SURVEY AND RECOMMENDATIONS CONCERNING ALUMINUM ANCHOR BOLTS ON BRIDGE RAILS

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Introduction

This report presents the results of a recent survey conducted to determine the condition of aluminum anchor bolts, nuts, and rail posts used on structures completed in the period 1959 through 1961. The investigation was initiated as a result of a meeting held in the office of N. C. Jones, on December 21, 1973. There was general agreement at the meeting that rails with aluminum anchor bolts should receive high priority for replacement. Structures in the lower portion of the State were to be considered first because increased salt usage may affect corrosion rate.

The purpose of this investigation was to determine the extent of damage caused by corrosion of the anchor bolts and nuts, to obtain pertinent information required for establishing methods of replacement, and to outline a priority order for replacement of rails anchored with aluminum hardware.

General Information

The Design Division furnished a list of 41 structures to be surveyed. Of these, seven are located in the Upper Peninsula and were not surveyed, one structure has had the aluminum rails replaced by a concrete parapet, and twelve contained galvanized anchor bolts and nuts instead of aluminum as called for on the plans. A listing of surveyed structures found to have galvanized fasteners is given in Table 1. Upper Peninsula structures will be surveyed when winter snows have gone. The structure with the new parapet rail is B01 of 77041, M 136 over the Black River, 9.8 miles SE of M 19.

Determination of damaged fasteners was performed by visual observation; recording nuts and bolts that were cracked, missing, or broken. Fasteners which had been replaced at the time of the survey were recorded as being damaged.

Damage to aluminum posts consisted entirely of notches and cracks apparently caused by maintenance front-end loaders during snow removal.

A later survey will include all of approximately 500 additional structures having aluminum railing and steel anchor bolts. These will be classified and priorities for replacement will be recommended based on traffic, roadway width, curvature, etc.

TABLE 1
STRUCTURES WITH GALVANIZED FASTENERS

S04 of 13081	I 94 under 5 Mile Rd, 5.0 miles E of Kalamazoo Co. line
B01 of 18033	US 27 NB over South Br. Tobacco River at N limits of Clare
B02 of 18033	US 27 SB over South Br. Tobacco River at N limits of Clare
S03 of 38103	I 94 WB over Race Rd, 6.4 miles W of Washtenaw Co. line
S04 of 38103	I 94 EB over Race Rd, 6.4 miles W of Washtenaw Co. line
S30 of 50111	I 94 under 21 Mile Rd, 1.1 miles NE of M 59
B01 of 61152	I 96 EB over Norris Creek, 0.9 miles NW of Ottawa Co. line
B02 of 61152	I 96 WB over Norris Creek, 0.9 miles NW of Ottawa Co. line
S01 of 61152	I 96 ramp over US 31 at US 31
S02 of 61152	I 96 ramp over ramp to US 31 at US 31
B02 of 67061	M 61 over Middle Branch River, 0.1 mile E of M 66
B02 of 70052	M 29 over Pine River, in St. Clair

Objectives

Twenty-one structures containing aluminum anchor bolts and nuts were surveyed. The objectives of the survey were as follows:

1. Determine percentage of structures exhibiting corrosion
2. Determine percentage of damaged nuts and bolts per structure
3. Record type of rail post (whether two or three-rail type)
4. Determine percentage of damaged posts
5. Record roadway width (whether full width or narrowed at the structure)
6. Obtain sidewalk dimensions.

Results

Results of the survey are given in Table 2.

Approximately 70 percent of the structures surveyed showed corrosion damage to some extent. Percentage of damaged fasteners per structure varied from less than 1 percent to 54 percent; the average being 12 percent for those structures showing damage. These failures are not uniformly distributed, and in many instances more than one fastener has failed on a single post. The structure showing the highest percentage of damaged fasteners (S12 of 47065) contained 142 steel nuts which apparently had replaced the aluminum fasteners. It is quite possible here that this replacement may have resulted from vehicle impact.

