SAFETY AND ECONOMIC CONSIDERATIONS IN USE OF CORROSION-RESISTANT STEEL FOR BRIDGE STRUCTURES

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This report presents new considerations and also elaborates and updates previous discussion of reasons for continued experimental use of corrosion-resistant steel for freeway bridges in locations where maintenance painting is a very serious, growing problem. Our current use of corrosion-resistant steel has been in such locations and anticipated future use would be confined to this same type of situation. A previous publication, "Economic Considerations in the Use of Corrosion-Resistant A 242 Structural Steel for Bridge Structures," Research Report No. R-587 (June 1966), discussed Departmental reasons for further performance evaluation of A 242 steel, and the expected economic savings resulting from reduction of both initial painting costs and subsequent maintenance painting of these structures. The following discussion of the advantages of steels that do not require maintenance painting will be covered in four phases: Background, Traffic Safety, Economic Considerations, and Insignificance of Structural Depreciation Without Painting.

Background

The frequency of occurrence of bridges and highway appurtenances per mile of roadway has been increasing significantly with each succeeding year, but at the highest rate since the inception of the Interstate program. For example, in 1955 the Michigan highway system had about 10,000 miles of highways and about 1,400 bridge structures. By 1965, structures had increased to about 2,850 (more than double) for about the same roadway mileage.

The increase for highway appurtenances has been even more marked during this 10-year span. Protective coatings have been used to maintain structural soundness of the steel framework of these bridges and structures. However, to cope with the increasing maintenance problem, the Department has had to study and utilize longer-lived coating protection including galvanizing on such appurtenance items as guard rails, sign posts, fencing, etc., instead of a paint system formerly specified. Surprisingly, the galvanizing is also justified economically since it results in significant savings to the Department. Sometimes structural steel has been replaced by other metals requiring no paint protection, such as aluminum in sign support structures and panels, to effect the same advantages of durability and economy.

The appearance of bridge structures built in the 1940's and early 1950's in the Detroit area and later utilized in the Interstate system, was originally maintained by touch-up painting of only the fascia beams. Complete maintenance repainting of the steel of some of these bridges was advised in 1961. Since then, 48 structures have been repainted. The cost of this repainting doubled from 1962 through 1966. The complexity and restrictions also increased during this period due to increased traffic counts and dislocations caused by other maintenance functions conducted along the roadway.

Traffic Safety

Freeways are designed for high volume, high speed traffic flow. Traffic studies have shown the progressive decay in efficiency of such a system where lane blockages occur due to accidents and maintenance repairs. In maintenance painting of bridges over freeways, five separate operations require blocking of freeway traffic. These include sandblasting and then the application of each coating of a four-coat paint system. In Wayne County there are approximately 60 bridges on the Edsel Ford Freeway and approximately 45 on the John Lodge. The present average repainting cycle of 11.5 years means that on the average 10 bridges per year on these two freeways alone require repainting that will create bottlenecks and points of traffic congestion on these systems. Approximately two-thirds of the painting on these bridges is over the freeway, and requires barricading one lane at a time with the redistribution of traffic on the remaining lanes. With freeway traffic during certain morning and late afternoon hours exceeding optimum traffic flow conditions, the blockage of even one lane at a time has been considered intolerable, and therefore painting has been restricted to daytime hours of 10:00 a.m. to 2:00 p.m. Night painting has also been attempted, using floodlighting. However, it is felt that painting during the night, even in the limited painting season of approximately six months, results in a paint system of decreased durability.

These Detroit freeways are constructed at a cost of $10,000,000 or more per mile. Painting of bridges over this system, necessitating barricading of lanes, reduces the efficiency of this system both approaching and leaving the point of lane blockage. According to research being conducted by the National Proving Ground For Freeway Surveillance Control and Electronic Traffic Aids, a three-lane, single-directional roadway will handle approximately 35 cars per lane per minute, or a total of 105 cars per minute for the three lanes. When one is barricaded to permit maintenance painting, the resulting traffic flow is reduced to between 20 and 25 cars per lane per minute on the remaining lanes, due to the resulting traffic

congestion. Thus, total traffic on this roadway is reduced from 105 to 45 cars per minute. This is a loss in efficiency of 57 percent due to barricading of one lane of a three-lane roadway (Figs. 1 and 2). Experience has shown that traffic congestion resulting from the painting of a single bridge spreads over a linear length of several miles of freeway, some ahead of and the other portion beyond the point of lane obstruction.

