INTERIM REPORT ON EFFECTS OF CORROSION ON BRIDGES OF UNPAINTED A588 STEEL AND PAINTED STEEL TYPES

J. D. Culp
G. L. Tinklenberg

Research Laboratory Section
Testing and Research Division
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Michigan Transportation Commission
Hannes Meyers, Jr., Chairman; Carl V. Pellonpaa,
Vice-Chairman; Weston E. Vivian, Rodger D. Young,
Lawrence C. Patrick, Jr., William C. Marshall
John P. Woodford, Director
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Background - Use of Unpainted Weathering Bridge Steel

Several types of high-strength low-alloy steels are available which are marketed as having "enhanced atmospheric corrosion resistance" and, as such, are promoted as steels that can be put into service without any paint or other corrosion protective system. The Department, after considering the cost and difficulty of repainting bridge steel in high traffic, decided to specify this type of steel first in the Detroit area and later statewide. The steels marketed for this type of bare exposure are ASTM A242, ASTM A588, and ASTM A709, Grades 50W and 100W. The majority of the Michigan Department of Transportation's unpainted bridges were fabricated of the several grades of A588 steel. A588 is manufactured in nine different grades, each grade being essentially a proprietary product of a particular producer. The Department's Standard Specifications for Highway Construction allows the use of five of these grades with modifications placed on the chemical requirements of one grade. A588 is specified by ASTM as having an atmospheric corrosion resistance of approximately two times that of carbon structural steel with copper (thus a corrosion resistance of approximately four times that of plain carbon steel without copper). In addition to this, A588 steel has a minimum specified yield point of 50,000 psi that is utilized in the design of a structure to reduce the required section size (1). The increased atmospheric corrosion resistance of the A588 steel has been considered its greatest attribute since in certain environments a rust layer (patina) formation on its surface protects the steel from continued corrosion and thus eliminates the need for painting (2, 3, 4). We have found that formation of this protective patina, however, is dependent on the following conditions:

1) Exposure to the atmosphere that allows intermittent cycles of wetting and drying without prolonged wetting periods (5)

2) The absence of heavy concentrations of corrosive pollutants, especially salt-bearing water from any source

3) Washing of the exposed surface by rainwater (6)

4) The absence of detail geometries that can trap moisture, dirt, or debris and hence foster a corrosive condition (7).

It has been our observation that if any of these conditions are not met in an unpainted exposure of A588 steel, the protective oxide layer will not form and corrosion will continue as with any other low carbon structural steel. Field observations over the past four years have revealed that nearly all of the highway bridges in the Michigan system contain departures

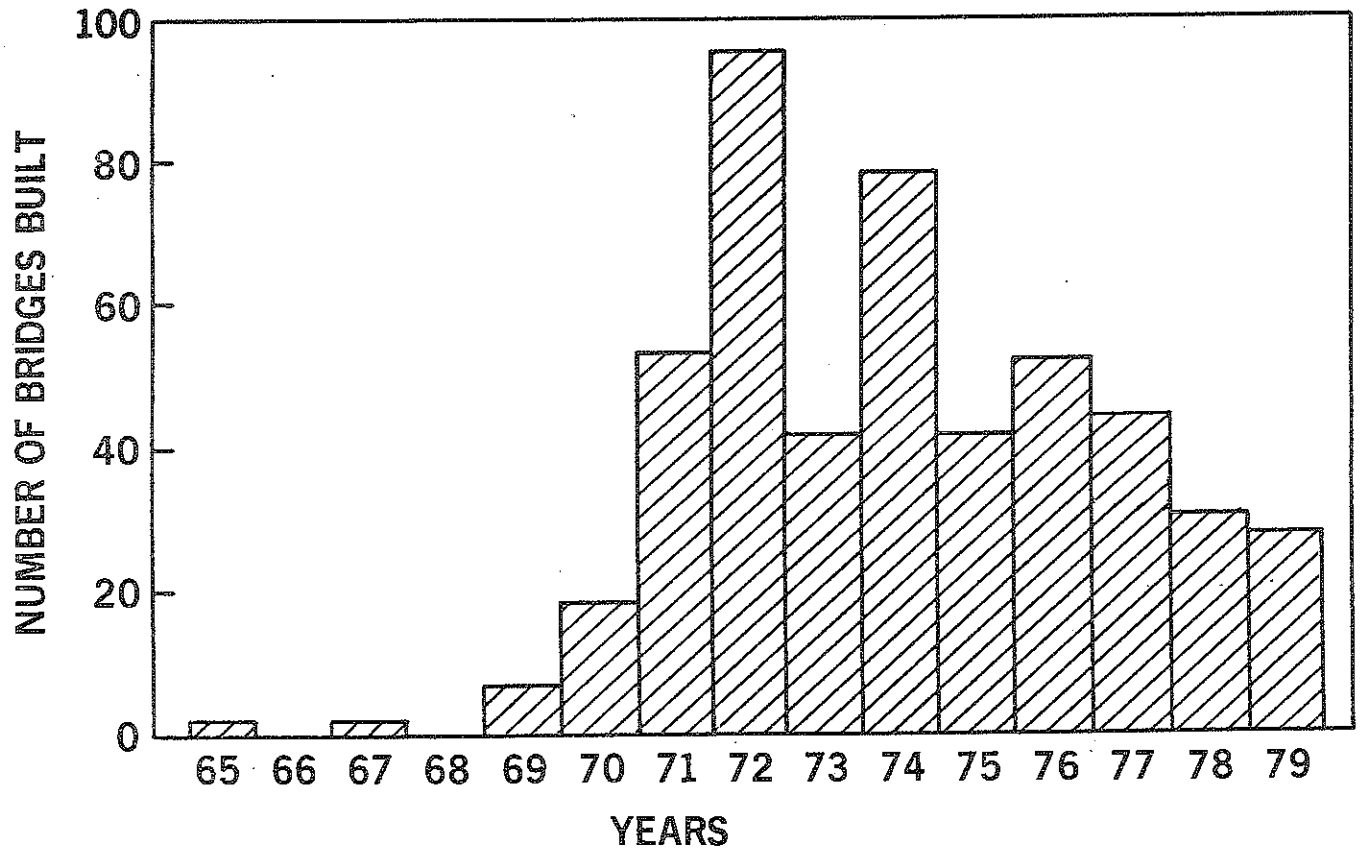


Figure 1. Histogram of bridges built by the Michigan Department of Transportation with unpainted "weathering" steel. Total number of unpainted bridges is approximately 500 (nine bridges built in 1980 of A588 are to be painted).

from these conditions and are thus experiencing various degrees of corrosion damage.

The history of the Michigan Department of Transportation's use of unpainted A588 steel for bridges is illustrated in Figure 1. The first bridges built of unpainted steel were at the crossing of 8 Mile Rd over US 10 in Detroit in 1965. Two years later, another structure was built at the 8 Mile Rd and I 75 interchange in Detroit. These structures contain the grades of A588 steel supplied by the two major producers of weathering steel. As can be seen by the plot in Figure 1, a major commitment to the use of unpainted steel in bridges began in 1970. Initially, the steel was used wherever a high volume of traffic under the bridge caused the traffic control involved in maintenance painting to become a major expense and safety hazard. As the use of the unpainted steel became more accepted it was specified for nearly all bridge situations, regardless of traffic volume. To date, there are approximately 500 bridges constructed of unpainted weathering steel in the Michigan trunkline system. This number does not include the unpainted structures owned by various local government agencies.

The majority of our field investigations have been directed at the bridges on 8 Mile Rd built in 1965 and 1967 and several bridges built around 1972, thus representing service lives of 14 to 15 years and 7 to 8 years, respectively. The results of these investigations are presented in the Research Findings section and give a good indication of what is expected to happen to the majority of these 500 unpainted bridges if they are left unpainted. Investigations into the corrosion problems on painted bridges will be carried out in future project work.

Moratorium Action

On May 2, 1979, the Engineering Operations Committee of the Michigan Department of Transportation's Bureau of Highways instituted a partial moratorium on the use of ASTM A588 steel in the unpainted condition for bridges in the following situations:

1) On "depressed roadway" sections where low underclearance (less than 20 ft) and vertical retaining walls trap salt sprays and other atmospheric pollutants.

2) In urban and industrial areas where roadway salting and automotive and industrial pollution create an aggressively corrosive environment.

On February 6, 1980, the Engineering Operations Committee extended this moratorium to include all uses of unpainted A588 steel in the state

highway system. This action included structures placed in rural locations which were not affected by the earlier moratorium.

This interim report presents the research findings and conclusions that led to the moratorium actions taken by the Department. In summary, field investigations of the performance of unpainted A588 steel have revealed that it is not exhibiting the resistance to corrosion that was initially anticipated. The steel in the unpainted condition is continuing to corrode (rust) in the typical Michigan highway environment. The primary reason for this continued corrosion is attributed to the use of deicing salt (sodium chloride) on our state highway system. The saltwater that runs off the roadway comes in direct contact with the steel by leakage through the bridge deck expansion joints and by spray thrown up by traffic passing beneath the bridge. When dry conditions exist in the winter season a salt-laden 'dust' blows up on the steel when traffic passes below the bridge. In such a salt contaminated atmosphere the A588 weathering steel does not exhibit better corrosion resistance than other type steels and thus should be given a corrosion-protective coating system as with any other structural steel (8, 9, 10, 11, 12). This salt contamination has been found to exist on rural freeway bridges as well as on those in the urban and suburban areas. Airborne salt spray and dust reaches the steel beams even on bridges which have no traffic beneath them, e.g., a river bridge.

The initial decision to use unpainted A588 steel for bridges was based on the possibility of avoiding maintenance painting of the structures over their life spans if the corrosion process was arrested by the steel's inherent corrosion resistance. It was anticipated by the Department that if the steel did not exhibit such corrosion resistance the main consequence would be the need to maintenance paint the structures within the first 10 to 20-year service period. In the past, this has been the general service life of most bridge paint systems applied to Michigan's new structures. Thus, from an economics point of view, the need for maintenance painting of the existing bare A588 bridges doesn't represent anything different than the maintenance repainting of painted bridge structures. However, some unique problems do exist in the maintenance cleaning and painting of the bare A588 bridges that may increase the cost of the work in comparison with that of initially painted structures.

Based on the current assessment that bare exposures of A588 steel will require maintenance painting within a 10-year service life, it is no longer economical to use unpainted structures. Modern high-performance paint systems, such as inorganic zinc paints used with a vinyl topcoat, when properly applied, can offer in excess of a 20-year service life in our corrosive highway environment. This type of coating system can currently be

applied to a new bridge structure fabricated from a less costly type of high strength steel, ASTM A572, Grade 50, for the cost of the differential between the A572 and A588 steel plus the cost of sandblasting the unpainted A588 steel (the recommendation for sandblasting unpainted A588 steel will be discussed later). The Grade 50, A572 steel is a high-strength steel that is comparable to A588 except that it has no "enhanced ability to resist corrosion" in the unpainted condition. Thus, the Department's decision to change to painted steel structures on future bridge work will incur no additional initial cost and should increase the length of service life to 20 years before the first maintenance coating is required.

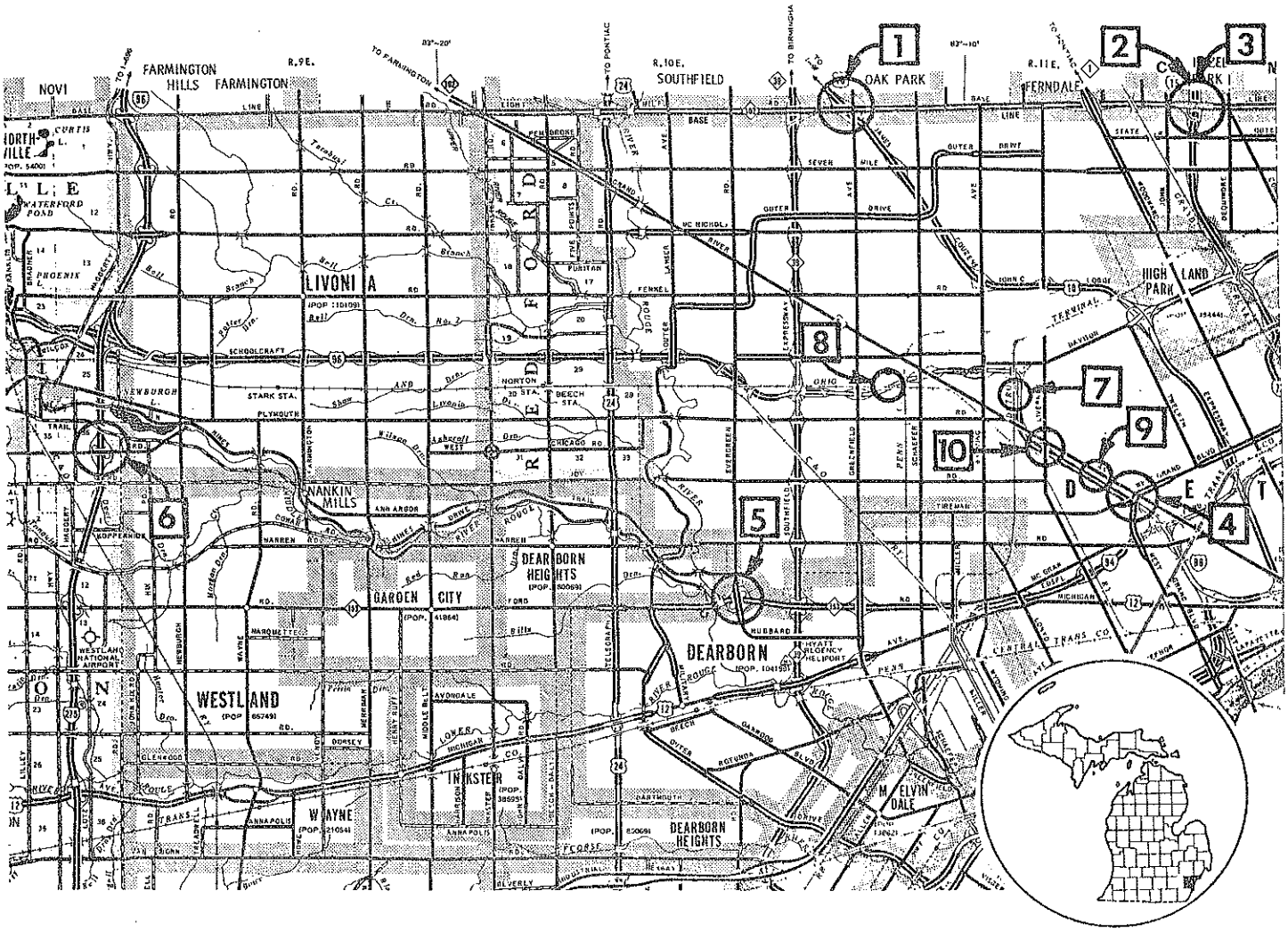
Research Findings

Visual inspections have been conducted on about 50 unpainted A588 bridges including urban, suburban, and rural freeway environments. In the course of these inspections seven corrosion problems have been identified as prevalent on the unpainted bridges. These problem areas are as follows:

1) Salt contamination (by sodium chloride)
2) Crevice corrosion
3) Galvanic corrosion caused by dissimilar metals in contact
4) Accumulation of debris
5) Capillarity of corrosion products causing 'wicking' of saltwater
6) Pitting of beams, cover plates, and weldments
7) Mill scale causing selective corrosion.

Most of these corrosion problems have occurred because of a departure from the weathering conditions previously mentioned that are necessary for the satisfactory performance of weathering steel. The only parts of a bridge structure that could be classified as having an exposure with intermittent cycles of wetting and drying and washing by rainwater are the outside faces of the fascia beams (on our typical stringer-slab type of bridge). Wetting of interior beams (which are never directly washed by rainwater) occurs only by the spraying of water from traffic, by the leakage of water from the bridge deck, or by condensation from the air. The quantity of water from these sources is not sufficient to wash the contaminants from the steel. Interior beams also experience prolonged wetting periods, especially in the winter months. Thus, it is our observation that this type of bridge experiences an environment that does not conform to the conditions required for the successful corrosion resistance of weathering steels.

The most serious corrosion problems are due to salt contamination of the steel. The sodium chloride that is used in Michigan for deicing the highways and bridges reaches the unpainted steel through deck leakage,



	Bridge	Clearance	Year Built	Season Sampled (Year)	% NaCl	
					High	Low
1	8 Mile Rd over US 10	15 ft-0 in.	1965	Summer (1979)	5.1	1.8
2	8 Mile Rd over I 75	15 ft-2 in.	1969	Summer (1979)	4.2	0.52
3	8 Mile Rd over I 75	15 ft-7 in.	1969	Winter (1980)	8.86	--
4	West Grand Blvd over I 96	15 ft-0 in.	1972	Summer (1979)	1.9	1.3
5	Evergreen over Ford Rd	15 ft-3 in.	1972	Summer (1979)	1.2	0.3
6	Ann Arbor Rd over I 275	16 ft-8 in.	1972	Summer (1979)	1.7	0.1
7	Oakman over I 96	15 ft-0 in.	1971	Winter (1980)	2.9	--
8	Hubbel Ave over I 96	14 ft-8 in.	1970	Winter (1980)	2.8	--
9	Pacific Ave over I 96	14 ft-9 in.	1972	Winter (1980)	4.6	--
10	Livernois over I 96	15 ft-0 in.	1972	Summer (1979)	3.6	0.8

Figure 2. Results of salt analyses (sodium chloride) of beam corrosion samples taken from bridges in the Detroit Metro District.

