FIELD PERFORMANCE OF GALVANIZED REINFORCING STEEL

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VERMONT ROUTE 12
SPRING STREET BRIDGE
MONTPELIER VERMONT

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INTRODUCTION

In a continuing effort to overcome the problem of bridge deck deterioration, the Vermont Agency of Transportation, in cooperation with F.H.W.A., initiated the use of galvanized reinforcing steel in a new bridge deck in 1971. This interim report on the project was prepared in response to a solicitation of comments on current F.H.W.A. policy on the use of galvanized rebars published in the Federal Register, Volume 46, No. 146, July 30, 1981 (F.H.W.A. Docket No. 81-7). The report gives a brief description of the construction details and presents the data obtained from periodic evaluations of the deck over the ten year period since initial construction.

BRIDGE DESCRIPTION

The Spring Street bridge is located on Vermont Route 12 over the North Branch of the Winooski River, in Montpelier, Vermont, and is a bare surface deck.

The 75' simple span utilized A-588 weathering steel W Beams with a 52'- 8" wide composite concrete deck. The grade varied from +1% to -1.2%.

Galvanized reinforcing steel was used for the top mat of steel and conventional black steel was used on the bottom mat. The two mats were not connected or touching each other at any locations. The concrete portion of the deck was cast in two layers; the first layer poured October 1, 1971 was 6 1/2 inches deep and covered both the bottom mat of black steel and the top mat of galvanized steel. Concrete coverage over the top of the galvanized bar averaged 1/2" after the first pour.

On October 22, 1971, a second layer, 2 1/4 inches in depth was cast over the first layer. Prior to placement of this layer, a neat cement slurry was broomed onto the surface to serve as a bonding agent. The concrete for the 2 1/4" overlay contained an extra half bag of cement per cubic yard. For information on the mix design and results of the testing of material as placed, see Attachment 1 on page 6.

BRIDGE CONDITION

Since construction in 1971, the bridge has been periodically evaluated for delamination, steel corrosion by half-cell potential readings, cracking, and chloride content.

Delamination between the two courses of concrete has been on the increase since 1973 when it was calculated at 9% of the deck surface area. The initial delamination was confined mainly to the deck perimeter along the curb lines. By 1977, the area had expanded to 12% of the deck surface and a 1981 survey revealed a sharp increase to 32%.

The latest increase consisted of extensions to previously detected areas and the development of 12 additional isolated areas.

Physical removal of the delaminated surface course from a two square foot area first noted in 1973 revealed a 1 to 2 inch thick layer of concrete rubble. The layer of deterioration appeared to have occurred more in the surface course than the base course. This was evidenced by the lack of rebars visible at the top of the exposed base course. Rebar corrosion was noted at a single location within an area approximately two feet square. Cores taken in areas of delamination detected in 1981 revealed a lack of bond between layers but no concrete deterioration.

Half cell potential readings have been taken on five occasions at 1, 4, 8, and 12 foot offsets from the westerly curb line. Generally the readings have varied little between 1972 and 1981 and definite indication of corrosion can be found only at the ends of the span.

No evidence of corrosion was visible on cores taken through the rebars. The specimens will be examined further in the laboratory by the Portland Cement Association in an attempt to determine the condition of the galvanizing. For potential readings see Attachment 3 on page 9.

There is 225 lineal feet of visual cracking on the deck surface, randomly spaced over the entire deck. Forty percent of the cracking is transverse varying from 1 foot long to 15 feet long. Longitudinal cracks make up 36% of the cracks and range from 1 to 6 feet in length. The remaining 24% are miscellaneous. See illustration of cracking on Attachment 4, page 10.

Pulverized concrete samples were obtained in 1974, 1975, 1976 and in 1981 to determine chloride contamination levels. The samples were taken at 1.0', 11.5', and 19.5' off the westerly curb line at depths ranging from 0 to 3". The latest results in September, 1981, show an average chloride contamination level for the three locations of 13.2 lb/cy at 0 to 1", 7.8 lb/cy at 1" to 2", and 3.2 lb/cy at 2" to 3". A breakdown of results over the years is given on Attachment 5, page 11.

SUMMARY

The condition of the Spring Street bridge and the performance of the galvanized reinforcing steel may be summarized as follows:

Delamination between the structural concrete slab and wearing course has progressively worsened over the ten year period with one third of the surface area presently delaminated. A layer of deterioration has occurred between the two courses in areas where the delamination was first noted in 1973. No evidence linking the delamination problem to the use of galvanized reinforcing steel was found.