It takes three to four weeks to paint a bridge over a freeway. For the John Lodge and Edsel Ford, with approximately 10 bridges to be painted per year, lane closure is required at some spots along these freeways for the entire five- to six-month painting season. This means that $20,000,000 to $30,000,000 segments of the freeway are operating at only 43-percent efficiency during part of the year due to the need for painting over the roadway.

Even though precautionary signs and warning devices notifying the driver of a lane closure have been extensive, the painter contractor for last year's contract work on the freeways has a suit pending for reimbursement for substantial extra costs incurred in replacing barricades and warning signs as a result of motorists running into them during such lane closures. It appears that temporary signing is ineffective in this regard, but that permanent signing, such as used for the lane closures in the television controlled area of the John Lodge, is more effective. E. F. Gervais, Director of the National Proving Ground, has mentioned that the number of accidents occurring during lane closure is so great that the subject is now being studied and a report will be forthcoming. Subjectively, however, it is already known that lane closures, in addition to reducing the efficiency of the freeway system, are also very significant contributors to traffic accidents.

Other factors that should be assessed in connection with bridge painting over freeways include 1) the generally unfavorable reaction of motorists to such lane closures--particularly if it appears that such lane closures could be eliminated in initial design and construction--and 2) the possibility of damage suits as a result of painting operations. For various reasons, spray painting of bridges over freeways generally has not been allowed. Even though brush painting is used, the Department may still incur damage claim from sandblasting of steel to condition it for painting, or from the painting itself.

Economic Considerations

In order to reduce maintenance painting expenditures, the Department recently went to an improved paint system. For example, on the Rouge River bridge the steel was sandblasted prior to application of one coat of paint at the fabricating shop. After this, three coats of paint were applied in the field. In the economic analysis presented in Research Report No. R-587 (June 1966), the $30 cost listed for shop and field painting was for a three-coat paint system. With the improved paint system, the revised figures for initial cost difference are as follows:

	A 242 Steel, per ton	A 441 Steel, per ton
Materials	$22.70	--
Blast Cleaning, fascia and bottom surface of stringers	4.73	--
Blast Cleaning, with one coat applied in shop	--	$22.00
Field Painting, three coats	--	26.00
	$27.43	$48.00
	$48.00 (A 441)	
	- 27.43 (A 242)	
Savings in Initial Cost with Use of A 242 Steel	$20.57	

In this analysis, the cost of sandblasting is based on $15 per ton rather than $10 per ton as in the previous report. Again, with A 242 steel only the fascia and bottom surfaces of the stringers would be sandblasted for a more uniform appearance, but for painting (as in the Rouge River Bridge specifications) all surfaces would be sandblasted to improve the performance of the paint system. Thus, if A 242 steel is compared to A 441 steel with the improved paint system, initial savings alone through use of A 242 steel are $20.57, compared with the $4.15 reported previously for the three-coat paint system. Using the same costs as before for maintenance painting and expecting that the initial four-coat system will last 15 years rather than the 11.5 years for a three-coat system, these bridges would have to be repainted approximately twice in the next 30 years. The cost would be $190 per ton more for maintenance painting, on the basis of current prices. Thus, the difference in cost between the two types of steel for a 30-year period would be a minimum of $210 favoring the use of A 242 steel. As previously stated, however, the cost of maintenance painting has nearly doubled in the past five years, and projection of this trend for the future would make the difference even greater.

Insignificance of Structural Depreciation Without Painting

An aspect of the use of weathered steel to be considered in designing unpainted structures is the rate of corrosion. In his paper, "Unpainted Low-Alloy Steel for Pavement Structures," R. B. Madison* showed that corrosion for long-term tests in "moderate" and "industrial" exposures was a maximum of 4.1 mils at the end of 20 years. These results can be extrapolated to 35 years for an estimated maximum corrosion of 4.85 mils. Using this maximum corrosion rate from exposure tests and multiplying it by three to account for increased deterioration at a bridge's most critical corrosion points, we could expect a maximum corrosion for analysis purposes of 14.6 mils at the end of 35 years. To determine the extent of this corrosion on structural members, we will consider a 36 WF 194 rolled section. At three times the maximum corrosion rate observed in tests this would result in a loss in area of 2.8 percent at the end of 35 years, and a loss in moment of inertia of approximately 3.2 percent. Even with the extreme rate of corrosion considered in this analysis, this loss of structural efficiency after 35 years is minor.