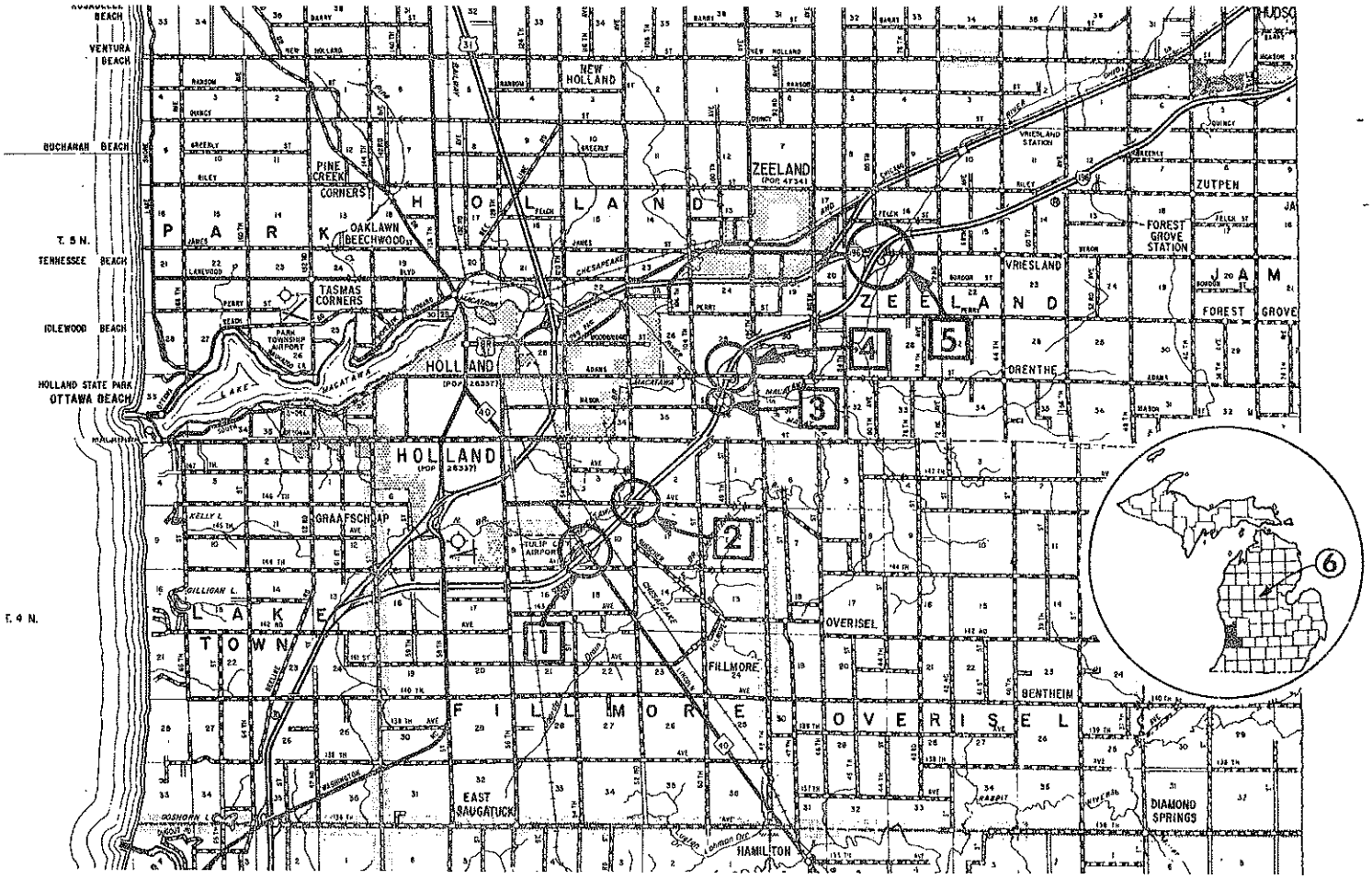
water spray, and dusting when the roadways are dry. This salt contamination has been found to occur in all our highway locations, i.e., urban, suburban, and rural. Figures 2 and 3 present the results of hundreds of debris samples that were removed from beam webs and flanges and tested for sodium chloride. Salt concentrations as high as 8 percent have been found on the unpainted beam flanges beneath leaking expansion joints. Salt concentrations as high as 3 percent have been found on beam flanges where roadway spraying and dusting were the only contamination sources. Saltwater runoff from Michigan's highways can have a sodium chloride concentration higher than that of seawater (3-1/2 percent). With this type of salt contamination, the weathering steel will not show any enhanced resistance to corrosion and represents a departure from the environmental conditions necessary for proper weathering performance.

Salt leakage through a bridge deck expansion joint is illustrated in Figures 4 through 6. As can be seen in these pictures, the saltwater runs for long distances along the beam flanges from the joints and coats cross bracing, diaphragms, and stiffeners in the vicinity of the joints. This type of salt contamination occurs on nearly all bridges regardless of location. Even many of the better types of bridge deck expansion joints which have been in service are beginning to leak after six or seven years of service life. As a result of this problem, around 1972, the Department initiated the policy of painting all steel surfaces within 5 ft of the expansion joint. A newer type of continuous joint has been used since October 1977 and has performed satisfactorily to date. However, the improvement of joint seals is not considered a reliable method for excluding saltwater from the unpainted steel.

Figure 7 illustrates how the capillarity of the rust coating on unpainted A588 steel draws the saltwater vertically up the web surfaces. This saltwater line is most prevalent where leaking joints admit runoff water to the bridge beams. Significant losses of metal thickness have occurred in the webs and flanges where this type of salt contamination has occurred.

The top surface of the bottom flanges on bridge beams accumulate corrosive debris from road dirt, salt, rust products shed from the webs, birds' nexts and droppings, and miscellaneous debris. This debris holds moisture on the flange surface for long periods of time and effectively prevents any chance for a protective rust coating to form. Figures 8 and 9 illustrate these conditions.

A specific problem is occurring at unpainted bridge cantilever expansion joints involving crevice corrosion and galvanic corrosion behind the suspender link plates and at the link pins. Crevice corrosion is an accelerated



	Bridge	Clearance	Year Built	Season Sampled (Year)	% NaCl	
					High	Low
1	M 40 over I 196	16 ft-6 in.	1972	Summer (1979)	2.1	0.15
2	146th Ave over I 196	16 ft-7 in.	1972	Summer (1979)	0.6	0.1
3	I 196 over Black River	----	1972	Summer (1979)	0.2	0.1
4	Adam Rd over I 196	16 ft-7 in.	1972	Summer (1979)	0.5	0.1
5	I 196 over 88th Ave	16 ft-10 in.	1972	Summer (1979)	0.6	0.2
6	US 10 Ramp 5 over I 75*	16 ft-7 in.	1973	Winter (1980)	7.5	0.1

* Not shown on map--rural bridge near Clare, Michigan.

Figure 3. Results of salt analyses of beam corrosion samples taken from bridges in the rural area around Zeeland, Michigan.

type of corrosion that occurs between two surfaces that are in close contact with each other in a corrosive environment. Its rate can be 10 to 100 times that of general corrosion. Galvanic corrosion is also an accelerated form of corrosion that occurs between two dissimilar metals placed in contact in a corrosive environment. Both of these situations occur behind the link plates on the cantilever expansion joint detail illustrated in Figure 10.

Crevice corrosion between the link plate and the beam end proceeds rapidly and results in the 'tight packing' of the space between the contact surfaces with a dense form of rust. This rust cannot be removed without disassembling the joint (Fig. 11). This rust packing, in combination with the link pins corroding tight to the link plate and beam holes, appears to prevent movement of the expansion joints and thus causes other structural damage to the bridge. This has occurred on unpainted bridges with seven years of service life. The Department's Maintenance Division removed the link plates on one such detail that had about 13 years of service. The condition of the web beneath the link plate is shown in Figure 12 before sandblasting and in Figure 13 after sandblasting and painting. Note in Figure 13 the outline of the link plate that has been imprinted into the beam end by the accelerated crevice corrosion.

The smooth ring outlined around the pin hole in Figure 13 occurred by galvanic corrosion action of the bronze washer that was used between the beam end and the link plates. Since bronze is cathodic (i.e., electrically positive) to steel when these two metals are placed in contact in a corrosive environment, the steel corrodes sacrifically to the bronze. This accounts for the sharp step that can be seen at the edge location of the bronze washer. Pit depths as much as 0.25 in. occurred in the beam end behind the link plates. The pin plates and pins were in such poor condition that we recommend that any maintenance work on this type of assembly include the replacement of link plates and pins, the coating of all joint surfaces with high performance coatings (such as zinc-rich epoxy with an epoxy topcoat) and the provision of some type of self-lubricating bushing between the link plate and pin. Some work has been done to evaluate the performance of the standard link plate and pin expansion detail on painted bridges. The two joints that have been disassembled show some of the same types of corrosion damage occurring. However, after about 20 years of service life the joints were not in as bad a condition as those of less than half that age in the unpainted condition. The detail is not a good one from a corrosion perspective, painted or unpainted, since it is impossible to maintain or lubricate it. We recommend the elimination of this detail whenever possible. The Department's Design Division is currently implementing this recommendation.

The effects of salt, sprayed and dusted on the bridge from highway traffic, are illustrated in Figures 14 and 15 for a bridge with 15 years of service life and Figures 16 and 17 for a bridge with 7 years of service life. This type of corrosion, where large sheets of rust build up and slough off, seems to have a periodic cycle that is related to the seasonal use of deicing salts. During the summer months a more normal rust layer may be observed in formation but the introduction of salt the next winter will penetrate this layer and again cause the sheet type failure. Any exposure of A588 steel that has previously developed a "tightly adherent patina" will not afford protection against corrosive contaminants since they can easily penetrate the rust layer and result in accelerated corrosion.

The most serious corrosion occurring due to salt contamination of unpainted A588 steel is pitting. Figure 18 illustrates the pitting typical of a beam flange exposed to seven years of service near a leaking expansion joint. The pit morphology presents a porous or honeycombed steel surface.

The presence of the pits will increase the likelihood of fatigue cracking since they represent significant stress raisers placed in the areas that are already the most susceptible to fatigue cracking, e.g., welds at the ends of cover plates. Experimental work on the fatigue life of corroded steel and weldments is currently being conducted at the University of Maryland in cooperation with the Maryland Department of Transportation and the Federal Highway Administration under the Federal HPR Program. Preliminary reporting (13, 14) of fatigue test results show a significant reduction of the fatigue life of welded specimens that were weathered under "ideal conditions" in the absence of any salt contamination. The reductions of fatigue life in the weathered specimens were attributed mainly to the formation of pits. Hence, we expect that the more severe pit formation we have observed in a salt-contaminated environment will have a greater effect in reducing the fatigue life of a welded detail. The effects of pitting, as seen in Figure 18, on the fatigue life of flange plate butt welded splices is also an area of concern. This condition is currently under study by the Maryland research project in both small specimen and full-scale beam tests. In addition, such surfaces present obstacles to the effective use of nondestructive testing techniques applied for flaw detection and evaluation or thickness measurements. This problem is critical in terms of inspecting pitted fillet welds (as illustrated in Figures 19 through 21) for fatigue cracks. This type of pitting on fillet welds makes it extremely difficult to apply visual, dye-penetrant, ultrasonic, magnetic particles, or X-ray inspection techniques.

At the recommendation of the weathering steel producers, the practice of leaving mill scale on the exposed, unpainted A588 beams except on fascia

beams was adopted by the Department (15). The practice has been to only remove mill scale from the fascia beams where appearance is important, thus giving a uniform, brown appearance. Since interior beams are not visible to traffic passing beneath a bridge, their appearance was not critical and thus mill scale could be left on and allowed to 'weather off.' The problem we have observed in the field is that the underlying base metal is corroding and sometimes pitting preferentially to the mill scale. This is to be expected because mill scale is cathodic to steel and hence a galvanic corrosion couple is established in the presence of moisture (16). Thus, any break or scratch in the mill scale becomes a line for selective attack of the base metal by the galvanic corrosion mechanism. Such pitting and selective corrosion appears to be serious enough in our field observations and laboratory testing that we would recommend the complete removal of mill scale from unpainted weathering steel, even in the absence of a salt-contaminated environment.

In the winter of 1979, the Department decided to perform some maintenance painting of A588 bridge steel to arrest corrosion at leaking joint areas. A contract to clean and coat 19 structures, 5 ft either side of the joint, was let during the summer of 1979. Assuming that these structures would clean and coat similar to our experience with ASTM A36 steel, a single component of inorganic zinc-rich coating with a vinyl topcoat was specified. There were, however, two characteristics of the salt-contaminated A588 steel that presented some difficult coating problems:

1) Pitting - Where saltwater remained on the steel for long periods of time (tops of flanges, in heavy rust or debris, or areas of small crevices around and behind hanger plates) the area was covered with small pits (1/64 to 1/4-in. deep) after seven years exposure (17). These pits were impossible to clean by the sandblasting applied due to their depth and small diameter. The steel was, however, blasted to an acceptable appearance for a near-white (SSPC-10) before coating. In at least one case, the inorganic zinc primer was left exposed without the topcoat for two weeks. At the end of this time, rust products were easily visible at the base of the pits indicating that even a near-white blast and a 2 to 3 mil coating of inorganic zinc had not arrested pit growth. It is anticipated that the vinyl topcoat will slow the corrosion process but it is obvious that coating life of the paint system will be significantly reduced.

2) The "Green Mold Phenomenon" - After the steel had been blasted to a near-white or better, the steel developed a moldy green appearance in pitted areas in very short periods of time (1/2-hour if the humidity was very high, 1 to 2 hours with a 60 to 80 percent relative humidity). In most cases, the inspectors would not allow these surfaces to be painted and required

that they be reblasted. Figures 22 through 24 show the steel before reblasting, after reblasting, and again just before coating. The humidity was about 70 to 80 percent at 1:00 a.m. on a warm summer night. It was very difficult to blast, clean up the sand, and get back up to coat the steel before these corrosion products became visible.

In discussing this phenomenon with a corrosion engineer, he expressed the opinion that it was due to the copper in A588 which migrates to the surface and is highly activated by the blasting operation. The activated copper reacts very quickly with chloride to form copper salts (hence, the green color) under the right humidity conditions.

There are no data available as to what effect the above conditions will have on the coating life but it is generally assumed that they will significantly shorten it. The Research Laboratory is proceeding to test various coating systems over environmentally pitted A588 and salt-fog pitted A588 steel. The experimental systems include:

1) a no-lead alkyd (four coat),
2) an aluminum-filled epoxy mastic (one coat),
3) a single component inorganic zinc with a vinyl topcoat (two coat),
4) a two-component inorganic zinc with an epoxy topcoat (two coat),
5) a single component organic zinc with an epoxy topcoat (two coat),
6) a water-based inorganic zinc with an epoxy intermediate coat and an aliphatic urethane topcoat (three coat), and
7) several zinc-rich epoxies with epoxy topcoats (two coat).

The results should indicate whether laboratory contaminated panels and environmentally contaminated panels are similar and which coating system best retards corrosion on salt-contaminated steel. It is very difficult to obtain environmentally salt-contaminated steel for test purposes since it must be removed from the joint area of a bridge (a very expensive operation). Additional samples should be available in the summer of 1980 and at that time the conditions necessary for, and the effects of, the "green mold phenomenon" will be documented.

Research Conclusions

Field observations of over 50 bridges constructed of unpainted A588 steel in Michigan's freeway system have identified many corrosion problems. Most of the problems are related to the sheltered nature of the underside of bridges and the contamination of the unpainted steel by deicing salt (sodium chloride). The salt accumulations on Michigan's bridges in both urban and rural locations are high enough to cause corrosion and pitting

of the steel and weldments. Some additional problems exist at selected locations where crevice corrosion, galvanic corrosion, and debris accumulation are accelerating corrosion damage. These observations have resulted in the conclusion by the Department that the unpainted bridges must be maintenance painted to assure the 50-year design life of the structures.

Because such corrosion problems are occurring, it is no longer economically justifiable to omit the initial painting. A properly applied coating system of inorganic zinc with a vinyl topcoat should extend the service life to 20 years or more before the first maintenance coating is required. In view of the difficulties of coating a bridge in the field, with the traffic control and environmental problems that exist, it is not cost effective to omit the initial coating of A588 steel. The total 'service life cost' of a bridge will be lower in the Michigan freeway environment if the steel is coated initially. Since new bridge structures will be painted before being put into service, a design change to ASTM A572, Grade 50 steel has been implemented where possible. This steel has the same strength as A588 in thicknesses of 2 in. or less.

