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THE PRESERVING AND RECONDITIONING
OF
CONCRETE BRIDGES

by

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THE PRESERVING AND RECONDITIONING OF CONCRETE BRIDGES

In October, 1945 the Research Laboratory of the Testing and Research Division was requested by Chief Deputy Commissioner Harry T. Hard to make a study of the preservation and reconditioning of concrete bridges. Consequently a research project was established involving two specific problems: First, the application of surface treatments to concrete for protective or aesthetic purposes; and second, the restoration of existing concrete structures which show evidence of disintegration due to weathering or other causes.

The work on the project so far has been of an exploratory nature and has been limited to a search for factual information which would provide a better understanding of the fundamental aspects of the whole subject with particular emphasis on the problem of painting structures as a protective and decorative treatment. This search has been in two directions, a comprehensive study of the literature on the subject, and a survey of several bridge and grade separation structures which had been painted experimentally in 1944 and 1945. The Bridge Division has expressed considerable interest in the matter of reconditioning existing structures and will cooperate in this phase of the problem as a separate study.

This report has been prepared with the intention of setting forth the results of the study in relation to the painting of concrete bridge structures. The results indicate that it is not practical or economically justifiable under present conditions of workmanship and with existing materials to attempt painting of such structures as bridges and grade separations.

The merits of oil and portland cement paints are discussed in the report as well as important factors relative to painting concrete structures which were revealed in the survey.

SURFACE TREATMENT OF CONCRETE

In the matter of painting or otherwise treating the concrete surfaces of bridges for preservation and eye appeal of the structure there are several factors which must be taken into consideration. The following paragraphs contain a discussion of the more important factors, such as materials and methods, and economics of painting as they affect the problem under consideration.

Materials and Methods

The two classes of coatings most widely used for concrete surface treatments are portland cement paints, and oil and resin type paints. Both types have been tried experimentally on several bridges and other structures with generally unsatisfactory results. A survey of these structures which were painted by a maintenance crew of the Bridge Division in 1944 and 1945, some with oil and others with portland cement paint, has just been completed and the results of this survey with pertinent comments will follow a brief discussion of the two classes of paints mentioned above.

Oil and Resin Paints: Although oil and resin paints offer certain advantages over portland cement paints as a coating for exterior concrete, there are also disadvantages in their use which would probably make them unsuitable under the conditions encountered in our work. They are easier to apply, provide a more positive moisture seal during the service life of the film, and can be cleaned more readily than portland cement paints. On the other hand, the film loses its flexibility in a comparatively short time making it unable to follow volume changes due to temperature and moisture variations in the concrete resulting in failure by cracking and peeling. One of the most serious objections, however, lies in the fact that most paints of this type should not be applied when the concrete is damp, or may become damp subsequently. This

objection generally rules out their use on concrete in contact with water or moist earth. The very fact that the film is more impermeable to moisture is conducive to peeling and loss of adhesion under conditions where moisture is constantly diffusing through the concrete to the surface which is exposed to the air.

Portland Cement Paints: A complete and thorough discussion of the whole subject of portland cement paints appears in a report by Committee 515, American Concrete Institute, of which E. E. Copeland is Chairman entitled "The Nature of Portland Cement Paints and Proposed Recommended Practice for Their Application to Concrete Surfaces", a reprint of which is attached to this report and which will be freely used herein as a reference. The typical portland cement paint film is hard, strong and relatively brittle; it generally adheres satisfactorily to the concrete and to preceding coats, and seldom fails by peeling or blistering. Cement paints can and should be applied to damp concrete but should not be applied to new concrete that is actively effloresceing or is in contact with water containing sulfates or other soluble salts which might permeate to the painted surface. The film produced by portland cement paints is more durable than that of oil paints, having a service life of approximately 8 years** when properly applied to wall surfaces exposed to the weather against 3 to 5 years* for the latter type. It should be particularly

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* Paint for Durability on Concrete Surfaces. P. O. Blackmore, A.C.I. Journal 55:545-51, June, 1959.

