant performance, a total of 163 field density tests were made during this installation. Any tests that failed, additional effort in compaction was exerted and a retest was made. A Troxler nuclear device was used to test the soil density. The density ranged from 90% to 95% Modified Proctor.

Backfill was completed 5' over the crown of the structure on November 19, 1975.

RISE AT CENTERLINE

WEST END SEAM	No backfill 10/22/75	@ 6' 10/24/75	@ 9' 10/27/75	@ 12' 10/28/75	@ 14' 10/29/75	@ 18'-2" Bottom T.B. 10/30/75	@ 18'-2" Bottom T.B. 11/12/75	@ 21'-5" 11/14/75	@ 23'-2" Top of T.B. 11/17/75	@ 29' 11/18/75	@ 31' 11/19/75
1	25.82	25.83	25.83	25.84	25.83	25.60*	25.78**	25.82	25.84	25.83	25.83
2	25.75	25.72	25.72	25.76	25.73	25.59	25.81	25.83	25.85	25.87	25.84
3	25.79	25.75	25.82	25.81	25.79	25.70	25.87	25.91	25.95	25.98	25.96
4	25.89	25.88	25.86	25.91	25.90	25.74	26.04	26.00	26.08	26.14	26.10
5	25.92	25.92	25.91	25.90	25.92	25.86	26.07	26.09	26.12	26.19	26.16
6	25.90	25.92	25.86	25.91	25.91	25.95	26.08	26.07	26.12	26.15	26.12
7	25.91	25.95	25.86	25.86	25.93	25.96	26.06	26.09	26.09	26.12	26.10
8	25.91	25.92	25.92	25.92	26.07	25.98	26.10	26.13	26.15	26.21	26.20
9	-	25.97	25.92	26.01	26.00	26.09	26.18	26.20	26.27	26.27	26.28
10	25.83	25.87	25.86	26.07	26.04	26.22	26.19	26.20	26.22	26.27	26.27
11	25.93	25.91	25.93	25.97	26.00	26.12	26.16	26.17	26.20	26.27	26.27
12	25.81	25.82	25.75	25.78	25.84	25.98	26.00	25.98	26.06	26.09	26.06
13	25.76	25.79	25.76	25.80	25.98	26.02	26.03	26.02	26.11	26.12	26.10
14	25.77	25.71	25.78	25.83	25.98	26.03	26.01	26.01	26.07	26.11	26.10
15	25.84	25.85	25.91	25.89	25.98	26.13	26.18	26.14	26.18	26.24	26.23
16	25.95	25.94	25.96	26.00	26.03	26.13	26.21	26.19	26.24	26.28	26.24
17	25.93	25.92	25.92	25.94	26.01	26.11	26.16	26.16	26.18	26.25	26.20
18	25.94	25.93	25.95	25.95	26.04	26.13	26.17	26.17	26.21	26.24	26.22
19	26.02	26.02	25.97	26.01	26.05	26.14	26.17	26.18	26.23	26.25	26.25
20	26.05	26.02	26.02	26.02	26.10	26.18	26.20	26.18	26.24	26.31	26.28
21	26.03	25.94	26.02	26.05	26.09	26.16	-	-	-	-	-
22	25.92	25.85	25.95	25.96	25.98	26.03	26.08	26.10	26.17	26.20	26.12
23	25.96	25.83	25.97	26.01	26.02	26.03	26.08	26.12	26.13	26.16	26.14
24	25.99	25.87	26.00	26.01	26.02	26.00	26.06	26.10	26.12	26.12	26.14
EAST END	Average 25.90	25.88	25.89	25.93	26.00	26.00	26.07	26.08	26.12	26.16	26.14

* Measurements taken before thrust beams constructed.
** Measurements taken after thrust beams constructed.