In addition to the foregoing considerations of service life coating costs, a potential exists for high maintenance costs on unpainted A588 bridges due to the structural damage being caused by corrosion. One such area has already been identified, i.e., the need to replace hanger plates and pins on bridges with the cantilever expansion joint detail. Due to the damaging effects of salt, coupled with crevice corrosion and galvanic corrosion, such joints have been rendered inoperable in 14 years. Another potential for structural degradation related to corrosion is the reduction of the fatigue life of welded details due to pitting. This type of damage could lead to repair work on bridges where sufficient traffic volume exists to generate such fatigue failures.

The need for maintenance painting on Michigan's existing unpainted A588 bridges has been established. Based on the observations of the effects of saltwater, it is recommended that a program be scheduled to maintenance coat all bare weathering steel structures. The highest priorities should be assigned on the basis of age, location (urban, suburban, or rural), and traffic volumes under and over the structure. Traffic volume is very important because it affects the amount of salt applied to the highway, the intensity of salt spray contamination, and the fatigue cycle life of the bridge. The Appendix contains a listing of all the unpainted A588 bridges belonging to the Michigan Department of Transportation, grouped by District. From this list and other information available on the structures, a logical coating priority listing will be generated.

Recommendations for Future Research

The current research project (78 G-241) will be continued by the MDOT Research Laboratory. This future work will be under the direction of C. J. Arnold, Supervising Engineer of the Structural Mechanics Group, for the corrosion damage evaluations of existing structures, and G. L. Tinklenberg, Coatings Chemist of the Coatings, Sealers, and Plastics Group, for the experimental work required on cleaning and coating of salt-contaminated steel. The major research areas that need to be investigated (but will not necessarily be included in the Michigan project) are:

1) Effects of corrosion pitting on the fatigue life of welded details,

2) Development of effective ways of cleaning and coating salt contaminated bridge steel,

3) Quantification of corrosion damage in terms of beam section losses and pitting damage,

4) Development of nondestructive testing techniques that can be applied to corroded and pitted A588 steel weldments.

The Michigan DOT is currently working in several of these areas, but due to limitations of personnel and test equipment capabilities, studies by other research organizations are urgently needed.

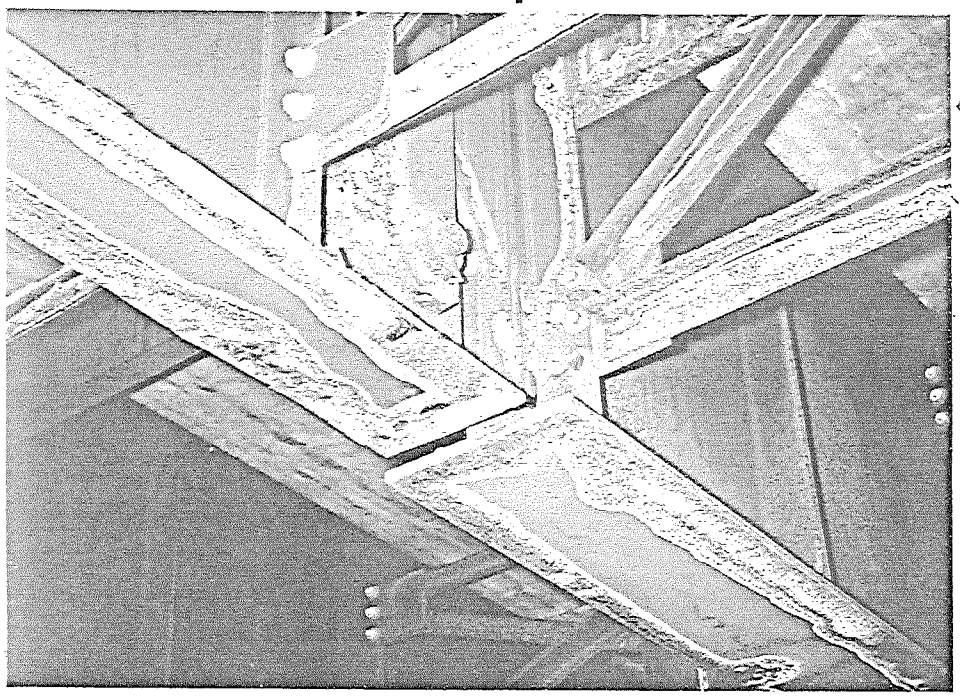


Figure 4. Salt deposits on unpainted steel under a leaking expansion joint.

Figure 5. Saltwater runs along unpainted beams for long distances from the leaking joint.

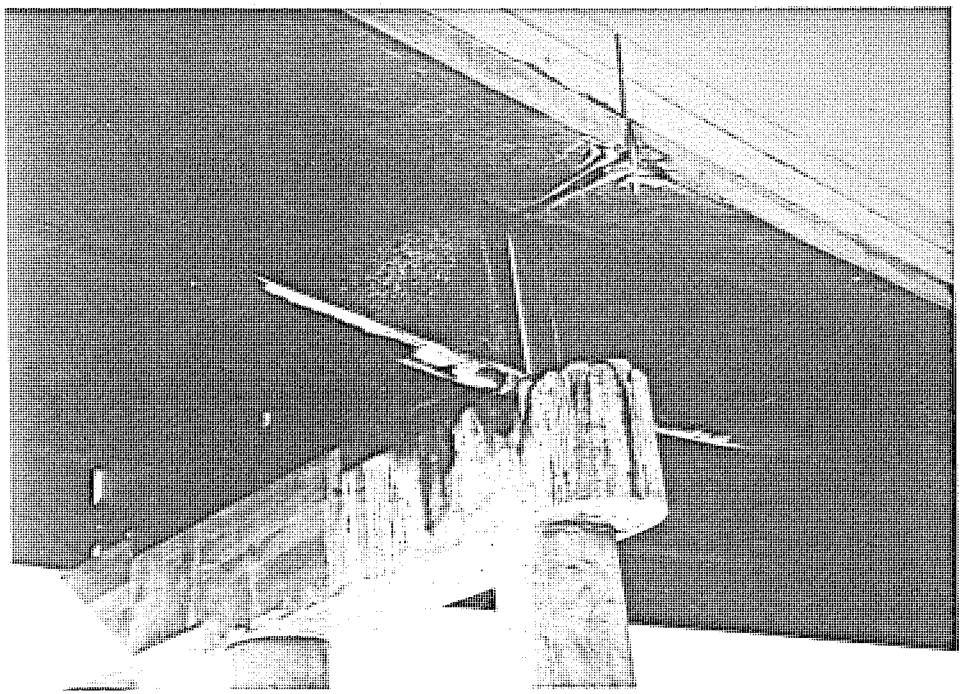


Figure 6. Saltwater leakage on a rural bridge after seven years of service.

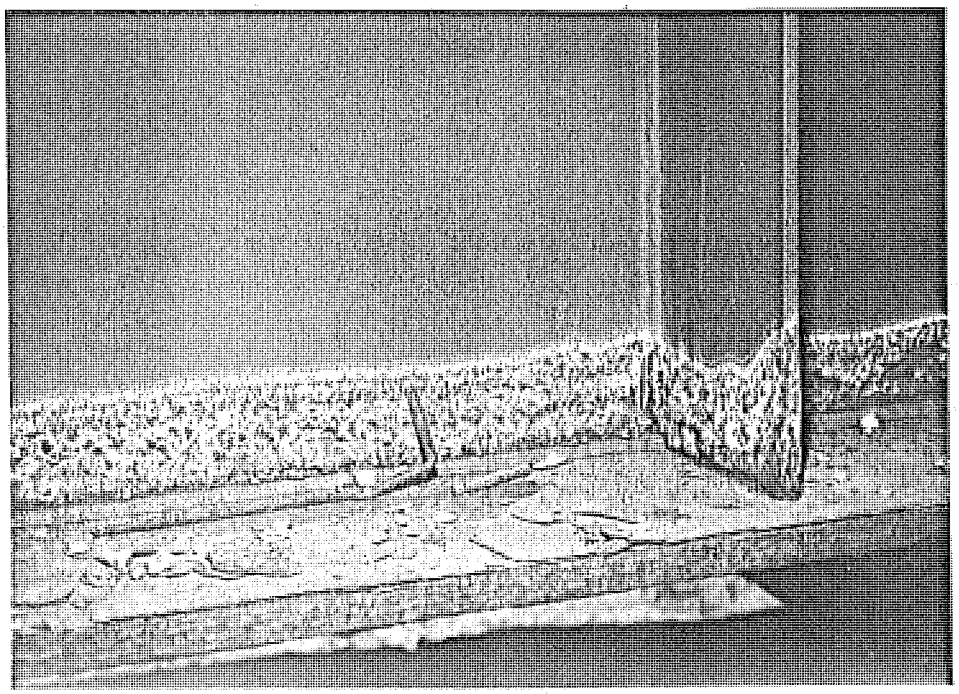


Figure 7. Capillarity of the rust patina on A588 steel causes saltwater to migrate up the vertical surfaces on beam webs as high as 10 in.

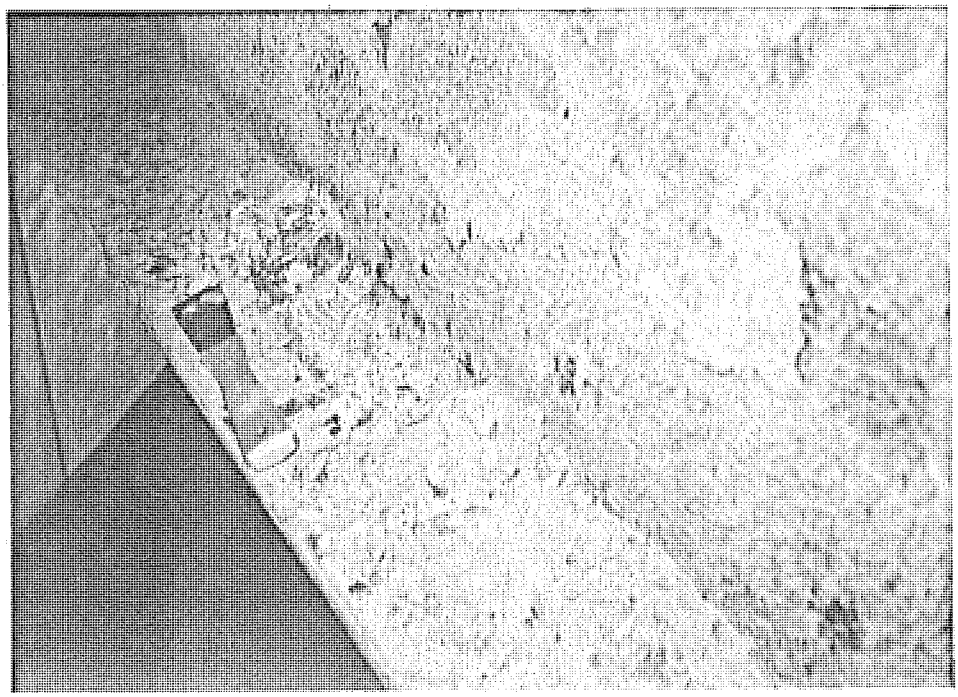


Figure 8. Rust products and salt collecting on the top of a beam flange as they are shed from the web. Corrosion pictured is due to traffic spray of saltwater (side opposite traffic).

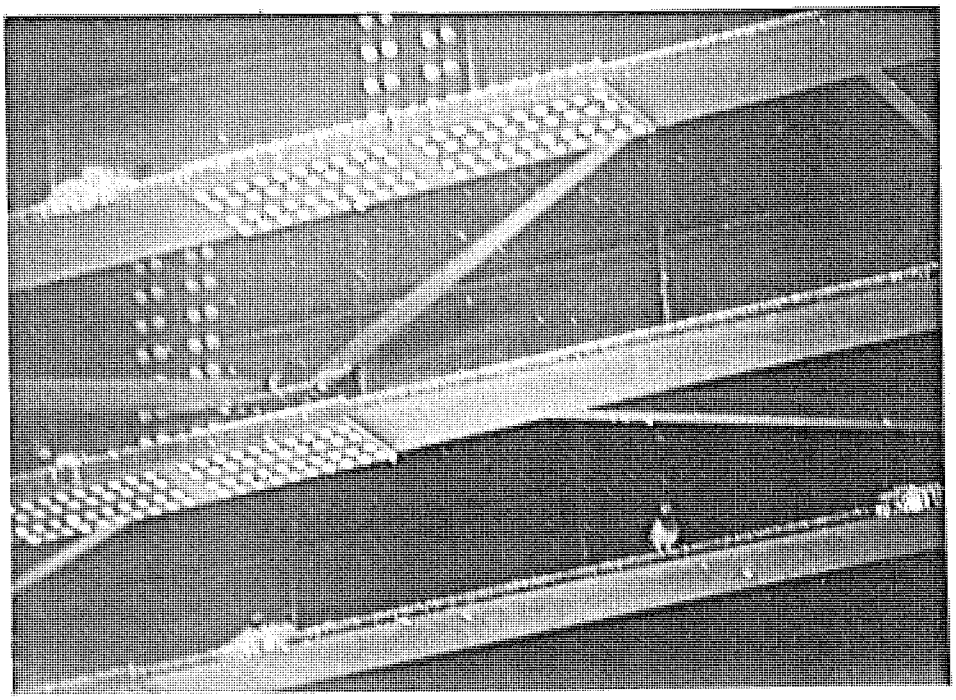


Figure 9. Bird nests on beam flanges of a high level unpainted A588 bridge.

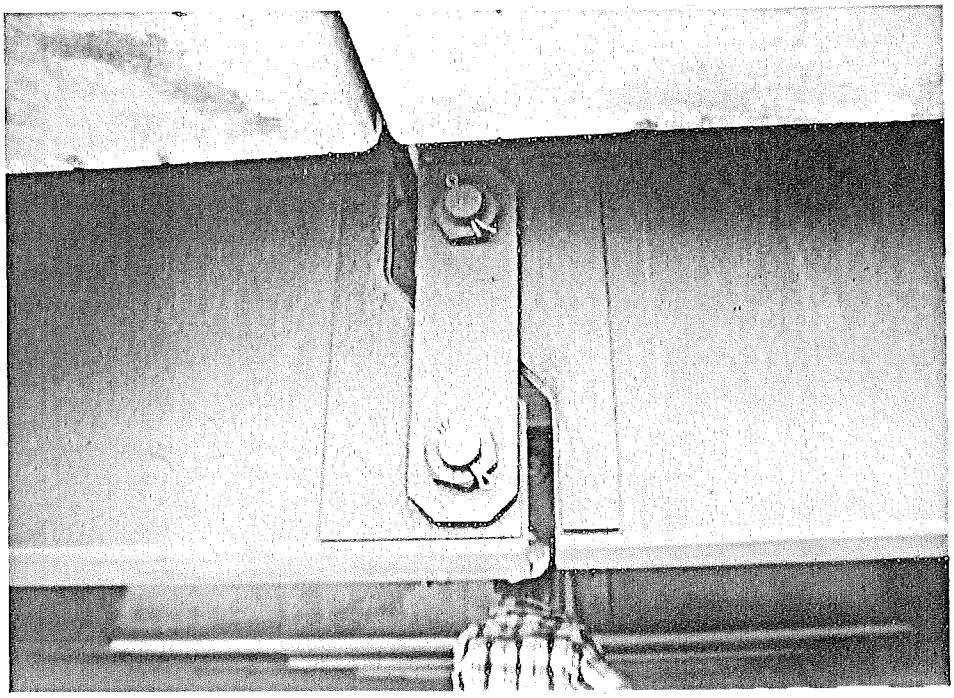


Figure 10. Cantilever expansion joint detail showing the link plate and link pin assembly.