Chemical analysis of concrete samples taken in September, 1981, reveal average chloride contamination levels at the 0 to 1 inch, 1 to 2 inch, and 2 to 3 inch depths of 13.2, 7.8, and 3.2 pounds per cubic yard respectively.

Half cell potential reading on the reinforcing steel have varied little between 1972 and 1981. Current readings range from a low of 0.19 volts to a high of 0.42 volts with an overall average of 0.25 volts. The average reading is low considering the 3.2 pound per cubic yard chloride content at the rebar level. Physical removal of the delaminated surface course from an area approximately two square feet revealed the existence of rebar corrosion at a single location adjacent to the northern approach slab joint.

Condition surveys will be continued on an annual basis.

ATTACHMENT 1
SPRING STREET BRIDGE, MONTPELIER, VT.

DECK CONSTRUCTION DATA

First 6 1/2" course placed on October 1, 1971. Deck cured 7 days before placing sidewalks and then 14 additional days before top course placed.

Water Cement Ratio - 0.44

Type Cement - Northeast Cement, Inc. - Type I

Slump - 3" Avg. on 5 Tests

Temp. of Concrete - 68° F

Air - 6% Avg. on 12 Tests

Cover - 1/2" Avg. on 21 Tests

Mix Design - Class AA - 1 Cubic Yard

3/4" Stone - 1703 lbs.

Sand - 1290 lbs.

Cement - 611 lbs.(6-1/2 Bags)

Bottom Mat - Black Steel

Top Mat - #5 Bar - Galvanized (not chromated)

Top 2 1/4" course placed on October 22, 1971 following a period of 48 hours of continuous water soaking. The overlay was preceeded by a thick consistency neat cement slurry.

Water Cement Ratio - 0.44

Type Cement - Iron Clad Cement Co. - Type I

Slump - 1" to 2" Avg. on 5 Tests

Temp. of Concrete - 68° F

Air - 6% Avg. on 6 Tests

Cover - 2-1/4" Avg. on 18 Tests

Mix Design - Class AA - 1 Cubic Yard

3/4" Stone - 1548 lbs.

Sand - 1281 lbs.

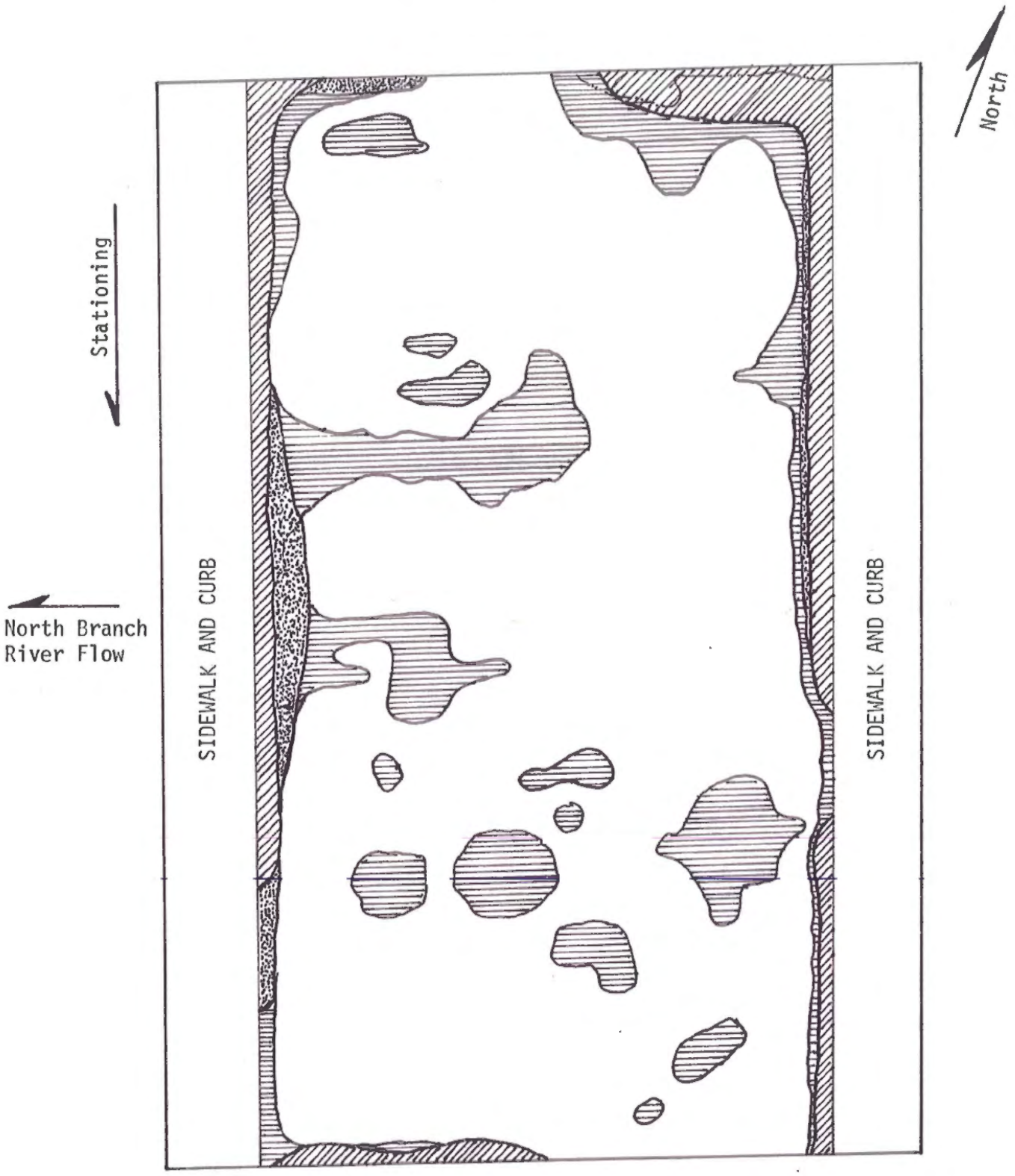
Cement - 658 lbs. (7 Bags)