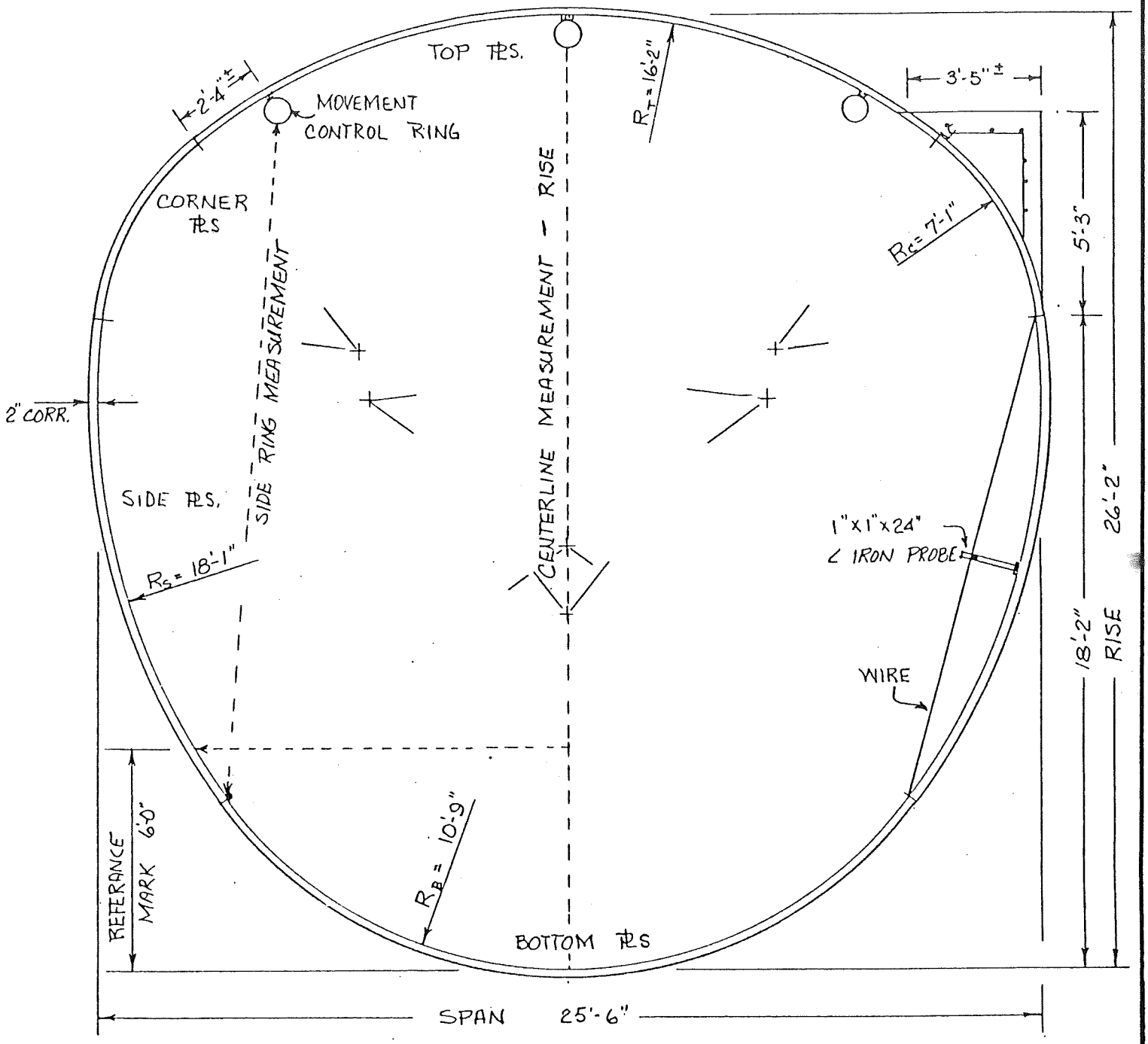
DESIGN RISE 26'-2" = 26.17'
2% = .52' = 6.25"

\+ Tolerance - 26.69'
\- Tolerance - 25.65'