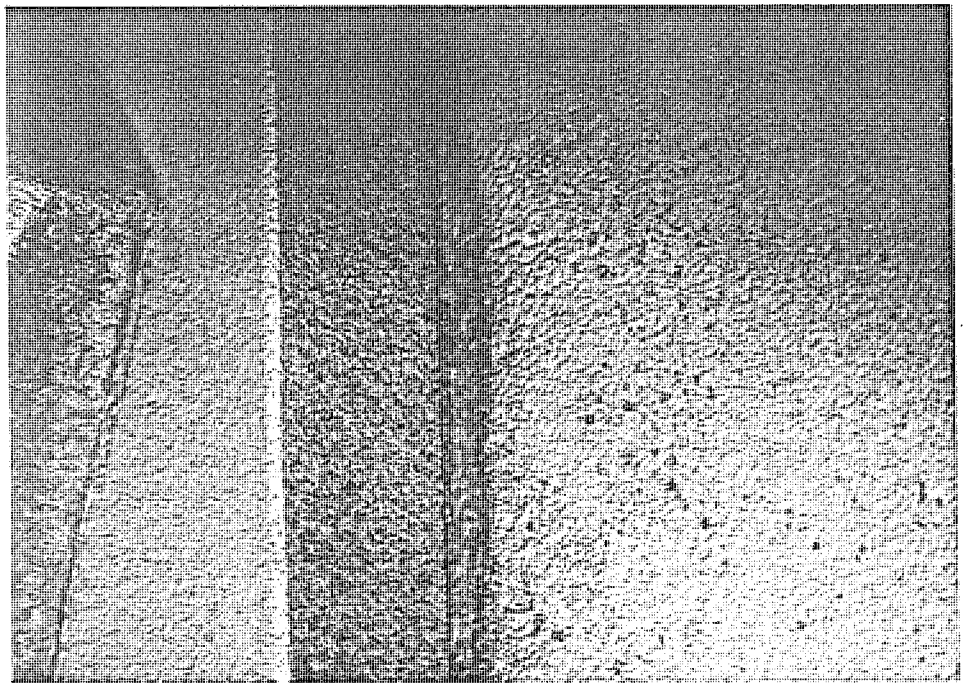
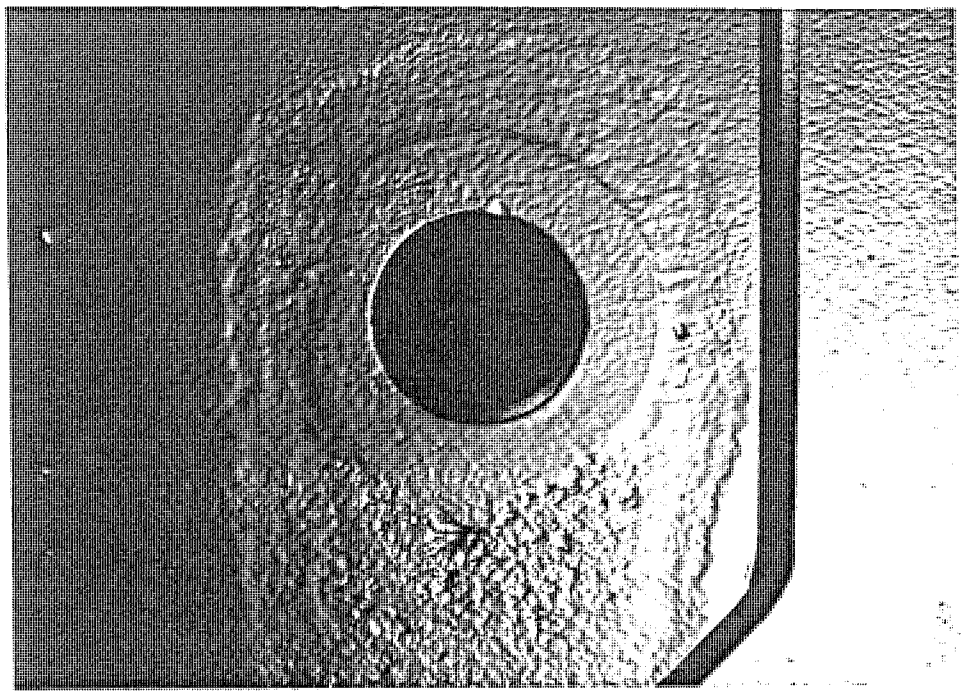


Figure 11. Pack rust behind the link plate on a seven-year old expansion joint. Rust could not be removed by sandblasting and helps to fix the movement of the expansion joint.



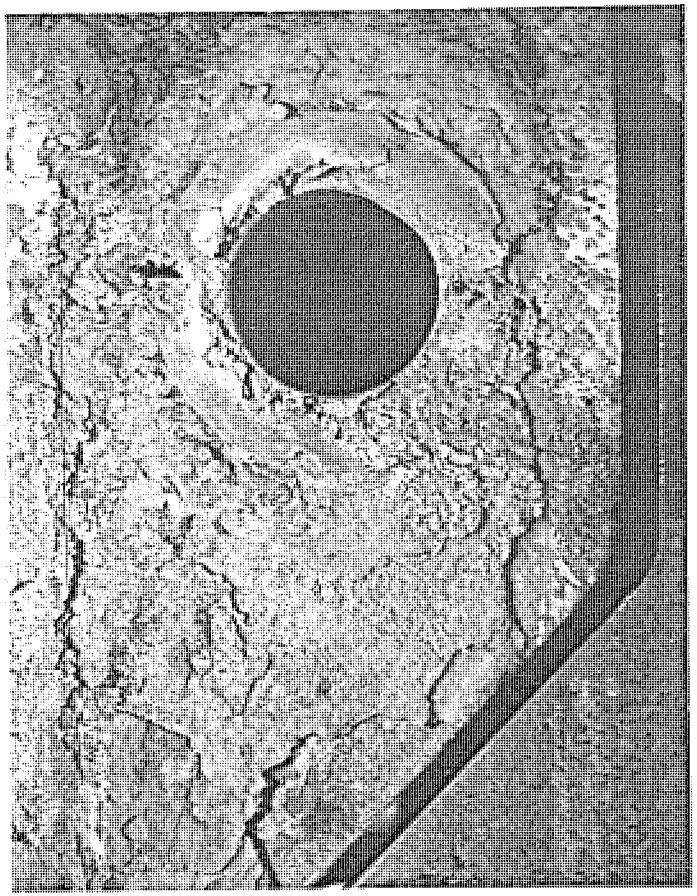


Figure 12. Pack rust deposits left on beam end after the link plate and pin were removed with a cutting torch.

Figure 13. Beam end after sandblasting and painting the area behind the link plate in Figure 12. Note the effects of crevice corrosion and galvanic corrosion behind the plate.

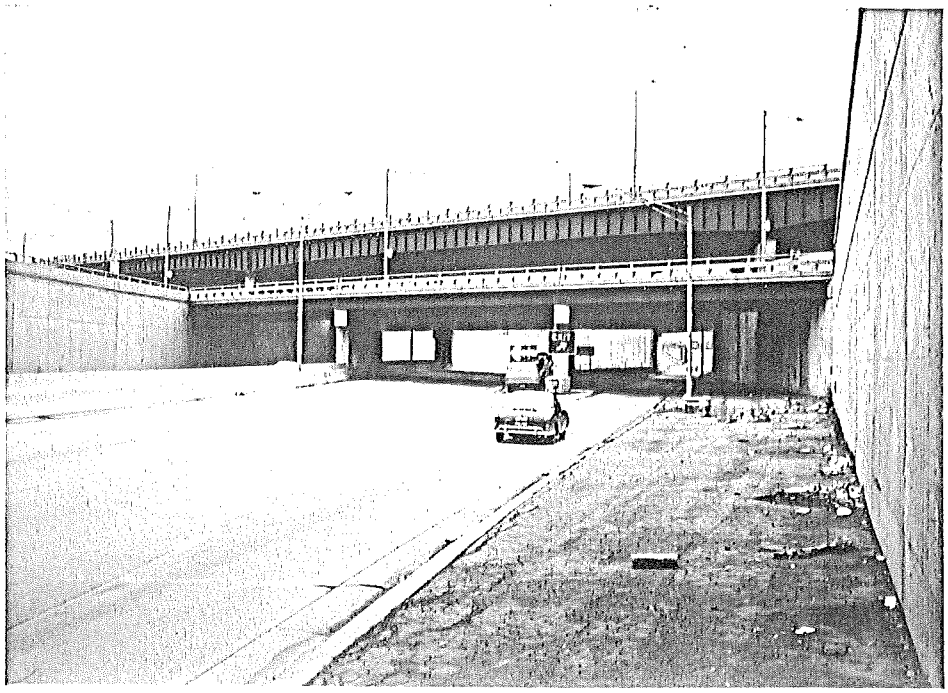


Figure 14. Geometry of bridge (lower structure) where salt spraying and dusting contaminates the unpainted steel.

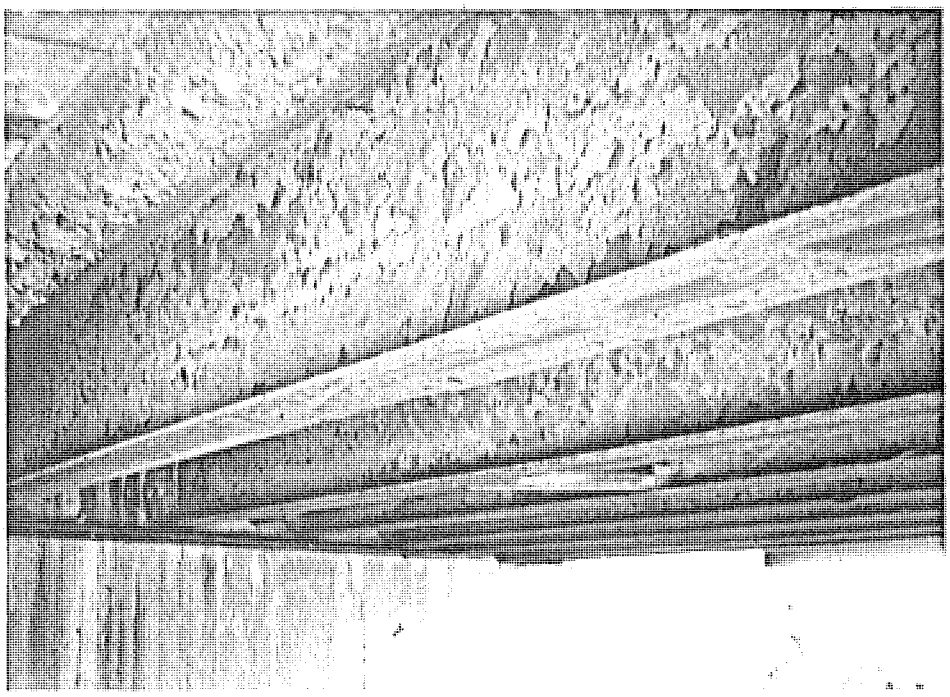
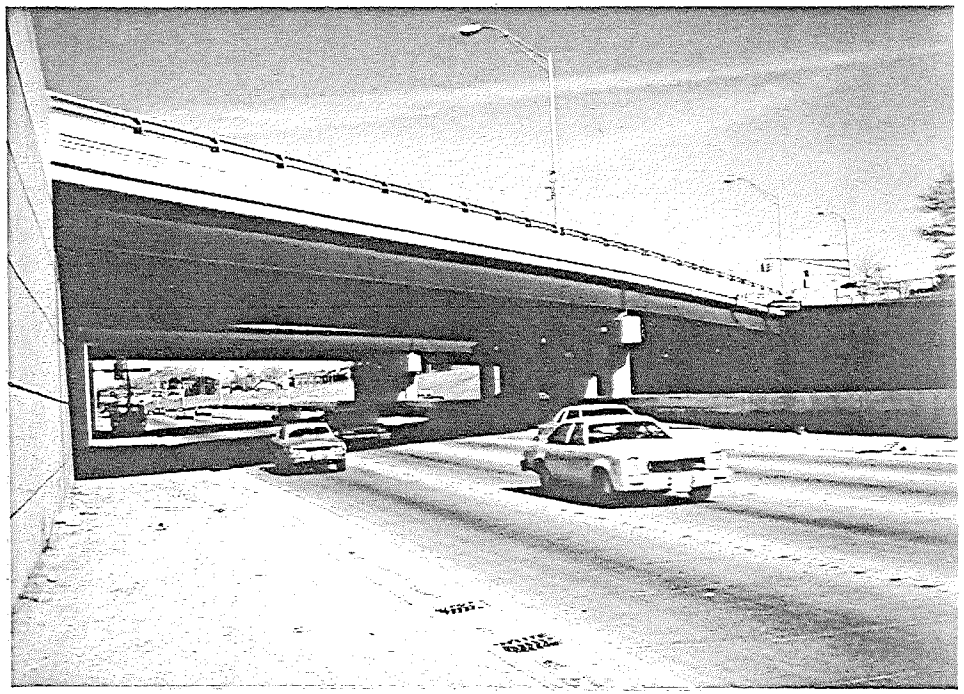


Figure 15. Appearance of steel on one end of bridge in Figure 14 after 15 years of service.

Figure 16. Geometry of bridges in an urban freeway where salt spraying occurs. Note the good appearance of the fascia beams where washing by rainwater occurs.



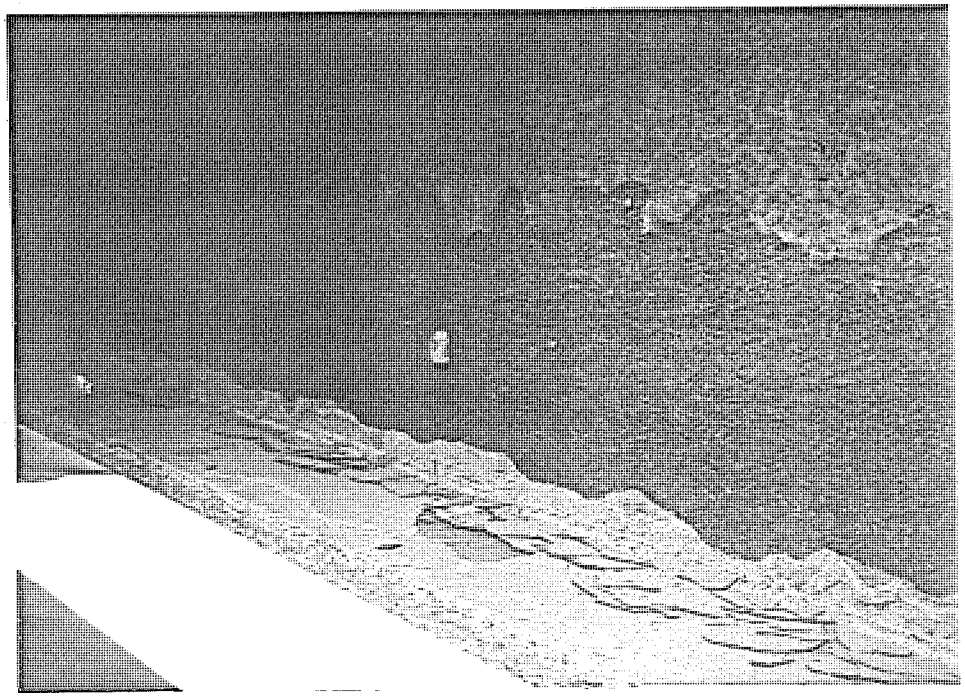
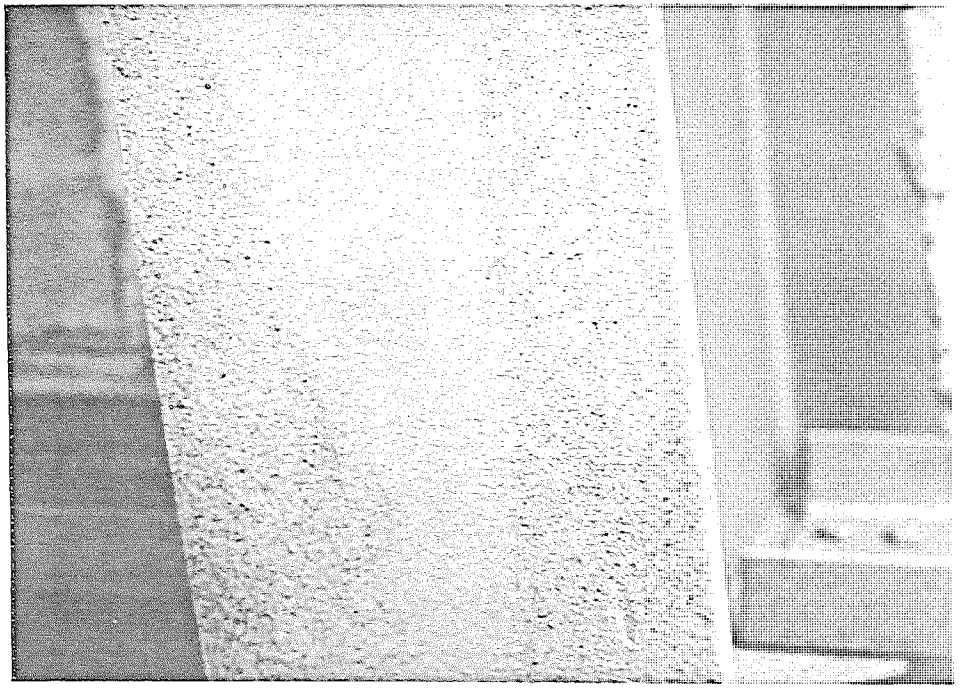


Figure 17. Appearance of interior beam on side facing traffic. (Bridge shown in Figure 16 after seven years of service.)

Figure 18. Pitting of beam flange caused by saltwater from a leaking expansion joint.