Top Mat - No Steel

ATTACHMENT 2

Spring Street Bridge - Montpelier, Vermont

DELAMINATION



ATTACHMENT 3

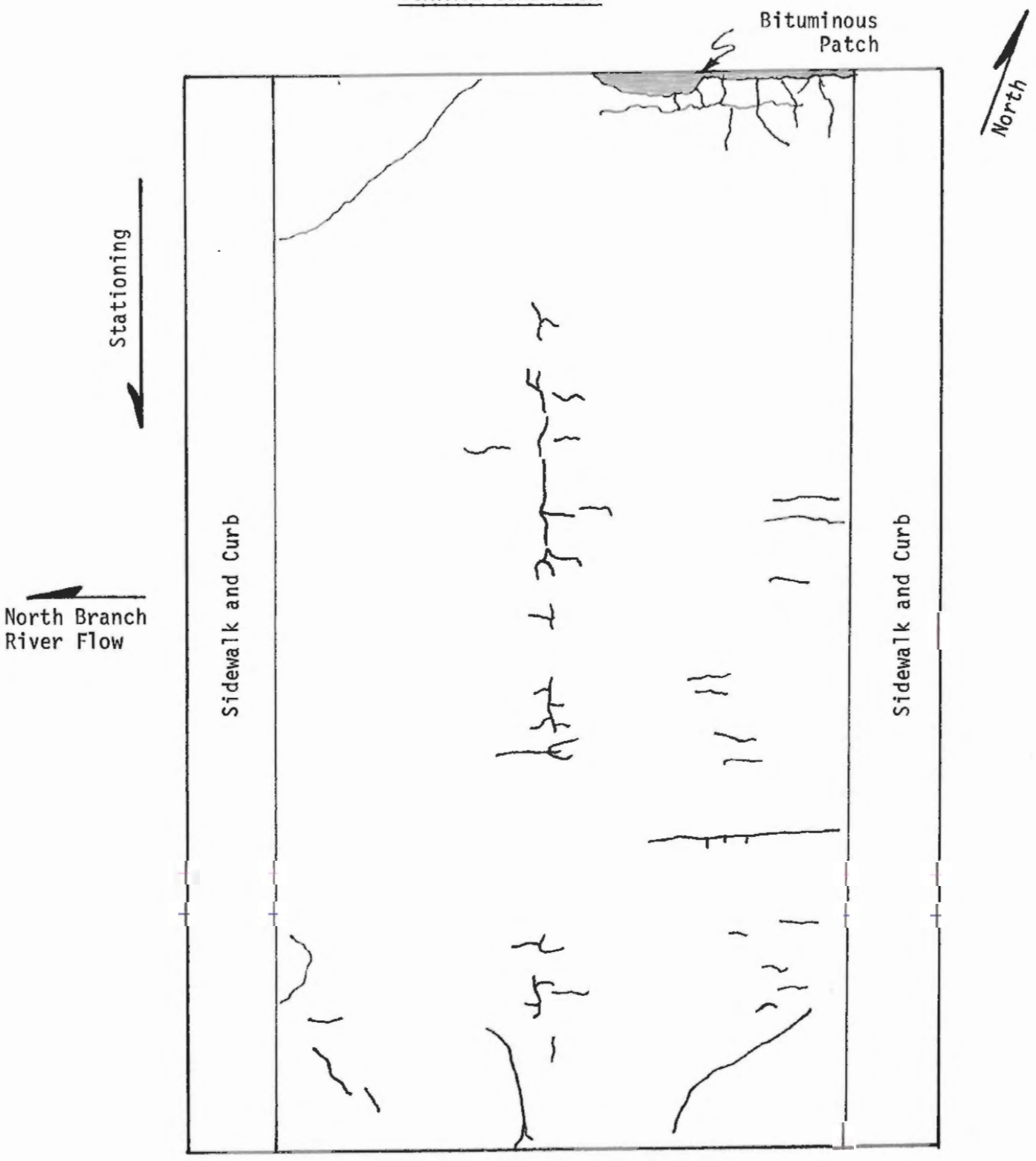
Spring St. Bridge, Montpelier, Vt.
Half-Cell Potential Readings
Readings in volts x10-2