SIDE RING MEASUREMENTS

	NORTH RING					SOUTH RING				
	A	B	C	D	E	A	B	C	D	E
1	-	19.63	19.77	19.79	19.76	-	19.45	19.53	19.55	19.54
2	-	19.82	19.88	20.00	19.98	-	19.49	19.56	19.58	19.57
3	19.84	19.75	19.91	19.93	19.92	-	19.50	19.60	19.62	19.62
4	19.89	19.87	20.00	20.02	20.00	-	19.56	19.59	19.61	19.61
5	19.98	20.03	20.12	20.15	20.12	-	19.67	19.70	19.72	19.71
6	20.05	20.02	20.19	20.21	20.21	-	19.66	19.65	19.66	19.65
7	20.03	20.02	20.18	20.20	20.19	-	19.66	19.62	19.64	19.62
8	20.00	20.14	20.18	20.20	20.19	-	19.67	19.62	19.64	19.61
9	19.98	20.11	20.14	20.15	20.13	19.60	19.72	19.65	19.67	19.65
10	19.89	20.03	20.07	20.09	20.08	19.66	19.76	19.70	19.72	19.65
11	19.78	19.92	19.94	19.95	19.94	19.63	19.76	19.72	19.72	19.71
12	19.86	19.99	20.04	20.06	20.05	19.52	19.65	19.60	19.62	19.60
13	19.72	19.87	19.93	20.95	19.95	19.52	19.69	19.68	19.68	19.66
14	19.85	19.99	20.05	20.07	20.06	19.47	19.65	19.65	19.67	19.65
15	19.90	20.05	20.08	20.15	20.13	19.52	19.70	19.65	19.66	19.65
16	19.79	19.95	19.99	20.01	19.99	19.61	19.77	19.73	19.75	19.74
17	19.84	19.98	20.01	20.23	20.01	19,72	19.88	19.84	19.85	19.86
18	19.82	19.95	19.99	20.03	20.00	19.82	19.95	19.90	19.92	19.94
19	19.84	19.96	19.98	19.99	19.97	19.72	19.85	19.81	19.83	19.84
20	19.88	19.97	20.00	20.02	19.99	19.67	19.78	19.76	19.78	19.80
21	19.90	19.97	20.00	20.01	19.98	19.76	19.83	19.79	19.82	19.84
22	19.89	19.95	19.98	20.05	19.97	19.73	19.80	19.79	19.81	19.82
23	19.87	19.91	19.94	19.96	19.92	19.75	19.80	19.78	19.80	19.81
24	19.68	19.83	19.86	19.89	19.86	19.82	19.69	19.66	19.69	19.70
Avg	**19.87**	**19.94**	**20.00**	**20.08**	**20.01**	**19.65**	**19.70**	**19.69**	**19.70**	**19.70**

A = 10/23/75 No backfill
B = 10/30/75 Backfill at bottom of thrust beams - before pour
C = 11/12/75 Backfill at bottom of thrust beams - after pour
D = 11/17/75 Backfill at top of thrust beams
E = Backfill at 5' over crown of structure



CROSS SECTION OF SUPER SPAN
SHOWING LOCATION OF SHAPE MONITORING
DEVICES AND MEASUREMENT LOCATIONS

DRAWN 12-5-75	ARMCO MULTI-PLATE SUPER SPAN	SCALE —
BY JEG	S.G. PHILLIPS CO., ST. JOHNSBURY, VERMONT	ORDER NO.
REVISED	VERMONT DEPT. OF TRANSPORTATION # RFF 041-4(2)	DRAWING NO.
	ARMCO STEEL CORPORATION * METAL PRODUCTS DIVISION ATLANTIC REGION - BALTIMORE, MARYLAND	

0815 REV. 8/69

HIGHWAY DEPARTMENT OFFICE MEMORANDUM

TO: W. M. Smith, Bridge Engineer via J. R. Phalen, Construction Engineer

FROM: A. E. Remick, Chief Resident Engineer

DATE: November 17, 1976

SUBJECT: St. Johnsbury RFF 041-4 (2)
Shape Monitoring Taken Nov. 8 and 9, 1976 for Armco Super-Span for St. Johnsbury & Lamoille County Railroad