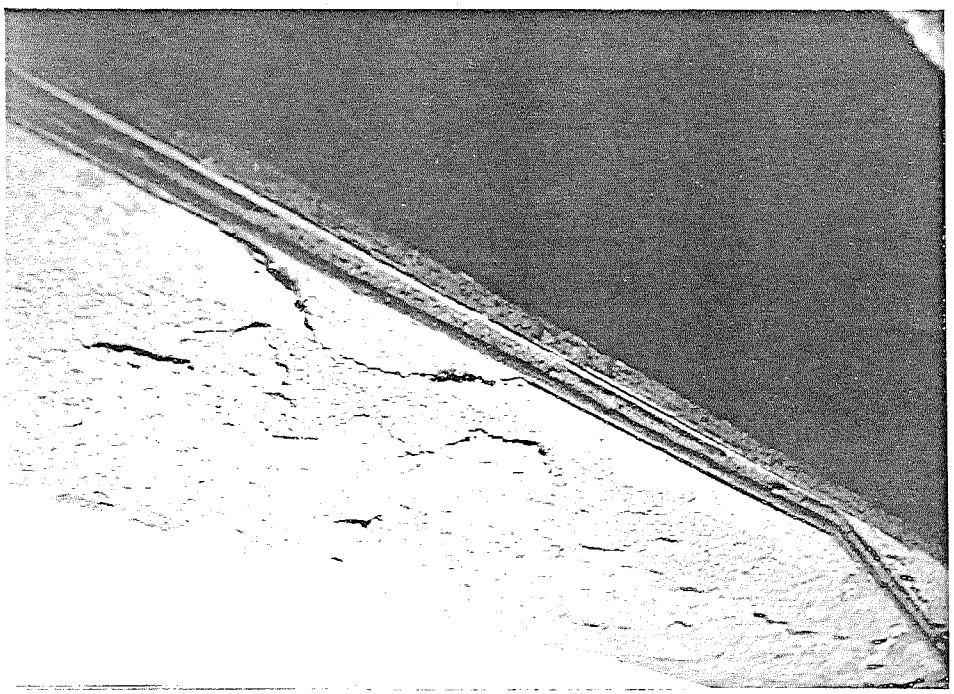


Figure 19. Corrosion of welded cover plate detail due to salt spraying after 14 years of service.

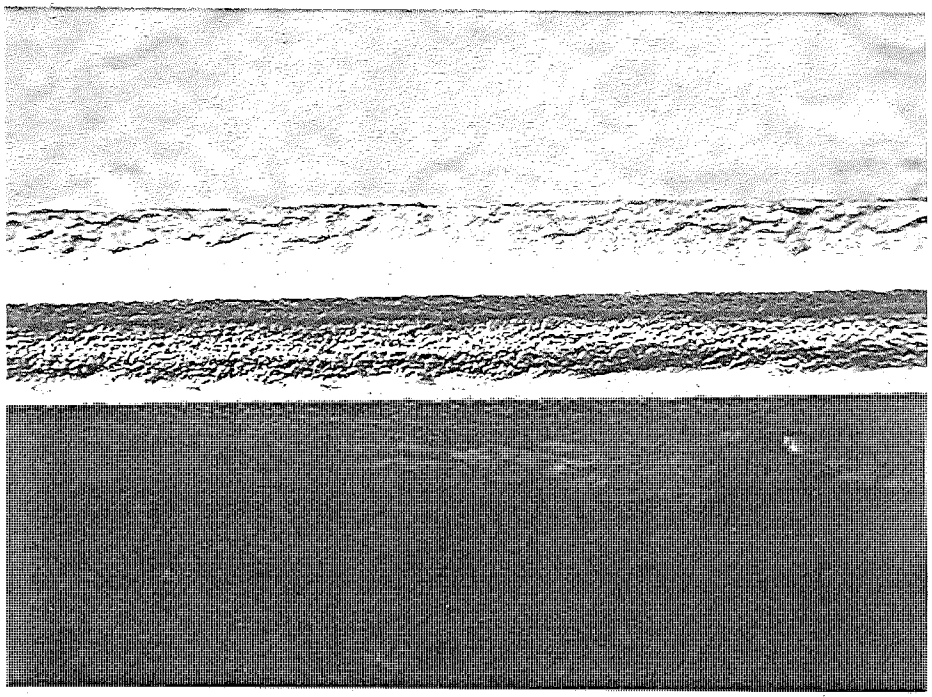


Figure 20. Wire-brushed fillet weld on a beam cover plate showing pitting after 14 years of service.

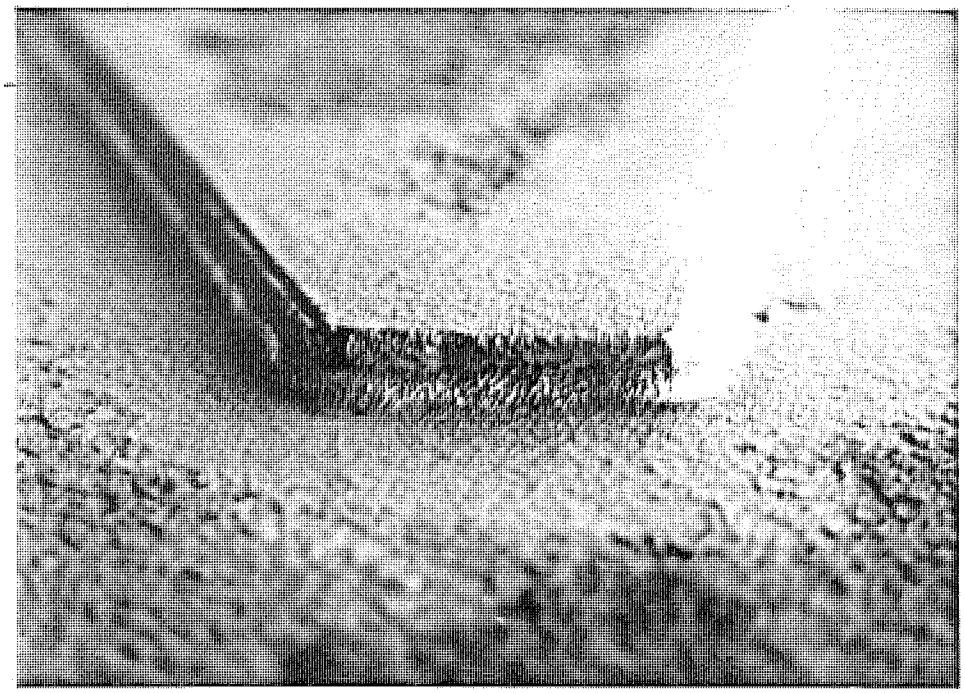


Figure 21. Pitting of fillet weld at the end of a beam cover plate.

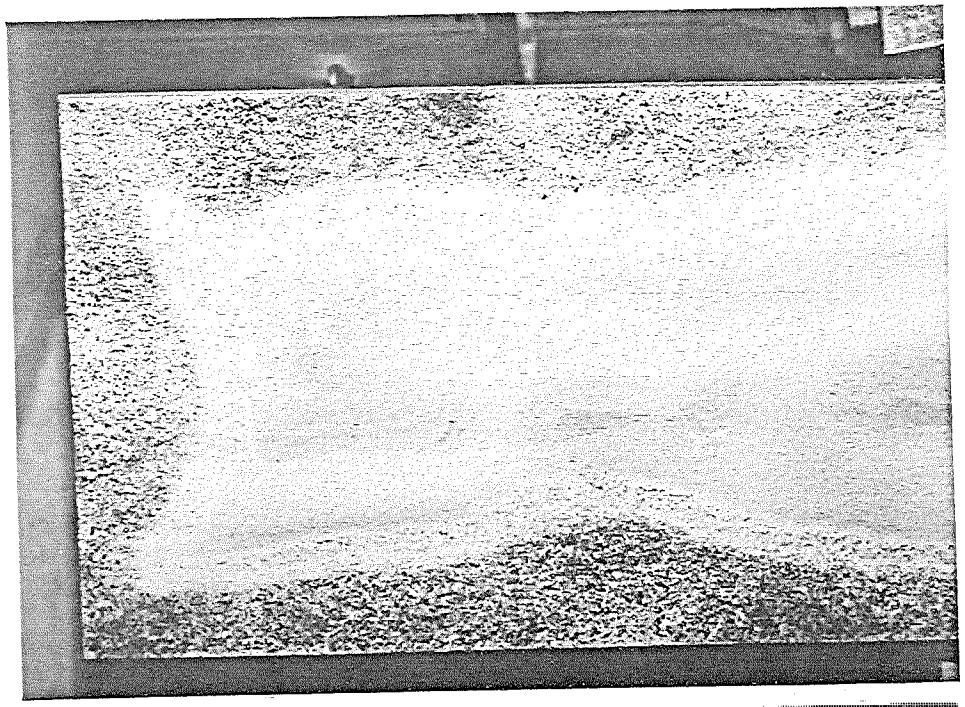


Figure 22. The "green mold phenomenon" of a blasted flange surface just before reblasting.

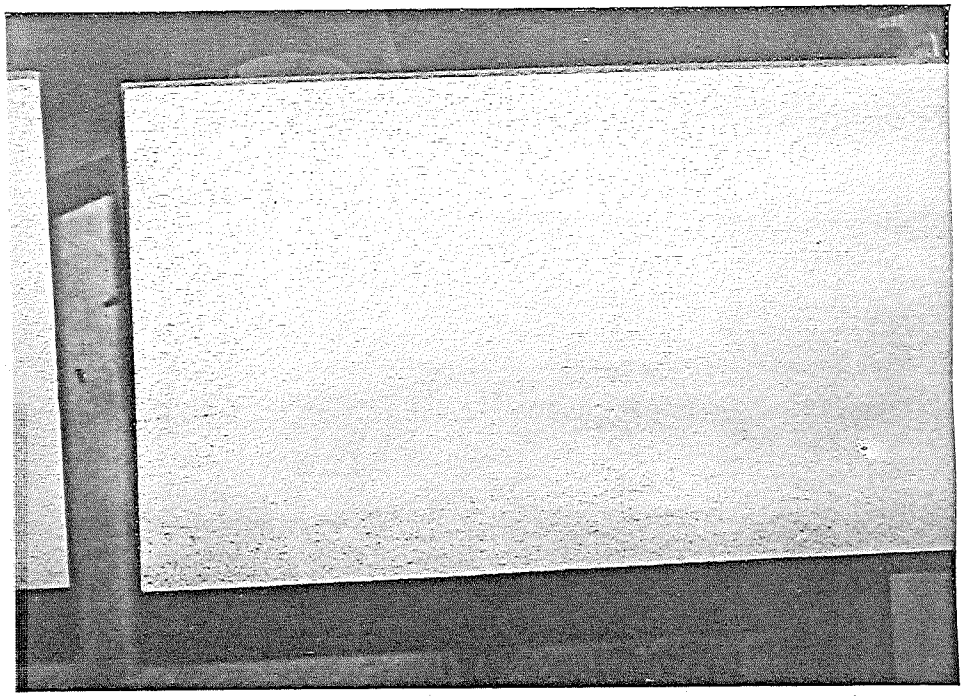


Figure 23. Condition of flange pictured in Figure 22 after a second blasting.

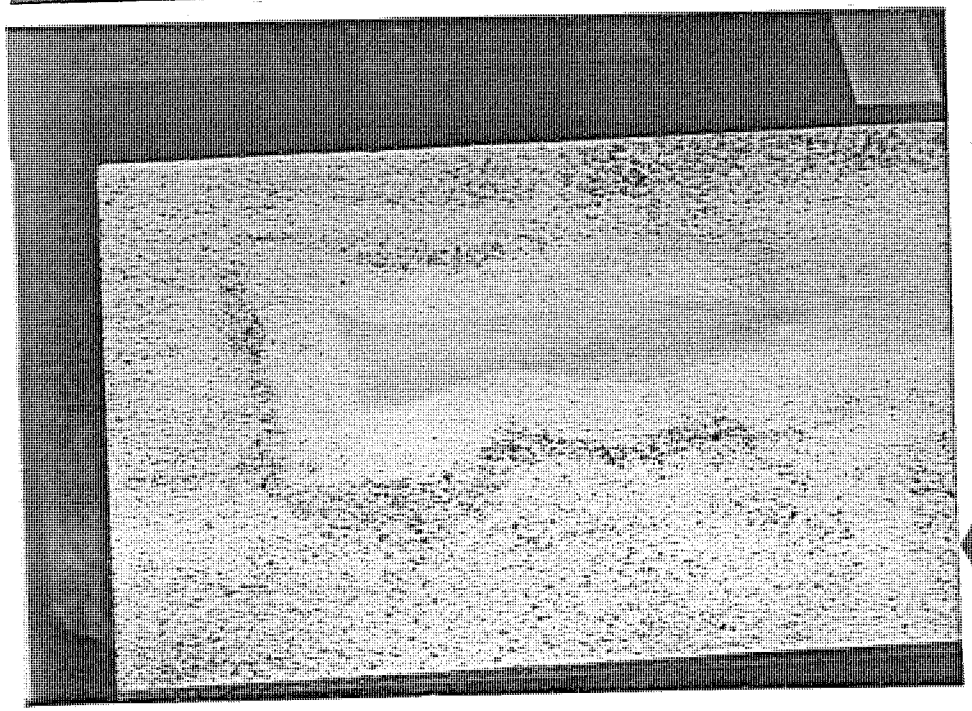


Figure 24. Typical condition of a flange after reblasting and just before coating.

REFERENCES

1. 1980 Annual Book of ASTM Standards - Part 4, American Society for Testing and Materials, Philadelphia, PA, 1980, p 566.

2. Bethlehem Steel Corp., "Weathering Steel, a 'Natural' Alternative to the High Cost of Paint Maintenance," Engineering News-Record, Vol. 204, No. 6, February 7, 1980, pp 40 DO - 40EO.

3. United States Steel, "Bare Steel: A New Factor in Mississippi Bridge Design," Engineering News-Record, Vol. 204, No. 7, February 14, 1980, pp 90-91.

4. United States Steel, "Steel Box-Girder Bridges Complement the Natural Beauty of Vail Pass, Colorado," Civil Engineering, Vol. 49, No. 10, October 1979, pp 6-7.

5. "Mayari R - Weathering Steel for Bridges," Booklet 2858, n.d., Bethlehem Steel Corp., Bethlehem, PA, p 23.

6. Zoccola, J. C., "Eight Year Corrosion Test Report Eight-Mile Road Interchange," 1801-1e, TZ-34-75019, April 5, 1976, Bethlehem Steel Corp., Bethlehem, PA, p 2.

7. Brockenbrough, R. L., and Schmitt, R. J., "Considerations in the Performance of Bare High-Strength Low-Alloy Steel Transmission Towers," C 75 041-9, a paper presented at the IEEE Power Engineering Society Winter Meeting, January 26 - 31, 1974, United States Steel Corp., Monroeville, PA.

8. Cassidy, Donald P., "Coated Sheet Steels Combat Corrosion," Metal Progress, Vol. 116, No. 5, October 1979, p 77.

9. Komp, M. E., and Mathay, W. L., "Steels for the Pulp and Paper Industry," Materials Performance, Vol. 16, No. 6, June 1977, p 27.

10. Wonders, H. W., "15-Year Data on the Performance of Painted Cor-Ten and Carbon Steels in a Marine Atmosphere," 10-F-015(005-2), June 29, 1976, United States Steel Corp., p 2.

11. "Mayari R - Weathering Steel for Bridges," Booklet 2858, n.d., Bethlehem Steel Corp., Bethlehem, PA, p 7.

12. Fletcher, E. E., High-Strength, Low-Alloy Steels: Status, Selection and Physical Metallurgy, Battelle Press, Columbus, OH, 1979, p 71.

13. Friedland, I., Albrecht, P., and Irwin, G. R., "Fatigue Behavior of 2-Year Weathered A588 Steel Specimens with Stiffeners and Attachments," October 1979, University of Maryland, Department of Civil Engineering, College Park, MD.

14. Albrecht, P., and Friedland, I., "Preliminary Fatigue Test Data for a Weathered A588 Weldment," FHWA-MD-R-78-7, July 1978, Maryland Department of Transportation, Booklandville, MD.

15. "Mayari R - Weathering Steel for Bridges," Booklet 2858, n.d., Bethlehem Steel Corp., Bethlehem, PA, p 13.

16. United States Steel Corp., "The Making, Shaping, and Treating of Steel," Herbick and Held, Pittsburgh, PA, 1971.

17. McKenzie, M., "The Corrosion Performance of Weathering Steel in Highway Bridges," Report 837, 1978, Transport and Road Research Laboratory, Crowthorne, England.

FURTHER REFERENCES

Cosaboom, B., Mehalchick, G., and Zoccola, J. C., "Bridge Construction with Unpainted, High-Strength, Low-Alloy Steel: Eight Year Progress Report," 79-001-7799, February 1979, New Jersey Department of Transportation, Trenton, NJ.

"Paint R.A. Examines Paint Performance on Cor-Ten Steel," PRA Newsletter, No. 15, January 1980.

Cosaboom, B., Kozlov, G. S., and Zoccola, J., "Atmospheric Corrosion Tests of Unpainted Steels for Use in Construction of Highway Bridges," Highway Research Record, No. 287, 1969, Highway Research Board, Washington, D.C.

"Corrosion Failures," Metals Handbook - Vol. 10, 8th ed., American Society for Metals, Metals Park, OH, 1975, pp 173-174.