Station (Page 9)	Offset from Westerly Curb (Downstream)																			
	1'					4'					8'					12'				
	1972	1973	1974	1977	1981	1972	1973	1974	1977	1981	1972	1973	1974	1977	1981	1972	1973	1974	1977	1981
0	37	34	44	46	35	34	28	42	38	37	34	20	40	40	42	36		40	32	35
5'	31	20	31	35	28	23	20	22	30	25	37	18	25	30	26	28		26	20	26
10'	20	22	27	32	24	22	18	20	28	24	24	18	22	24	19	24		20	16	21
15'	23	24	29	30	24	22	22	22	27	21	21	18	20	22	21	26		22	16	21
20'	23	22	29	28	21	20	18	24	29	25	22	18	20	22	22	24		20	16	21
25'	24	20	28	29	25	20	18	22	29	24	23	18	22	23	23	24		20	18	23
30'	25	18	25	28	25	25	20	25	29	25	24	18	22	22	23	25		21	18	22
35'	21	16	19	26	25	23	20	22	28	22	24	18	22	17	25	24		22	18	25
40'	26	18	16	24	25	24	21	22	30	24	37	20	22	20	25	25		23	19	24
45'	20	20	25	27	25	28	22	22	28	25	26	18	32	20	24	28		23	19	22
50'	20		27	31	25	22		20	30	20	22		19	18	21	25		21	20	22
55'	23		32	35	28	21		22	29	25	23		20	19	19	26		20	19	20
60'	22		27	33	26	24		34	28	25	25		20	19	22	26		21	18	20
65'	25		30	30	26	23		24	28	21	24		20	18	22	23		21	17	24
70'	22		30	32	30	22		24	29	27	22		21	20	25	20		20	20	25
+	31		28	40	36	24		32	34	32	30		32	30	35	32		32	28	32
Ave.	25	21	28	32	27	24	21	24	30	25	25	19	24	23	25	26		23	20	24

ATTACHMENT 4

SPRING STREET BRIDGE - MONTPELIER, VERMONT

SURFACE CONDITION



Cracking As Of August, 1981

ATTACHMENT 5

Spring Street Bridge
Montpelier, Vermont

CHLORIDE ANALYSIS

Offset From Westerly Curb	Depth Of Sample Inches	1974 PPM	1974 Lb/cy	Depth Of Sample Inches	1975 PPM	1975 Lb/cy	1976 PPM	1976 Lb/cy	1981 PPM	1981 Lb/cy
1'	0-1	1617	6.5	0-1	2121	8.5	1846	7.4	2403	9.6
	1-1 1/2	418	1.6	1-2	461	1.8	755	3.0	1110	4.4
	2-2 1/2	67	0.3	2-3	-	-	198	0.8	745	3.0
	2 1/2-3	43	0.2							
11.5'	0-1	2446	9.8	0-1	2740	11.0	5480	21.9	4359	17.4
	1-1 1/2	1159	4.6	1-2	804	3.2	796	3.2	2363	9.4
	2-2 1/2	213	0.8	2-3	-	-	233	0.9	943	3.8
	2 1/2-3	43	0.2							
19.5'	0-1	1652	6.6	0-1	1879	7.5	2313	9.3	3157	12.6
	1-1 1/2	489	1.9	1-2	397	1.6	1038	4.2	2407	9.6
	2-2 1/2	57	0.2	2-3	-	-	508	2.0	665	2.7
	2 1/2-3	46	0.2							

ATTACHMENT 6

Spring Street Bridge
Montpelier, Vermont

Concrete deterioration adjacent to northerly approach slab.

Concrete rubble at two course interface and corrosion product at a single location.

Lack of bond between courses. No visible signs of corrosion on galvanized rebar.