		To Top of Span Rise at Center	Side Ring Measurements North Ring	South Ring
West End	1	25.70	19.93	19.73
	2	25.81	20.12	19.76
	3	25.88	20.09	19.84
	4	26.07	20.20	19.77
	5	26.07	20.29	19.84
	6	26.09	20.36	19.79
	7	26.02	20.36	19.76
	8	26.14	20.33	19.74
	9	26.22	20.30	19.76
	10	26.20	20.23	19.82
	11	26.20	20.08	19.83
	12	26.03	20.18	19.74
	13	26.04	20.10	19.84
	14	26.02	20.22	19.82
	15	26.18	20.30	19.81
	16	26.21	20.15	19.91
	17	26.13	20.18	20.02
	18	26.11	20.17	20.11
	19	26.16	20.14	20.00
	20	26.21	20.15	19.99
	21	-	20.13	20.01
	22	26.08	20.14	20.02
	23	26.11	20.12	20.03
	24	26.06	20.03	19.90
	Avg.	26.08	Avg. 20.18	Avg. 19.87

Note: Rise at center was determined by taking measurement from bottom of center ring to a mark on wall 6' above invert. By adding the 6' to this measurement, plus the ring height of 0.70', we get total height.

AER:EBH

RSH

ARMCO STEEL CORPORATION

METAL PRODUCTS DIVISION

ARMCO

ADDRESS REPLY TO
P. O. BOX 152
PALMER, MA 01069
PHONE: 413-283-7611

December 17, 1976

Mr. Richard Haupt
Vermont Department of Highways
State Office Building
Montpelier, VT 05602

Dear Dick:

REF: St. Johnsbury, Vermont
SUPER-SPAN

Thank you very much for the field measurements that were taken in November on the St. Johnsbury SUPER-SPAN. We're most pleased to see that the vertical change in dimension with the fill completed on it is actually less than 1%, and indeed computes to about 0.6% of design.

The side ring measurement movement, again, shows dimension change of less than two inches which is excellent.

You asked for our comments regarding future monitoring; I would suggest that the structure appears to be reacting as anticipated and its shape conforms very closely to the design. Further monitoring on a station by station basis wouldn't appear to be necessary. I would suggest that you move this now to a stage of just future "walk through visual inspections" to confirm the condition of structure and if there is any visual indication of need then measurements could be taken.

Thanks again for the data on this structure and I hope you have a very happy Holiday Season. I expect to see you shortly after the first of the year.