APPENDIX

LISTING OF UNPAINTED WEATHERING STEEL BRIDGES IN MICHIGAN BY DISTRICT

	Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
				District 1				
1	B02 - 52042	1017	US 41	over Carp River	SMS 332	73	A588	
	B01 - 66061	2600	M 107	over Union River	SMS 332	75	A588	
	B02 - 36021	0679	US 2	over S. Branch of Iron River	SMS 332	76	A588	
	B04 - 52041	2690	US 41	over Carp River in Ishpeming	SMSC 332	79	A588	
	X01 - 52041	2691	US 41 and M 28	over L.S.&I. R.R. at West Limits of Ishpeming	SMSC 332	79	A588	
				District 2				
2	B03 - 02041	0032	M 28	over Rock River	SMS 332	32 & 75	A588 Widened Steel	
	B02 - 02041	0033	M 28	over AuTrain River	SMS 332	32 & 75	A588 Widened Steel	
	B01 - 17063	0245	M 28	over W. Branch Waiska River	SMH 332	75	A588	
	B01 - 17051		M 221	over Waiska River	SMH 382	77	A588	
	B01 - 48032	2660	M 123	over the West Branch of Tahquamenon River, 1.3 miles north of Newberry	SMC 332	78	A588	
	X01 - 75022	2692	US 2	over Soo Line R.R., 2 miles east of Manistique	SMSC 332	79	A588	
				District 3				
3	S01 - 18024	2259	US 10 WB	over M 115, Farwell	SMH 382	73	A588	Fel-Span
	S02 - 18024	2260	US 10 EB	over M 115, Farwell	SMH 382	73	A588	Fel-Span
	S05 - 18024	2261	US 10	under Old State Road	SMH 332	73	A588	Fel-Span
	S07 - 18024	2262	US 10	under Harrison Road	SMH 332	73	A588	Type 190
	S09 - 18024	2263	US 10	under Grant Road		73	A588	Type 190
	S11 - 18024	2264	US 10 WB	over US 27	SMH 382	73	A588	
	S12 - 18024	2265	US 10 EB	over US 27	SMH 382	73	A588	
	X01 - 18024	2266	US 10 WB	over Ann Arbor RR	SMH 332	73	A588	Fel-Span
	X02 - 18024	2267	US 10 EB	over Ann Arbor RR		73	A588	Fel-Span
	B01 - 57023	2584	M 55	over Clam River	SMG 382	73	A588	
	B01 - 67062	2411	M 61	over Muskegon River	SMH 332	73	A588	
	S03 - 67015	2601	US 131	under Rose Lake Road	SMH 382	75	A588	
	S04 - 67015	2602	US 131 SB	under Marion Road	SMG 382	75	A588	
	S05 - 67015	2603	US 131 NB	under Marion Road	SMG 382	75	A588	
	X02 - 83031	2629	US 131	over Penn Central RR	SMH 332	75	A588	
				District 4				
4	X01 - 71091	9000	US 23 BR	over Mich. Limestone Access Route	SMG 432	75	A588	
				District 5				
5	B01 - 70024	2364	I 196 EB	over Black River	SMH 332	72	A588	Transflex
	B02 - 70024	2365	I 196 WB	over Black River		72	A588	Transflex
	B03 - 70024	2366	I 196 EB	over Black River	SMH 332	72	A588	Transflex
	B04 - 70024	2367	I 196 WB	over Black River		72	A588	Transflex
	S01 - 70024	2368	I 196	under Adams Road	SMH 382	72	A588	Transflex
	S02 - 70024	2369	I 196 EB	over 96th Ave.	SMG 382	72	A588	
	S03 - 70024	2370	I 196	under 88th Ave.	SMH 382	72	A588	Transflex
	S04 - 70024	2371	I 196 EB	over Byron Road	SMH 382	72	A588	Transflex
	S05 - 70024	2372	I 196 EB	over 64th. Ave.	SMG 382	72	A588	
	S06 - 70024	2373	I 196 WB	over 64th. Ave.	SMG 382	72	A588	
	S14 - 70024	2381	I 196 WB	over 96th. Ave.	SMG 382	72	A588	
	S15 - 70024	2382	I 196 WB	over Byron Road	SMH 382	72	A588	Transflex
	S01 - 64014	2383	US 31 SB	over US 31 Existing	SMG 382	73	A588	Type 190
	S02 - 64014	2384	US 31	under Webster Road	SMH 382	73	A588	Fel-Span
	S03 - 64014	2385	US 31	under Winston Road	SMH 382	73	A588	Type 190
	S05 - 64014	2386	US 31 SB	under Park Road	SMG 382	73	A588	Type 190
	S06 - 64014	2387	US 31 NB	under Park Road		73	A588	Type 190
	S07 - 64014	2388	US 31	under Garfield Road	SMG 382	73	A588	Fel-Span
	X01 - 64014	2390	US 31 SB	over C & O RR	SMH 332	73	A588	Type 190
	X02 - 64014	2391	US 31 NB	over C & O RR	SMH 332	73	A588	Type 190

Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
S08 - 64014	2389	US 31 NB	over Old US 31		74	A588	Type 190
S01 - 64015	2587	US 31 SB	under Hayes Rd.	SMH 382	75	A588	Delastic
S02 - 64015	2588	US 31 NB	under Hayes Rd.	SMH 382	75	A588	Delastic
S03 - 64015	2589	US 31 SB	over Grant Rd.	SMH 332	75	A588	Delastic
S04 - 64015	2590	US 31	under Shelby Rd.	SMH 382	75	A588	Fel-Span
S06 - 64015	2591	US 31 SB	over Buchaman Rd.	SMH 332	75	A588	Delastic
S07 - 64015	2592	US 31 NB	over Buchaman Rd.	SMH 332	75	A588	Delastic
S08 - 64015	2593	US 31	under Taylor Rd.	SMH 332	75	A588	Waboflex
S09 - 64015	2594	US 31 NB	over Polk Rd.	SMH 382	75	A588	
S17 - 64015	2596	US 31 NB	over Grant Rd.	SMH 332	75	A588	Delastic
S18 - 64015	2597	US 31	over Polk Rd.	SMG 382	75	A588	
X01 - 64015	2598	US 31 SB	over C & O RR	SMH 332	75	A588	Waboflex
X03 - 64015	2599	US 31 NB	over C & O RR	SMH 332	75	A588	Waboflex
S10 - 64015	2595	US 31	under Taylor Rd.	SMH 332	76	A588	
X01 - 41051		M 44	over G. T. W. RR	SMH 332	77	A588	
B01 - 64015	2633	US 31 SB	over South Branch of Pentwater River	SMH 332	77	A588	
B02 - 64015	2634	US 31 NB	over South Branch of Pentwater River	SMH 332	77	A588	
S12 - 64015	2635	US 31 SB	over Wayne Rd, 2.5 miles northwest of Hart	SMG 382	77	A588	
S13 - 64015	2636	US 31 NB	over Wayne Rd, 2.5 miles northwest of Hart	SMG 382	77	A588	
S14 - 64015	2637	US 31 SB	over Monroe Rd, 4 miles north of Hart	SMG 382	77	A588	
S19 - 64015	2638	US 31 NB	over Monroe Rd, 4 miles north of Hart	SMG 382	77	A588	
S03 - 41051	2647	M 37	over Entr. to Calvin College, Grand Rapids	SMS 332	78	A588	
S16 - 59012	2648	US 131 (reloc.)	under Cutler Rd, 4 miles northwest of Howard City	SMH 382	78	A588	
B01 - 41014	2659	US 131 BR	over the Grand River in Grand Rapids	SCG 482	78	A588	
S01 - 54013	2661	US 131 SB	under Jefferson Rd, 2.0 miles west of Morley	SMG 382	78	A588	
S02 - 54013	2662	US 131 NB	under Jefferson Rd, 2.0 miles west of Morley	SMG 382	78	A588	
S05 - 54013	2663	US 131 SB & NB	under 4 Mile Rd, 3 miles northwest of Morley	SMH 332	78	A588	
B03 - 54013	2664	US 131 SB	over the Little Muskegon River	SMG 482	78	A588	
B04 - 54013	2665	US 131 NB	over the Little Muskegon River	SMG 482	78	A588	
S15 - 64015	2667	US 31 (reloc.)	under Hammett Rd, 3/4 mile east of east limits of Pentwater	SMG 482	78	A588	
S16 - 64015	2668	US 31 (reloc.)	under US 31 Bus. Loop at the North Oceana County Line	SMG 482	78	A588	
S12 - 59012	2670	US 131 (reloc.)	under Edgar Rd (M 46 Extension), 2.5 miles northwest of Howard City	SCM 482	78	A588	
S13 - 59012	2671	US 131 (reloc.)	under Tamarack Rd, 3.3 miles northwest of Howard City	SCM 482	78	A588	
S15 - 59012	2672	US 131 SB (reloc.)	under Cutler Rd, 4 miles northwest of Howard City	SMH 382	78	A588	
S06 - 54013	2680	US 131 SB	over Six Mile Rd, 2.5 miles southwest of Stanwood	SMGC 382	79	A588	
S07 - 54013	2681	US 131 NB	over Six Mile Rd, 2.5 miles southwest of Stanwood	SMGC 382	79	A588	
S08 - 54013	2682	US 131 SB	over 8 Mile Rd (M 20), west of Stanwood	SMGC 382	79	A588	
S09 - 54013	2683	US 131 NB	over 8 Mile Rd (M 20), west of Stanwood	SMGC 382	79	A588	
S01 - 54014	2684	US 131 SB	under Old State Rd, 5.5 miles south of Big Rapids	SMGC 382	79	A588	
S02 - 54014	2685	US 131 NB	under Old State Rd, 5.5 miles south of Big Rapids	SMGC 382	79	A588	
B03 - 64015	2693	US 31 SB (reloc.)	over North Branch Pentwater River, 1.5 miles east of Pentwater	SCMG 482	79	A588	
B04 - 64015	2694	US 31 NB (reloc.)	over North Branch Pentwater River, 1.5 miles east of Pentwater	SCMG 482	79	A588	
S06 - 19043	2701	I 69 WB	over Turner Rd, 2.0 km south of the City of DeWitt	SMGC 382	80	A588 Paint	
S07 - 19043	2702	I 69	under DeWitt Rd, 1.0 km southeast of the City of DeWitt	SMGC 382	80	A588 Paint	
S08 - 19043	2703	I 69	under Clark Rd, 1.2 km southeast of the City of DeWitt	SMSC 332	80	A588 Paint	
S20 - 19043	2704	I 69 EB	over Turner Rd, 2.0 km south of the City of DeWitt	SMGC 382	80	A588 Paint	

	Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
				District 6				
	B01 - 73073	0012	M 81	(Turnback) Saginaw River	SMG 452	73	A588	
	B05 - 25132	2537	I 475	over Flint River	SMH 432	76	A588 Painted under joints	
	S17 - 25132	2538	I 475	under Third Street	SMH 332	76	A588	
	S18 - 25132	2539	I 475	under Second Street	SMH 332	76	A588	
	S19 - 25132	2540	I 475	under Kearsley Street	SMH 382	76	A588 Painted under joints	
	S20 - 25132	2541	I 475	under EB Robert Longway Blvd.	SMH 382	76	A588	
	S21 - 25132	2542	I 475	under WB Robert Longway Blvd.	SMH 332	76	A588	
	S22 - 25132	2543	I475 & ramps	over SB Service Road	SMH 332	76	A588	
	S23 - 25132	2544	I 475	over Stever Ave.	SMH 332	76	A588	
	X03 - 25132	2561	I 475	over C & O RR & Pierson Rd.	SMH 382	76	A588	
	S27 - 25132	2548	I 475	over Horton Ave.	SMH 382	77	A588	
	S30 - 25132	2550	I 475	under Selby St.	SMH 382	77	A588	
	S31 - 25132	2551	I 475	under Coldwater Rd.	SMH 332	77	A588	
	S45 - 25132	2554	I475(ramp B)	over Horton Ave.	SMH 332	77	A588	
	S46 - 25132	2555	I 475	under Ramp B	SMH 382	77	A588	
	S47 - 25132	2556	I475(ramp C)	over Ramp D	SMH 382	77	A588	
6	S48 - 25132	2557	I475(ramp E)	over Ramp F	SMG 382	77	A588 Painted under joints	
	S49 - 25132	2558	I 475	under Cornell Ave.	SMH 332	77	A588	
	S51 - 25132	2560	I 475	under Russell Ave.	SMH 332	77	A588	
	B02 - 73031	2604	M 52	over S. Branch of Bad River	SMS 332	77	A588	
	B04 - 73031	2605	M 52	over Beaver Creek	SMS 332	77	A588	
	S24 - 25132	2545	I 475	over Leith St in Flint	SMH 332	77	A588	
	S29 - 25132	2549	I 475	under Carpenter Rd in Flint	SMH 332	77	A588	
	S32 - 25132	2552	I 475	over Saginaw St in Flint	SMS 332	77	A588	
	S36 - 25132	2553	I 475	under Terry St in Flint	SMS 332	77	A588	
	S50 - 25132	2569	I 475	over Massachusetts Ave	SMS 332	78	A588	
	S25 - 25132	2546	I 475	over Stewart Ave in Flint	SMH 332	78	A588	
	S26 - 25132	2547	I 475	over Ramp "C" in Flint	SMH 332	78	A588	
	S15 - 44044	2686	M 21 (reloc.)	under M 53, 1.7 miles south of Imlay City	SCMG 482	79	A588	
	S16 - 44044	2687	M 21 (reloc.)	under Bowman Rd, 2.2 miles southeast of Imlay City	SCMG 482	79	A588	
	S17 - 44044	2677	M 21 (reloc.)	under Bristol Rd, 3.0 miles southeast of Imlay City	SCMG 482	78	A588	
	S18 - 44044	2688	M 21 EB	over Graham Rd, 4.2 miles southeast of Imlay City	SMGC 382	79	A588	
	S19 - 44044	2689	M 21 WB	over Graham Rd, 4.2 miles southeast of Imlay City	SMGC 382	79	A588	
				District 7				
	S06 - 03035	2255	I 196	under M 40	SMH 382	72	A588	Waboflex
	S07 - 03035	2256	I 196	over 146th Ave.	SMH 382	72	A588	Waboflex
	S08 - 03035	2257	I 196 EB	over Ottogan Ave.	SMG 382	72	A588	Transflex
	S12 - 03035	2258	I 196 WB	over Ottogan Ave.	SMG 382	72	A588	Transflex
	S11 - 39022	2407	I 94	over Kilgore Rd.	SMS 382	74	A588	Fel-Span
	X02 - 11012	2532	I 94 BL	over C & O RR	SMH 332	75	A588	
	B04 - 11013	2533	I 94 BL	over Morrison Channel & Indiana Ave.	SMH 382	78	A588	
	B05 - 11013	2534	I 94 BL	over St. Joseph River	SGF 316	76	A588	
	B03 - 13061	2535	I 94 WB BL	over Battle Creek River	SMH 332	76	A588	
	S01 - 11056	2657	US 31 (reloc.)	under Bertrand Rd north of State Line	SMH 332	77	A588	
7	S04 - 11056	2640	US 31 SB	over US 12, 2 miles southwest of Niles	SMH 382	78	A588	
	S05 - 11056	2641	US 31 NB	over US 12, 2 miles southwest of Niles	SMH 382	78	A588	
	S01 - 11057	2658	US 31	under Niles - Buchanan Rd	SMG 382	79	A588	
	S01 - 39997	2695	E-W Campus Conn.	over Howard St at Western Michigan University in the City of Kalamazoo	SMGC 382	79	A588	
	X01 - 11057	2696	US 31 SB Ramp	over Amtrak, 3.5 miles southwest of Niles	SMSC 332	79	A588	
	S17 - 11015	2654	I 94	crossing Lake Shore Dr, 12 miles northeast of Stevensville	SMS 332	78	A588 (Widening)	
	X07 - 11015	2656	I 94 WB Ramp	over C&O R.R., 1 mile north of Stevensville	SMH 332	78	A588	
	X04 - 11057	2699	US 31 NB Ramp	over Amtrak, 3.5 miles southwest of Niles	SMSC 332	79	A588	

Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
			District 8				
S02 - 81063	1648	I 94	under Grove St.	SMH 382	71	A588	Transflex
X01 - 23997	0308	Waho Dr.	over GTW RR	SMH 332	73	A588	
S03 - 81041	1640	I 94	under Rawsonville Rd.	SMH 382	73	A588	Fel-Span
S04 - 81062	2412	I 94	under Saline Rd.	SMH 382	73	A588	Fel-Span
S05 - 81062	2413	I 94	under State Rd.	SMH 382	73	A588	Fel-Span
X02 - 33011	2563	M 99 SB	over GTW RR and Grand River	SMG 382	75	A588	
X01 - 38101	0714	I 94	over Grand River & PC RR	SMG 452	75	A588 Painted under joint	
S09 - 81062	2414	I 94	under Carpenter Rd.	SMH 382	75	A588	
S12 - 81062	2607	I 94	under US 12	SMH 382	75	A588	
S12 - 81103	2608	M 14	under M 153 Conn. Ramps	SMH 382	75	A588	Fel-Span
S13 - 81103	2609	M 14	under Curtis Rd.	SMH 382	75	A588	Delastic
S14 - 81103	2610	M 14	under Joy Rd.	SMH 382	75	A588	Delastic
S15 - 81103	2611	M 14	under Gotfredson Rd.	SMH 382	75	A588	Delastic
S17 - 81103	2612	I 94 EB	over Pelham Rd.	SMG 382	75	A588	
S18 - 81103	2613	I 94 WB	over Pelham Rd.	SMG 382	75	A588	
S08 - 38101	0711	I 94	under M 106	SMS 332	76	A588	
B01 - 46061	2565	US 223	over Wolf Creek	SMS 332	76	A588	
P04 - 33011		M 99	at Edward St		77	A588	
P05 - 33011		M 99	at Woodbine St		77	A588	
S04 - 58152	2700	I 75	under Post Rd, 2 miles snuthwest of Newport	SMGC 382	75	A588	
X02 - 33082	2646	M 43 EB	over Grand Trunk Western R.R., 3/4 mile east of East Lansing	SMH 332	77	A588	
X02 - 46062	2674	US 223	over the N&W R.R., 1 mile south of Adrian	SMS 302	77	A588	
B01 - 23092	2642	M 99 NB	crossing Skinner Drain, 1-1/2 miles south of Holt Rd	SMC 332	78	A588	
B02 - 23092	2643	M 99 NB	crossing Grand River, 1-1/2 miles south of Holt Rd in Eaton County	SMH 332	78	A588	
B03 - 23092	2644	M 99 SB	crossing Grand River, 1-1/2 miles south of Holt Rd in Eaton County	SMH 332	78	A588	
B04 - 23092	2645	M 99 SB	crossing Skinner Drain, 1-1/2 miles south of Holt Rd	SMH 332	78	A588	
B02 - 46041	2676	US 223	over Wolf Creek, 1.5 miles west of Adrian	SMSC 332	78	A588	
X01 - 33011	2678	M 99 NB	over G.T.W.R.R. and the Grand River in Lansing	SMGC 382	79	A588	

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
			Metro District				
S34 - 82112	1877	US 10	under M 102 (four separate structures)	SMG 482	65	A 242 Mod.	
S06 - 82194	2055	I 75	over Fort St. North	SMG 482	67	A242	
S34 - 82123	1963	I 96	under Maple Wood Ave.	SMH 382	69	A588	
S35 - 82123	1964	I 96	under Pacific Ave.	SMH 382	69	A588	
S36 - 82123	1965	I 96	under W Grand Blvd., WB & Tireman WB	SMH 382	69	A588	
S37 - 82123	1966	I 96	under W Grand Blvd., EB & Tireman EB	SMG 382	69	A588	
S10 - 82252	2151	I 75	under 8 Mile Rd	SMH 482	69	A 242 Mod.	
S33 - 82252	2167	I 75	under I 75, M 14 Ramp	SMG 482	69	A 441 Mod.	
S04 - 82123	1934	M 39 U Turn	over M 39	SMH 332	70	A588	Transflex
S05 - 82123	1935	I 96 EB	over M 39	SMH 332	70	A588	Transflex
S06 - 82123	1936	I 96 EB	over M 39	SMH 332	70	A588	Transflex
S07 - 82123	1937	I 96 WB	over M 39	SMH 332	70	A588	Transflex
S08 - 82123	1938	I 96 Ramp	over M 39 U Turn	SMG 482	70	A588	Transflex
S09 - 82123	1939	I 96 WB	over M 39	SMH 332	70	A588	Transflex
S12 - 82123	1942	I 96	under Hubbel Ave.	SMH 332	70	A588 Painted under joint	Modular
S13 - 82123	1943	I 96	under Fullerton Ave.	SMH 332	70	A588 Painted under joint	Modular
S26 - 82123	1955	I 96	under Elmhurst Ave.	SMH 332	70	A588	
S27 - 82123	1956	I 96	under U Turn N of Grand River Ave.	SMS 432	70	A588	
S28 - 82123	1957	I 96	under Grand River Ave. (I 96 BS)	SMH 382	70	A588	
S29 - 82123	1958	I 96	under Chicago Ave.	SMS 432	70	A588	
S30 - 82123	1959	I 96	under Livernoise Ave.	SMH 332	70	A588	
S31 - 82123	1960	I96	under Livernoise Ave. Left Turn Ramp	SMS 432	70	A588	
S32 - 82123	1961	I 96	under Underwood Ave.	SMH 332	70	A588	
S33 - 82123	1962	I 96	under Joy Rd.	SMH 332	70	A588	
X02 - 82123	1982	I 96 Ramp	over C & O RR	SMG 482	70	A588 Fel-Span	Transflex
X03 - 82123	1983	I 96 Ramp	over C & O RR	SMH 332	70	A588	Transflex
X04 - 82123	1984	I 96 Ramp	over C & O RR	SMG 482	70	A588	
X06 - 82123		I 96	under C & O RR	SGF 403	70	A588	
S04 - 63103	1228	I 696 EB	over I 75	SMH 382	71	A588	
S05 - 63103	1229	I 696	over I 75 Ramp	SMG 482	71	A588	Transflex
S06 - 63103	1230	I 75	under Dallas Double U Turn	SMH 382	71	A588	
S07 - 63103	1231	I 696 EB	over N Service Rd	SMS 332	71	A588	
S08 - 63103	1232	I 696	over N Service Rd	SMS 332	71	A588	
S09 - 63103	1233	I 696 WB	over N Service Rd	SMS 332	71	A588	
S10 - 63103	1234	I 696	under John R. Rd	SMH 382	71	A588	Transflex
S11 - 63103	1235	I 696	under U Turn at Battelle	SMG 382	71	A588	Transflex
S12 - 63103	1236	I 696	under Couzens St.	SMH 332	71	A588	Transflex
S13 - 63103	1237	I 696	under 10 Mile Rd Conn.	SMG 482	71	A588	Transflex
S16 - 63103	1238	I 696 WB	over I 696 & Ramps from I 75 NB	SMH 382	71	A588 Painted under joint	
S17 - 63103	1240	I 696 EB	over I 696 & Ramps from I 75 SB	SMH 382	71	A588 Painted under joint	
S18 - 63103	1242	I 696 EB	over I 75 & Ramps to I 75 NB	SMG 382	71	A588 Painted under joint	
S19 - 63103		I 696 WB	over I 75 & Ramps to I 75 SB		71	A588 Painted under joint	
S28 - 63174	1287	I 75	under Woodwards Hts. Blvd.	SMH 382	71	A588	
S30 - 63174	1288	I 75	under 10-1/2 Mile Rd.	SMH 332	71	A588	
S01 - 63191	2346	I 96 EB	under Meadowbrook Rd.	SMH 382	71	A588	Transflex
S02 - 63191	2347	I 96 EB	under Haggerty Rd.	SMH 382	71	A588	Transflex
S03 - 63191	2348	I 96 WB	under Haggerty Rd.	SMH 332	71	A588	Transflex
S04 - 63191	2349	I 696 Ramp	over M 102	SMH 382	71	A588	Transflex
S05 - 63191	2350	I 96 WB & I 275 NB	over I 698	SMH 382	71	A588	Transflex
S06 - 63191	2351	I 696 SB	over I 96 WB & under M 275 NB	SMH 382	71	A588 Paint pier 1 and Suspension	
S07 - 63191	2352	I 96 WB	over M 102	SMH 332	71	A588	Transflex
S08 - 63191	2353	I 96 NB Ramp	over M 102	SMH 382	71	A588	Transflex
S09 - 63191	2354	I 96	under Grand River Ave.	SMH 382	71	A588	Transflex
S10 - 63191	2355	I 96 & M 275	under 10 Mile Rd.	SMH 382	71	A588	Transflex
S12 - 63191	2356	I 96 EB	over 9 Mile Rd.	SMS 332	71	A588	
S13 - 63191	2357	I 96 WB	over 9 Mile Rd.	SMS 332	71	A588	
S18 - 63191	2362	I 96 Ramp	over ramp from M 102	SMH 382	71	A588	
S19 - 63191	2363	M 275 NB	over M 102	SMH 382	71	A588	Transflex
S31 - 82022	1714	I 94	under Miller Rd.	SMH 332	71	A588	
S06 - 82081	1814	M 153	under Evergreen	SMH 382	71	A588	Transflex
P01 - 82122		I 96	at Bentler Ave.		71	A588	
P02 - 82122		I 96	at Stout Ave.		71	A588	
S01 - 82122	1885	I 96	under WB Schoolcraft Rd.	SMH 382	71	A588	Transflex
S11 - 82122	1895	I 96	under Middlebelt Rd.	SMH 332	71	A588	Transflex

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
S12 - 82122	1896	I 96	under Race Track Ent.	SMH 332	71	A588	Transflex
S13 - 82122	1897	I 96	under Cardwell Ave.	SMH 332	71	A588	Transflex
S14 - 82122	1898	I 96	under Inkster Rd.	SMH 332	71	A588	Transflex
S19 - 82122	1903	I 96	under US 24 (Telegraph Rd.)	SMH 482	71	A588	Transflex
S20 - 82122	1904	I 96	under Virgil St.	SMH 382	71	A588	Transflex
S21 - 82122	1905	I 96	under Outer Drive	SMH 382	71	A588	Transflex
S22 - 82122	1906	I 96	under Burt Rd.	SMH 332	71	A588	Modular
S23 - 82122	1907	I 96	under Schoolcraft crossover	SMH 382	71	A588	Modular
S24 - 82122	1908	I 96	under Glendale Ave.	SMH 332	71	A588	
S30 - 82122	1914	I 96	under Middlebelt left turn	SMH 332	71	A588	Transflex
S31 - 82122	1915	I 96	under E. left turn, Middlebelt Rd.		71	A588	Transflex
S32 - 82122	1916	I 96	under Inkster left turn	SMS 332	71	A588	Transflex
S33 - 82122	1917	I 96	under E. left turn, Inkster Rd.		71	A588	Transflex
X01 - 82122	1927	I 96; C&O RR	under Evergreen	SMH 332	71	A441 Mod.	
P01 - 82123		I 96	at Sorrento Ave.		71	A588	
P02 - 82123		I 96	at Mendota Ave.		71	A588	
P03 - 82123		I 96	at Cherrylawn Ave.		71	A588	
S14 - 82123	1944	I 96	under Schaefer Rd.	SMH 332	71	A588 painted under joint	Modular
S15 - 82123	1945	I 96	under Grand River Ave. left turn	SMH 332	71	A588 painted under joint	Modular
S16 - 82123	1946	I 96	under Grand River Ave.	SMH 382	71	A588 painted under joint	Modular
S17 - 82123	1947	I 96	under Meyers Rd.	SMH 332	71	A588 painted under joint	Modular
S18 - 82123	1948	I 96	under Wyoming Ave.	SMH 432	71	A588	Modular
S19 - 82123	1949	I 96	over EB. Davison Ave.	SMG 382	71	A588 painted under joint	
S21 - 82123	1950	I 96	over Davison Ave.	SMG 382	71	A588	
S23 - 82123	1952	I 96	over Davison Ramp	SMH 382	71	A588	
S24 - 82123	1953	I 96	under Fullerton	SMH 382	71	A588	Transflex
S25 - 82123	1954	I 96	under Oakman Blvd.	SMH 382	71	A588	
S38 - 82123	1967	I 96	under McGraw Ave.	SMH 332	71	A441 Mod.	
S39 - 82123	1968	I 96	over Ramp from I 94	SMS 332	71	A441 Mod.	
S40 - 82123	1969	I 96	over Ramp to I 94	SMS 332	71	A441 Mod.	
S41 - 82123	1970	I 96	under Ramp to I 94	SMG 482	71	A441 Mod.	
S42 - 82123	1971	I 96; Ramp	under Ramp from I 94	SMG 382	71	A441 Mod.	
S43 - 82123	1972	I 96; Ramp	under I 94 Ramp	SMH 332	71	A441 Mod.	
S44 - 82123	1973	I 96	under Ramp to I 94	SMS 382	71	A441 Mod.	
S45 - 82123	1974	I 96	under Ramp from I 94	SMH 332	71	A441 Mod.	
S46 - 82123	1975	I 96	over I 94	SMH 332	71	A441 Mod.	
S47 - 82123	1976	I 96 Ramp	under Grand River Ave., Exit Ramp	SMH 332	71	A441 Mod.	
S48 - 82123	1977	I 96	under Warren Ave., Exit Ramp	SMG 382	71	A588	
S49 - 82123	1978	I 96	under Warren Ave., Ent. Ramp	SMH 382	71	A588	
X09 - 82123		I 96	under DTRR at Davison		71	A588	
X10 - 82123		I 96	under DTRR		71	A588	
S01 - 82124	1986	I 96	under Warren Ave.	SMH 332	71	A588	
S02 - 82124	1987	I 96	under Buchanan St.	SMH 332	71	A441	
S03 - 82124	1988	I 96	under Myrtle St.	SMH 332	71	A441	
S27 - 82194	2077	I 96 NB	under US 12 conn.	SMH 332	71	A441 Mod.	
S11 - 82293	2231	I 275 NB	under SB. to EB. I 96	SMH 382	71	A588	
S12 - 82293	2232	I 96	under Five Mile Rd.	SMH 482	71	A588	Modular
P01 - 50061		I 696	at Thomas St.		72	A588	
S01 - 50061	2279	I 696	at Augustina under U-Turn Ramp	SMH 332	72	A588	Transflex
S02 - 50061	2566	I 696	under EB. 11 Mile Rd.	SMG 482	72	A588	
S03 - 50061	2281	I 696	under Ryan Rd.	SMH 332	72	A588	Transflex
S04 - 50061	2282	I 696	under Merideth Rd.	SMH 332	72	A588	Transflex
S05 - 50061	2283	I 696	under EB. 11 Mile Rd.	SMH 382	72	A588	
S16 - 50061	2289	I 696	under Eb. 11 Mile Rd.	SMH 382	72	A588	
S17 - 50061	2290	I 696	under U-Turn W. of VanDyke Ave.	SMG 482	72	A588	
S18 - 50061	2291	I 696	under VanDyke Ave.	SMG 482	72	A588	
S19 - 50061	2292	I 696	under Left Turn EB. VanDyke Ave.	SMG 482	72	A588	
S21 - 50061	2293	I 696	under Left Turn WB. Hoover Rd.	SMG 482	72	A588	
S22 - 50061	2294	I 696	under Hoover Rd.	SMG 482	72	A588	

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
X01 - 82291	2197	I 275 SB	over C&O RR	SMH 332	74	A588	Type 190
X03 - 82291	2198	I 275 NB	over C&O RR	SMH 332	74	A588	Type 190
B01 - 82292	2199	I 275 SB Ramp	over Lower Rouge River	SMH 332	74	A588 painted under joint	
B04 - 82292	2200	I 275 SB	over Fellows Creek	SMH 332	74	A588	
B05 - 82292	2201	I 275 NB Ramp	over Lower Rouge River	SMH 332	74	A588	
B06 - 82292	2202	I 275 NB	over Fellows Creek		74	A588	
B07 - 82292	2203	I 275 Ramp	over McClaughery Drain	SMS 332	74	A588	
B08 - 82292	2204	I 275 SB	over McClaughery Drain	SMS 332	74	A588 painted under joint	
B09 - 82292	2205	I 275 NB	over McClaughery Drain		74	A588 painted under joint	
B10 - 82292	2206	I 275 Ramp	over McClaughery Drain	SMS 332	74	A588	
B99 - 82292	2207	Cherry Hill	Service Rd. over Fellows Creek	SMH 332	74	A588	
S01 - 82292	2208	I 275	under Hannan Rd.	SMH 382	74	A588	
S02 - 82292	2209	I 275	under Tyler Rd.	SMH 382	74	A588	
S03 - 82292	2210	I 275	under Ecorse Rd.	SMH 382	74	A588	
S04 - 82292	2211	I 275 SB	over Van Born Rd.	SMG 382	74	A588	
S05 - 82292	2212	I 275 SB	over Michigan Ave.	SMH 382	74	A588	
S06 - 82292	2213	I 275	under Palmer Rd.	SMH 382	74	A588	
S07 - 82292	2214	I 275	under Cherry Hill	SMH 382	74	A588	
S10 - 82292	2216	I 275 NB	over Van Born Rd.	SMG 382	74	A588	
S11 - 82292	2217	I 275 NB	over Michigan Ave.	SMH 382	74	A588	
S06 - 50061	2567	I 696	under Ramp H	SMG 482	75	A588	
S08 - 50061	2568	I 696	under Ramp G	SMG 482	75	A588	
B06 - 58151	2578	I 75 Ramp	over LaPlaisance Creek	SMS 332	75	A588	
S07 - 58151	2579	I 75	under Allen Love Rd.	SMH 382	75	A588	
S08 - 58151	2580	I 75	under Otter Creek Rd.	SMH 382	75	A588	
S09 - 58151	2581	I 75	under Mortar Creek Rd.	SMH 382	75	A588	
S13 - 58151	2582	I 75	under Ramp A	SMH 382	75	A588	
S14 - 58151	2583	I 75	under Ramp B	SMH 382	75	A588	
S01 - 63082	1216	US 24	over SB. US 10	SMH 332	64 and 75	A588 widened steel	
S13 - 63101	1223	I 696	under Telegraph Rd. (US 24)	SMH 332	67 and 75	A588 widened steel	
B02 - 77052	2606	M 29	over Pine River	SGE 316	75	A588	
S02 - 82102	2616	M 14	under Napier Rd.	SMH 382	75	A588	Delastic
X01 - 82123	2416	I 96	over M 39 and C&O RR	SMG 482	75	A588	
S09 - 50061	2569	I 696 Ramps	under 10-1/2 Mile Rd.	SMH 382	76	A588	
S11 - 50061	2570	I 696 Ramps	under 11 Mile Rd.	SMH 382	76	A588	
S14 - 50061	2571	I 696 Ramps	under Sherwood Ave.	SMH 382	76	A588	
S32 - 50061	2572	I 696 Ramps	under SB. Service Rd.	SMG 382	76	A588	
S33 - 50061	2573 2574	I 696	under Mound Rd. and Service Rd. and Ramps	SMH 382	76	A588	
S35 - 50061	2575	I 696 Ramps	under SB. Service Rd.	SMG 382	76	A588 painted under joint	
S36 - 50061	2576	I 696 Ramps	under NB. Service Rd.	SMG 382	76	A588	
S40 - 50061	2577	I 696 Ramps	under NB. Service Rd.	SMG 382	76	A588 painted under joint	
B01 - 82102	2614	M 14	over Rouge River	SMG 382	76	A588	
P01 - 82102		Bikeway	over Edward Hines Dr. at M 14		76	A588	
S03 - 82102	2617	M 14	under N. Territorial Rd.	SMH 382	76	A588	
S04 - 82102	2618	M 14	under Ridge Rd.	SMH 382	76	A588	
S05 - 82102	2619	M 14	under Beck Rd.	SMH 382	76	A588	
S06 - 82102	2620	M 14 WB	over Sheldon Rd.	SMH 382	76	A588	
S07 - 82102	2621	M 14	under Ramps A and B	SMH 382	76	A588	
S08 - 82102	2622	M 14	over Edward Hines Dr.	SMG 382	76	A588	
S09 - 82102	2623	M 14	under Northville Rd.	SMH 332	76	A588	
S10 - 82102	2624	M 14	under Robinwood Dr.	SMH 382	76	A588	
X01 - 82102	2627	M 14 WB	over C&O RR	SMH 382	76	A588	
X02 - 82102		M 14	under C&O RR	SMG 382	76	A588	
X03 - 82102	2628	M 14 EB	over C&O RR	SMH 382	76	A588 painted under joint	
S01 - 82102	2615	M 14	under Haggerty Rd.	SMH 382	77	A588	
S11 - 82102	2625	M 14	under Schoolcraft Conn.	SMH 382	77	A588 painted under joint	
S12 - 82102	2626	M 14 EB	over Sheldon Rd.	SMH 382	77	A588	