Summary

In summary, it has been shown that A 242 steel, when left to weather without painting, undergoes a very minor loss in structural efficiency due to corrosion over a 35-year period.

The advantages of a steel that does not require maintenance painting, thus reducing freeway traffic accidents and improving freeway operating efficiency, in combination with definite savings both in initial cost and subsequent maintenance costs, direct that the Department continue experimental evaluation of this type of steel.

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*Presented at the Construction and Structural Divisions Joint Session, ASCE Environmental Engineering Conference, Kansas City, Missouri, October 20, 1965.

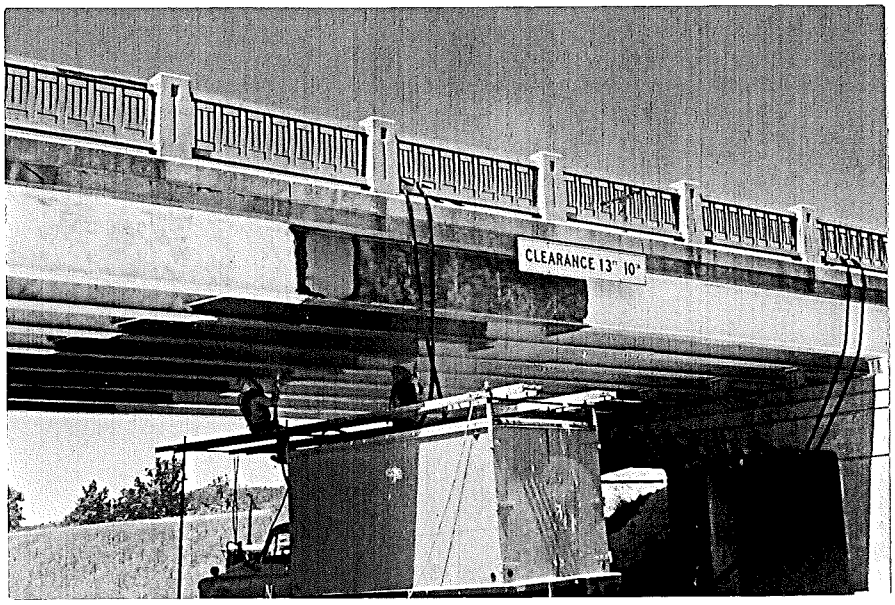

Figure 1. Truck scaffolding in position for sandblasting of bridge steel prior to maintenance painting, requiring the closing of one lane of traffic.

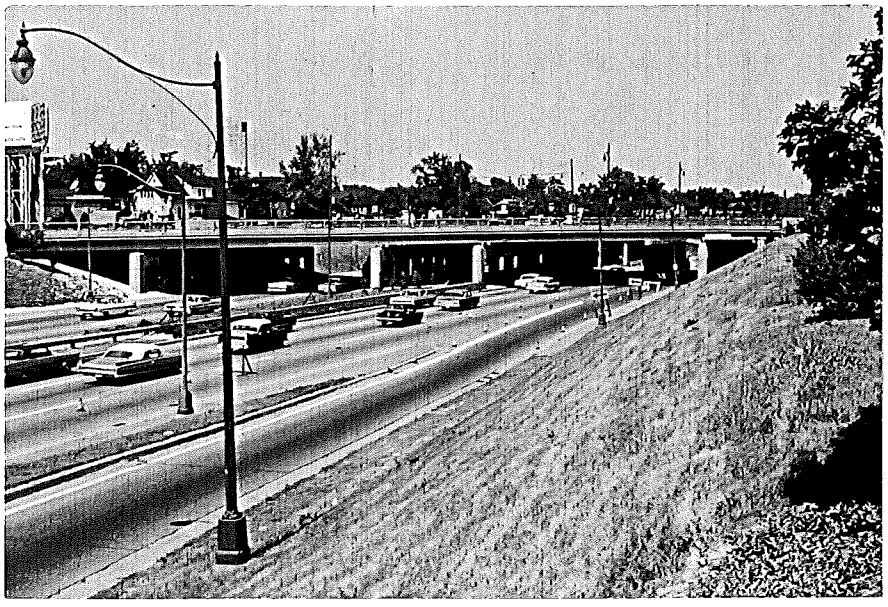

Figure 2. Redistribution of traffic by means of temporary signing and traffic cones to permit painting of bridge over expressway.