Yours very truly,

Arthur G. Taylor
District Engineer

hvk

cc: C. Hammond
J. E. Greenlaw
H. A. Moulton

HIGHWAY DEPARTMENT OFFICE MEMORANDUM

TO: *J. R. Phalen, Construction Engineer*

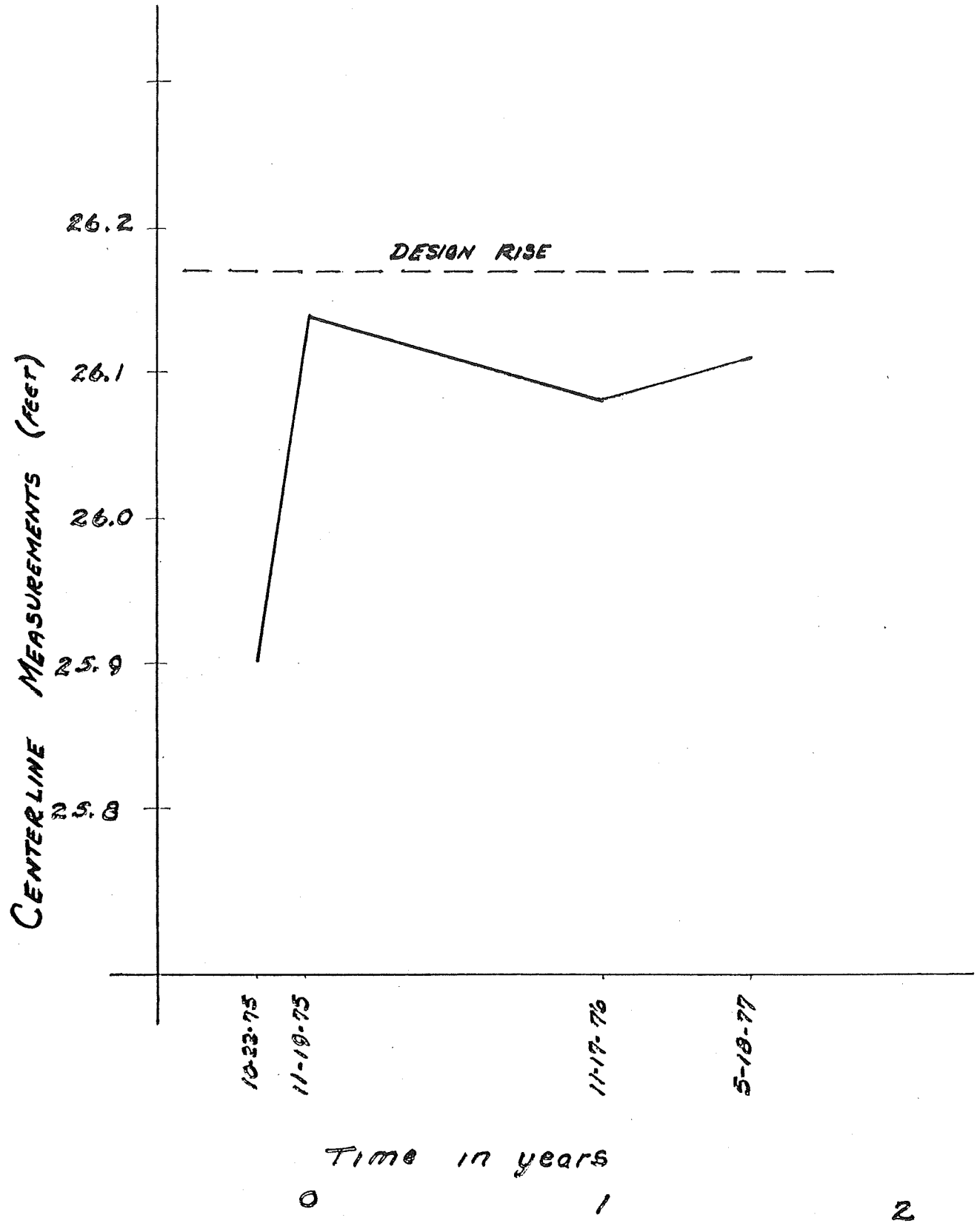
FROM: *A. E. Remick, Chief Resident Engineer* AER