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
S07 - 58171	2327	I 275	under Sigler Rd.	SMH 382	73	A588	Fel-Span
S08 - 58171	2328	I 275	under Ready Rd.	SMH 382	73	A588	Fel-Span
S09 - 58171	2329	I 275	under Carelton Rockwood Rd.	SMH 382	73	A588	Type 190
S10 - 58171	2330	I 275 SB	over Newburg Rd.	SMG 382	73	A588	Type 190
S11 - 58171	2331	I 275 NB	over Telegraph Rd. (US 24)	SMH 382	73	A588	Waboflex
S13 - 58171	2332	I 275 NB	over Newburg Rd.	SMG 382	73	A588	Type 190
X01 - 58171	2333	I 275 SB	over DT&I RR	SMH 332	73	A588	Type 190
X02 - 58171	2334	I 275 SB	over P.C.R.R.	SMH 332	73	A588	Type 190
X03 - 58171	2335	I 275 NB	over DT&I RR	SMH 332	73	A588	Type 190
X04 - 58171	2336	I 275 NB	over P.C.R.R.	SMH 332	73	A588	Type 190
B02 - 77051	1550	M 29	over Swan Creek	SMS 332	73	A588	
S01 - 82021	1688	I 94	under Belleville Rd.	SMH 382	73	A588	
S02 - 82021	1689	I 94	under Haggerty Rd.	SMH 382	73	A588	Fel-Span
S05 - 82122	1889	I 96	under Stark Rd.	SMH 332	73	A588	Type 190
S18 - 82122	1902	I 96	under Fenton St.	SMH 382	73	A588	
S26 - 82122	1910	I 96	under Berwyn St.	SMG 382	73	A586	Fel-Span
X02 - 82122		I 96	under C&O RR		73	A586	
S10 - 82123	1940	I 96, M 39	over I 96 EB.	SMH 332	73	A588	Fel-Span
S11 - 82123	1941	I 96	WB. I 96 Southfield Interchange	SMH 332	73	A588	Fel-Span
X05 - 82123	1985	I 96 and C&O RR	under Greenfield Rd.	SMH 382	73	A588 and A441	
S11 - 63081	2410	I 696 NB	over Evergreen Rd.	SMH 332	74	A588	
P03 - 82122		I 96	at Minock Dr.		74	A588	
S02 - 82122	1886	I 96	under Newburgh Rd.	SMH 332	74	A588	Fel-Span
S03 - 82122	1887	I 96	under Leran Rd		74	A588	Fel-Span
S04 - 82122	1888	I 96	under Yale Ave.	SMH 332	74	A588	Type 190
S06 - 82122	1890	I 96	under Farmington Rd.		74	A588	Fel-Span
S07 - 82122	1891	I 96	under Brookfield Rd.	SMH 332	74	A588	Fel-Span
S08 - 82122	1892	I 96	under Berwick Rd.	SMH 332	74	A588	Fel-Span
S09 - 82122	1893	I 96	under Merriman Rd.	SMH 332	74	A588	Fel-Span
S10 - 82122	1894	I 96	under Warner Ct.		74	A588	Fel-Span
S15 - 82122	1899	I 96	under Breakfast U-Turn	SMH 382	74	A588	Fel-Span
S16 - 82122	1900	I 96	under Beech Daly Rd.	SMH 332	74	A588	Fel-Span
S17 - 82122	1901	I 96	under U-Turn Bridge near Garfield	SMH 382	74	A588	Waboflex
S27 - 82122	1911	I 96	under Merriman W. Left Turn	SMH 332	74	A588	Fel-Span
S28 - 82122	1912	I 96	under Merriman E. Left Turn		74	A588	Fel-Span
S29 - 82122	1913	I 96	under Melvin Rd.	SMH 332	74	A588	Fel-Span
S34 - 82122	1918	I 96	under W. Left Turn Beech Daly	SMH 332	74	A588	Fel-Span
S35 - 82122	1919	I 96	under E. Left Turn Beech Daly		74	A588	Fel-Span
S36 - 82122	1920	I 96	under W. Left Turn Levan	SMH 332	74	A588	Type 190
S37 - 82122	1921	I 96	under E. Left Turn Levan	SMH 332	74	A588	Type 190
S38 - 82122	1922	I 96	under W. Left Turn Farmington Rd.	SMH 332	74	A588	Type 190
S39 - 82122	1923	I 96	under E. Left Turn Farmington Rd.		74	A588	Type 190
S40 - 82122	1924	I 96	under Wayne Rd.	SMH 332	74	A588	Type 190
S41 - 82122	1925	I 96	under Double U-Turn near Newburg Rd.	SMH 332	74	A588	Type 190
S42 - 82122	1926	I 96	under E. Left Turn Newburg Rd.		74	A588	Type 190
S22 - 82123	1951	I 96	over Davison Ramp	SMS 332	74	A588	
S01 - 82125	1989	I 96 EB	over 8 Mile Rd.	SMH 332	74	A588	
S02 - 82125	1990	I 96 WB	over 8 Mile Rd.	SMH 332	74	A588	
S03 - 82125	1991	I 96	under 7 Mile Rd.	SMH 382	74	A588	
S05 - 82125	1992	I 96	under 6 Mile Rd.	SMH 382	74	A588	
B01 - 82291	2178	I 275 SB	over Huron River	SMH 332	74	A588	Type 190
B02 - 82291	2179	I 275 NB	over Huron River	SMH 332	74	A588	Type 190
S01 - 82291	2180	I 275	under Will Carleton Rd.	SMH 382	74	A588	Fel-Span
S02 - 82291	2181	I 275	under Willow Rd.	SMH 382	74	A588	Fel-Span
S03 - 82291	2182	I 275	under West Rd.	SMH 382	74	A588	Fel-Span
S04 - 82291	2183	I 275	under Huron River Dr.	SMH 382	74	A588	Type 190
S05 - 82291	2184	I 275	under Sibley Rd.	SMH 382	74	A588	Fel-Span
S06 - 82291	2185	I 275	under Pennsylvania Rd.	SMH 382	74	A588	Fel-Span
S07 - 82291	2186	I 275	under Eureka Rd.	SMH 382	74	A588	Fel-Span
S08 - 82291	2187	I 275 SB	over Northline Rd.	SMH 382	74	A588	Type 190
S09 - 82291	2188	I 275 SB	over Huron River Dr.	SMG 382	74	A588	Type 190
S10 - 82291	2189	I 275	under Huron River Dr.	SMH 382	74	A588	Fel-Span
S13 - 82291	2191	I 275 NB	over Northline Rd.	SMH 382	74	A588	Type 190
S15 - 82291	2193	I 275 NB	over Huron River Dr.	SMG 382	74	A588	Type 190
S18 - 82291	2196	I 275	under Ramp to EB. I 94	SMG 382	74	A588	Fel-Span

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
S23 - 50061	2295	I 696	under Left Turn EB. Hoover Rd.	SMG 482	72	A588	
S30 - 50061	2300	I 696	under Wagner Rd.	SMH 332	72	A588	
S41 - 50061	2307	I 696	under Arsenal Rd.	SMG 482	72	A588	
S42 - 50061	2308	I 696	under Richard Cambell Rd.	SMG 482	72	A588	
S44 - 50061	2310	I 696	under Left Turn Ryan	SMH 332	72	A588	Transflex
X01 - 50061		I 696	under P.C.R.R.	SMH 382	72	A588	
X02 - 50061		I 696	under G.T.W.R.R.		72	A588	
P01 - 50062		I 696	East of Grandmont		72	A588	
P02 - 50062		I 696	at Fernwood		72	A588	
S02 - 50062	2311	I 696	under Groveland Ave.	SMG 482	72	A588	
S03 - 50062	2312	I 696	under Gratiot Ave.	SMH 382	72	A588	Fel-Span
S05 - 50062	2313	I 696	under Nieman St.	SMG 482	72	A588	
S06 - 50062	2314	I 696 EB	under S. Service Rd.	SMH 382	72	A588	
S07 - 50062	2315	I 696 WB	under N. Service Rd.	SMH 382	72	A588	
S08 - 50062	2316	I 696 Ramp	over I 94, 11 Mile Rd.	SMH 332	72	A588	
S09 - 50062	2317	I 696 Ramp	N. to W. under 11 Mile Rd.	SMH 382	72	A588	
S11 - 50062	2318	I 696 Ramp	N. to W. over I 94	SMH 382	72	A588	
S13 - 50062	2319	I 696	under Belanger Ave.	SMG 482	72	A588	
S14 - 50062	2320	I 696	under Barkman Ave.	SMG 482	72	A588	
S14 - 63101	2585	I 696	under Left Turn Lane near Dequindre	SMH 382	72	A588	
S15 - 63101	2586	I 696	under Dequindre Ave.	SMH 382	72	A588	
S03 - 82021	1929	I 94 WB	over Hannan Rd.	SMS 382	72	A588	
S06 - 82021	1980	I 94 EB	over Hannan Rd.	SMS 382	72	A588	
S37 - 82022	1928	I 94	under Ozga Rd.	SMH 482	72	A588	Waboflex
S25 - 82122	1909	I 96	under C&O RR Vehicular Br.	SMH 332	72	A588	
X03 - 82122		I 96	under P.C.R.R.		72	A588	
P04 - 82123		I 96	at Clarendon Ave.		72	A588	
P05 - 82123		I 96	at Ivanhoe Ave.		72	A588	
P06 - 82123		I 96	at Roosevelt Ave.		72	A588	
P07 - 82123		I 96; C&O RR	at Mansfield		72	A588	
S01 - 82123	1930	I 96 EB	over Ramps to M 39	SMG 482	72	A588	Transflex
S02 - 82123	1931	I 96 WB	over I 96 and M 39	SMG 482	72	A588	Transflex
S03 - 82123	1932	I 96 NB	over I 96 and M 39	SMG 482	72	A588	Transflex
S60 - 82123	1979	I 96	under Scotten Ave.	SMS 332	72	A588	
X07 - 82123		I 96	under P.C.R.R.		72	A588	
X08 - 82123		I 96	under P.C.R.R. Spur		72	A588	
S11 - 82291	2190	I 275	under I 94 EB.	SMH 382	72	A588	Waboflex
S14 - 82291	2192	I 94 WB	over I 275	SMH 382	72	A588	Waboflex
S16 - 82291	2194	I 94 WB	over I 275 SB.	SMG 382	72	A588	
S17 - 82291	2195	I 275 SB	under I 94 EB.	SMG 382	72	A588	
S08 - 82292	2215	I 275 SB	over Ford Ave.	SMH 382	72	A588	Waboflex
S15 - 82292	2218	I 275 NB	over M 153	SMH 382	72	A588	Waboflex
B02 - 82293	2219	I 275 SB	over Middle Rouge River	SMH 332	72	A588	
B03 - 82293	2220	I 275 NB	over Middle Rouge River	SMH 332	72	A588	
S01 - 82293	2221	I 275	under Warren Rd.	SMH 382	72	A588	Waboflex
S02 - 82293	2222	I 275	under Joy Rd.	SMH 382	72	A588	Waboflex
S03 - 82293	2223	I 275	under M 14	SMH 382	72	A588	Waboflex
S04 - 82293	2224	I 275	under Ann Arbor Trail	SMH 382	72	A588	Waboflex
S05 - 82293	2225	I 275 SB	over E. Hines Dr.	SMG 382	72	A588	
S15 - 82293	2234	I 275 NB	over Hines Dr.	SMG 382	72	A588	
S16 - 82293	2235	I 275 SB	over Koppernick Rd.	SMG 382	72	A588	
S17 - 82293	2236	I 275 NB	over Koppernick Rd.	SMG 382	72	A588	
X01 - 82293	2238	I 275 NB	over C&O RR	SMH 332	72	A588	Waboflex
X03 - 82293	2240	I 275 SB	over C&O RR	SMH 332	72	A588	Waboflex
S25 - 50061	2296	I 696	under Schoenherr Rd.	SMG 482	73	A588	
S26 - 50061	2297	I 696	under Bunert Rd.	SMG 482	73	A588	
S28 - 50061	2298	I 696	under Groesbeck Hwy.	SMG 482	73	A588	
S29 - 50061	2299	I 696	under Hayes Rd.	SMG 482	73	A588	
S31 - 50061	2301	I 696	under Fairfield Ave.	SMG 482	73	A588	
S43 - 50061	2309	I 696	under Left Turn W. of Schoenherr Rd.	SMG 482	73	A588	
S01 - 58171	2322	I 75	under I 275 SB. to I 75 NB.	SMG 382	73	A588	Type 190
S02 - 58171	2323	I 75	under I 75 to I 275 NB.	SMH 382	73	A588	
S04 - 58171	2324	I 275	under Newport Rd.	SMH 382	73	A588	Waboflex
S05 - 58171	2325	I 275 SB	over Telegraph Rd. (US 24)	SMH 382	73	A588	Waboflex
S06 - 58171	2326	I 275	under Lard Rd.	SMH 382	73	A588	Type 190

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Bridge No.	CDC No.	Route	Facility Intersected	Type	Year	ASTM Steel	Joint Type
S01 - 81032	2652	US 12 BR	under Ford Blvd	SMSC 332	77	A588	
P01 - 82021	--	I 94	under Pedestrian Bridge near Quirk Rd north of Belleville	SMS 332	78	A588	
S29 - 82022	2653	I 94	under Schaefer Rd in the City of Dearborn	SCM 482	78	A588	
S07 - 63022	2666	I 96	under Novi Rd, 1/4 mile north of Novi City Limits	SMG 482	78	A588	
S01 - 77024	2669	M 21	under Martin Rd (Extension), 2.5 miles southwest of Capac	SCG 482	78	A588	
S02 - 77024	2679	M 21	under Capac Rd, 2.5 miles south of Capac	SCMG 482	79	A588	
X02 - 63041	--	M 59 WB	under C&O R.R., 3.3 miles east of Livingston County Line	SMG 352	79	A588 Paint	
B03 - 77023	2705	M 21 EB (reloc.)	over Pine River, 2.6 miles southeast of Goodells	SMGC 382	80	A588 Paint	
B04 - 77023	2706	M 21 WB (reloc.)	over Pine River, 2.6 miles southeast of Goodells	SMGC 382	80	A588 Paint	
X05 - 77023	2707	M 21 EB (reloc.)	over G.T.W.R.R., 3.0 miles southeast of Goodells	SMSC 332	80	A588 Paint	
X06 - 77023	2708	M 21 WB (reloc.)	over G.T.W.R.R., 3.0 miles southeast of Goodells	SMSC 332	80	A588 Paint	