Some anchor bolts and nuts, on the same structure, are in far better condition than others, indicating the possibility of differences in material. However, samples of good and corroded fasteners from the same structure submitted for chemical analysis did not show any significant difference in chemical composition. Since the corrosion resistance of this alloy varies with heat treatment, it seems probable that the nuts may have been subject to differing cooling rates.

There were five structures with damaged posts. All are located in the same general geographical area, this being on M 78 and M 71 near Durand and Swartz Creek. The average percentage of notched or cracked posts for those structures showing damage is 8 percent with a range from 6 to 17 percent.

TABLE 2
RESULTS OF SURVEYED STRUCTURES WITH ALUMINUM ANCHOR BOLTS AND NUTS

Bridge No.	Year Built	Roadway	Total Number of Fasteners	Number of Fasteners Damaged	Per-cent	Type of Post	Total Number of Posts	Number of Posts Damaged	Per-cent	Width of Roadway	Sidewalk Dimensions, in.	
											Height	Width
B01 of 08042	1959	M 79 over Quaker Brook	40	0	0	2 rail	10	0	0	full	10	30
S04 of 11016	1960	Napier Road over I 94	240	27	11	3 rail	60	0	0	narrowed	10	45
S03 of 13081	1959	3 Mile Road over I 94	288	37	13	3 rail	72	0	0	narrowed	10	62
S06 of 13083	1960	22-1/2 Mile Road over I 94	240	0	0	3 rail	60	0	0	narrowed	10	45
S09 of 13083	1960	26 Mile Road over I 94	240	0	0	3 rail	60	0	0	narrowed	10	45
S03 of 39024	1959	9th Street over I 94	256	30	12	3 rail	64	0	0	narrowed	10	45
S12 of 47065	1961	Spencer Road over I 96	264	143*	54	3 rail	66	0	0	narrowed	12	42
B02 of 68041	1960	M 72 over E. Br. of Big Creek	144	0	0	3 rail	36	0	0	full	10	30
B03 of 76023	1961	M 78 EB over Holly Drain	72	11	15	2 rail	18	1	6	full	12	30
B03 of 76023	1961	M 78 WB over Holly Drain	72	3	4	2 rail	18	0	0	full	12	30
B04 of 76023	1961	M 78 EB over Webb Drain	72	14	19	2 rail	18	3	17	full	12	30
B04 of 76023	1961	M 78 WB over Webb Drain	72	4	6	2 rail	18	0	0	full	12	30
X02 of 76023	1961	M 78 EB over GT&WRR	200	24	12	2 rail	50	3	6	full	12	30
X02 of 76023	1961	M 78 WB over GT&WRR	200	39	20	2 rail	50	3	6	full	12	30
S07 of 76023	1961	M 71 over M 78	256	1	0.4	3 rail	64	0	0	narrowed	12	40
B03 of 76041	1961	M 71 over Holly Drain	72	2	3	2 rail	18	1	6	full	12	30
S02 of 80023	1960	62nd Street over I 94	240	13	5	3 rail	60	0	0	narrowed	10	45
S08 of 80023	1960	M 51 over I 94	256	2	0.8	3 rail	64	0	0	narrowed	10	45
S04 of 80024	1960	32nd Street over I 94	288	0	0	3 rail	72	0	0	narrowed	10	45
S06 of 80024	1959	24th Street over I 94	256	16	6	3 rail	64	0	0	narrowed	10	45
B01 of 82101	1959	M 14 over Fellows Creek	32	0	0	3 rail	8	0	0	narrowed	10	40

* Aluminum nuts have been replaced with steel. Possibly due to vehicle impact on rail.

Most of the structures on the arterial road system have 12-in. high barrier curb and full-width roadways, while those on county roads are generally narrowed at the structure with 10-in. high curbs.

Recommendations

Since there are no structures with aluminum rail posts and fasteners on Interstate routes, we recommend the following priority order for replacement of rails:

A. Replace railings of 10 structures on the arterial road system with preference given to those located on M 78 and M 71, followed by those located on M 51 and M 72.