DATE: *May 20, 1977*

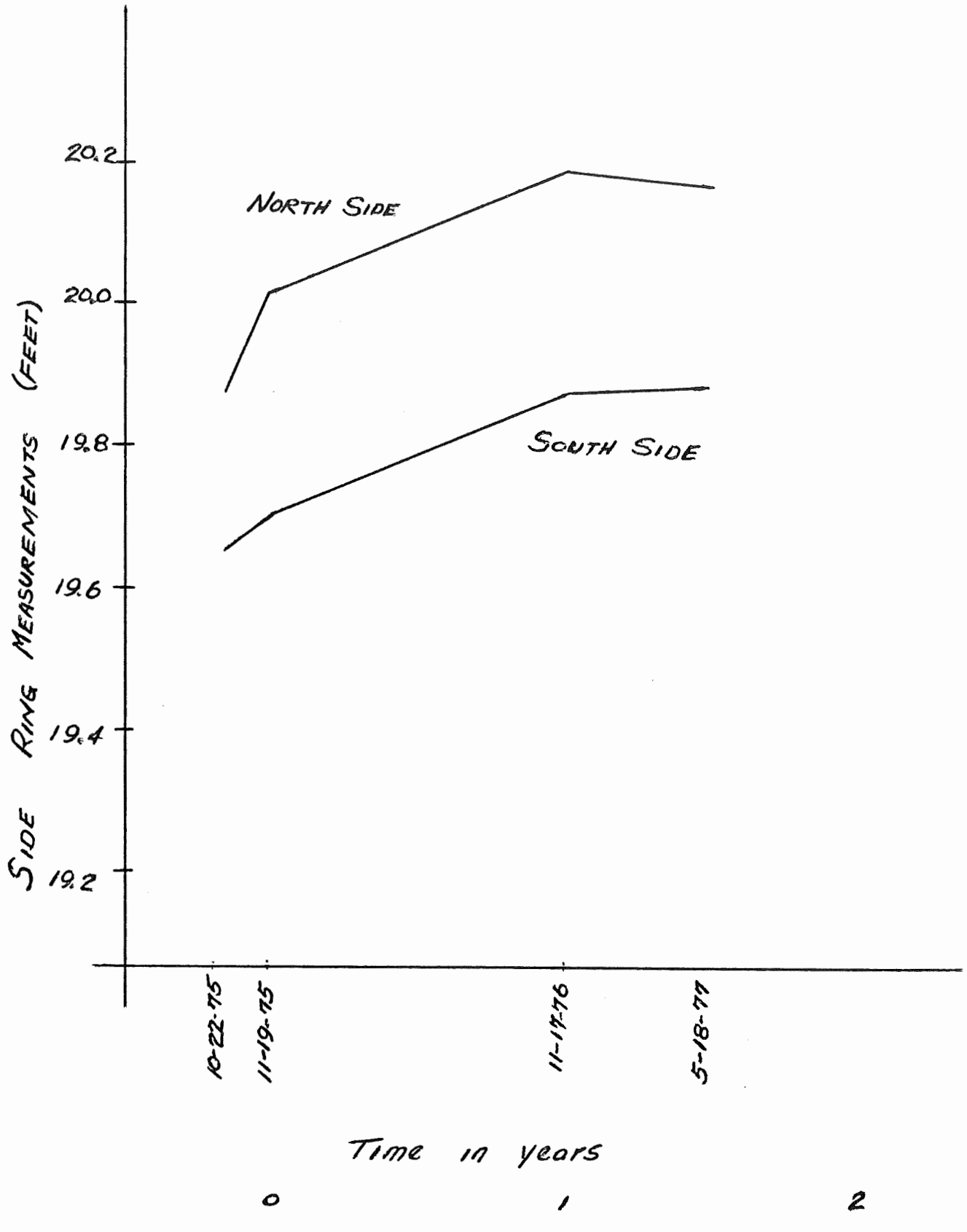
SUBJECT: *St. Johnsbury RFF 041-4 (2)*
Shape Monitoring Taken May 18, 1977 for Armco Super-Span for St. Johnsbury & Lamoille County Railroad

		To Top of Span Rise at Center	Side Ring Measurements North Ring	South Ring
West End	1	25.85	19.93	19.75
	2	25.87	20.12	19.77
	3	25.93	20.10	19.84
	4	26.12	20.19	19.77
	5	26.12	20.29	19.86
	6	26.12	20.36	19.80
	7	26.05	20.32	19.77
	8	26.16	20.32	19.75
	9	26.20	20.28	19.79
	10	26.14	20.21	19.81
	11	26.20	20.10	19.86
	12	26.07	20.16	19.75
	13	26.07	20.04	19.84
	14	26.05	20.18	19.81
	15	26.20	20.28	19.81
	16	26.20	20.13	19.90
	17	26.20	20.14	20.03
	18	26.16	20.12	20.12
	19	26.20	20.12	20.02
	20	26.24	20.12	19.99
	21		20.03	20.04
	22	26.13	20.13	20.04
	23	26.12	20.08	20.04
	24	26.10	20.03	19.91
	Avg.	26.11	Avg. 20.16	Avg. 19.88

St Johnsbury
RFF 041-4(2)
Super Span



ST JOHNSBURY
REF 041-4(2)
SUPER SPAN



Final Comments

The structure appears to be performing the purpose intended and the relative movement is stabilizing as may be seen from the attached charts and measurements.

Future monitoring by periodic visual walk-through inspections should be adequate.

It should be noted that the structure was fabricated for and installed on a 10^{o} horizontal curve and it is felt that this tends to prevent rotation of the structure as a whole compared to one placed on straight alignment.