B. Replace railings of county road overpasses. The following order of replacement is suggested:

1. S04 of 11016 - I 94 under Napier Rd, 1.4 mi SE of Benton Harbor
2. S12 of 47065 - I 96 under Spencer Rd, 0.8 mi NW of US 23
3. S03 of 39024 - I 94 under 9th St, 4.8 mi E of VanBuren Co. line
4. S06 of 80024 - I 94 under 24th St, 1.0 mi W of Kalamazoo Co. line
5. S03 of 13081 - I 94 under 3 Mile Rd, 3.0 mi E of Kalamazoo Co. line
6. S06 of 13083 - I 94 under 22-1/2 Mile Rd, 3.4 mi E of I 94 BL
7. S09 of 13083 - I 94 under 26 Mile Rd, 4.8 mi W of Jackson Co. line
8. S02 of 80023 - I 94 under 62nd St, 4.0 mi E of Berrien Co. line
9. S04 of 80024 - I 94 under 32nd St, 1.6 mi E of M 40.

C. Replace railings of two remaining structures located on M 14 and M 79, these are small bridges containing 8 and 10 posts, respectively.

Due to the aspects of safety, it is obvious that immediate action is required. Since some of the structures have broken posts, and posts without fasteners, temporary maintenance should be done right away, and contracts for rail replacement should be prepared as soon as possible. Temporary repairs should consist of replacement of cracked or missing nuts, and the few fractured posts on M 78. Replacement nuts should be aluminum alloy 6061-T6. Larger aluminum nuts or bored-out nuts may be required as spacers beneath new nuts in cases where the bolts are badly corroded. Obviously, such bolts are not as strong as they should be, but replacement of the fractured nuts seems to be a necessity to provide as much protection as possible until the rails can be replaced.

Steel nuts placed on the aluminum bolts should be done only on a very short term basis because of the metallurgical situation involved.

In general, it probably will be impossible to remove existing nuts in the usual manner, since corrosion will "set" the nut on the bolt, and the bolt may fail in torsion before the nut loosens. If it is necessary to remove existing nuts to replace posts, the job can be readily accomplished with a light hammer and cold chisel.

New bridge rails could be either the GM rail or the brush block and parapet wall. Since the sidewalks are generally in good condition on these structures, and since use of the GM barrier without removal of the sidewalk would require that the roadway be narrowed to some extent, it seems more reasonable to use the existing sidewalk and grout in rebars for anchoring a new parapet rail. (This method has been used successfully on several bridges in the past, notably for the replacement of the outside rail on many widened structures on I 94, southwest of the St. Joseph River. Recommendations for epoxy grouting of rebars for this purpose are included in Research Report R-619, January 1967.) The parapet rail also has the advantages of not interfering with surface drainage and it conforms well with the alignment of curbs on the approaches.

Replacement contracts should include provisions for reconstruction of the guard rail to bridge rail transition area and attachment of the guard rail to the bridge rail in accordance with current standards. Since these structures may be adjacent to the older type guard rail with 12 ft post spacing, a carefully constructed stiffness transition area with variable post spacing will be required adjacent to the structure, if the guardrail is not upgraded. However, it would seem wise to upgrade the guard rail on the approaches to current standards at the same time the bridge rail is replaced. Installation of the additional posts and wooden blocks should be possible at reasonable cost, when the associated alignment is done at the transition area.

Undoubtedly there will be numerous rail replacement contracts in the future as more structures are brought up to current standards, and therefore it might be a good idea to install the GM type rail on one or two of these structures to develop a method of seating the rail over the sidewalk edge, anchoring the rail to the structure, and making necessary transitions at junctions with curbs on the approaches.

Research Laboratory personnel will continue to survey the remaining structures with aluminum rail, as time permits, and a priority ranking of those structures will be presented in the future.