** The Nature of Portland Cement Paints and Proposed Recommended Practice for Their Application to Concrete Surfaces. A.C.I. Journal 58:485-501, June, 1962.

noted that by service life is meant the time required to produce failure of the film from the standpoint of protective value or coverage and is not meant to indicate a loss in decorative value.

At the present time there is a federal specification (TT-P-21) covering the compositional requirements of portland cement paints to which most producers conform in the manufacture of the commercial product. This specification represents the best practice in the formulation and use of cement paints according to present knowledge.

So far as is known it has not been established that portland cement paints appreciably protect good concrete from the effects of weathering. Their greatest use is on open textured or porous masonry and concrete surfaces, and they could not be expected to add materially to the durability of the smooth, dense concrete surfaces of bridge and grade separation structures.

Since waterproofing is an important function of the coating, it is questionable whether the use of portland cement paints could be justified on a utilitarian basis. In addition, a serious practical disadvantage lies in the necessity for the very precise and painstaking technique of application required to produce a durable film. This technique requires, first of all, a roughening of the concrete surface to anchor the film, then spraying with water to prevent excessive or selective absorption of the paint and provide a damp surface, but there must not be too much water as it will cause bridging instead of penetration of the voids. After application the film must be cured by the use of a fine water spray several times a day for at least two days. Too rapid drying out before the cement has had time to harden properly will materially shorten the life of the film.

Survey of Experimentally Painted Structures: As mentioned earlier, a survey of structures painted experimentally in 1944 and 1945 has just been completed. Pertinent data concerning these jobs are given in Table I. Two of the structures, one an overpass on US 16 near the airport west of Lansing, the other a culvert on M 78 near Charlotte, were painted in 1944 with a coat of oil paint pigmented with portland cement and finished with a coat of transparent seal. The oil type paint coat on the guard rail posts of the culvert at Charlotte had cracked and flaked so badly at the end of one year that they were repainted over the old paint with Peerless portland cement paint in 1945. The failure of the original oil paint was characteristic of this type of material when used on exterior concrete and, of course, repainting with portland cement paint has not remedied the situation. Lack of adhesion of the original oil paint coat will ultimately cause scaling of subsequent paint coats. An example of oil paint scaling is shown in Figure 1.

The overpass near the airport on US 16 has stood up somewhat better, but at two years the film is already showing signs of fatigue and is beginning to crack and flake off slightly on the southern exposures, an example of which is illustrated in Figure 2 (specked areas). Moist oil and resin type paint films on concrete lose their resiliency in a comparatively short time when exposed to the weather and the alkalis of the cement.

Three structures which had been surface treated with portland cement paint were also examined. Two of these were painted in 1945, one a bridge over the Manistee River at Manistee and the other an overpass on US 16 at Grandville over the Pere Marquette Railroad. The third, an underpass on US 16 east of Howell was painted in 1944. All three structures were painted by the same crew, using the same materials and procedure. Peerless portland cement

TABLE I

PAINTED BRIDGE AND GRADE SEPARATION STRUCTURES

Identification	Location	Year Built	Year Painted	Kind of Paint	Number Coats Applied	Number Men on Job	Number Days to Complete	Total Cost* Including Overhead
B1-51-6-1	Manistee	1952	1946	Peerless Portland Cement	2	8	59	3025.85
X5-41-24-11	Grandville	1936	1945	Peerless Portland Cement	2	6	16	1553.62
B1-28-1-1	Bellevue	1928	1945	Peerless Portland Cement	1	6	7	478.58
X1-47-5-2	Howell	1937	1946	Peerless Portland Cement	2	5	12	338.32
X1-19-16-2	Lansing Airport	1936-37	1944	#X-302 National Lead Color Paint	1	5	9	758.40
				Transparent-Seal	1			
C1-23-7-1	Charlotte	1942	1944	#X-302 National Lead Color Paint	1			
				Transparent Seal	1			
			1945	Peerless Portland Cement Rail Posts Only	1			

* Cost figures from Bridge Division

Figure 1. Top of culver wall at Charlotte painted with oil paint in 1944. Note extensive flaking of original coating.

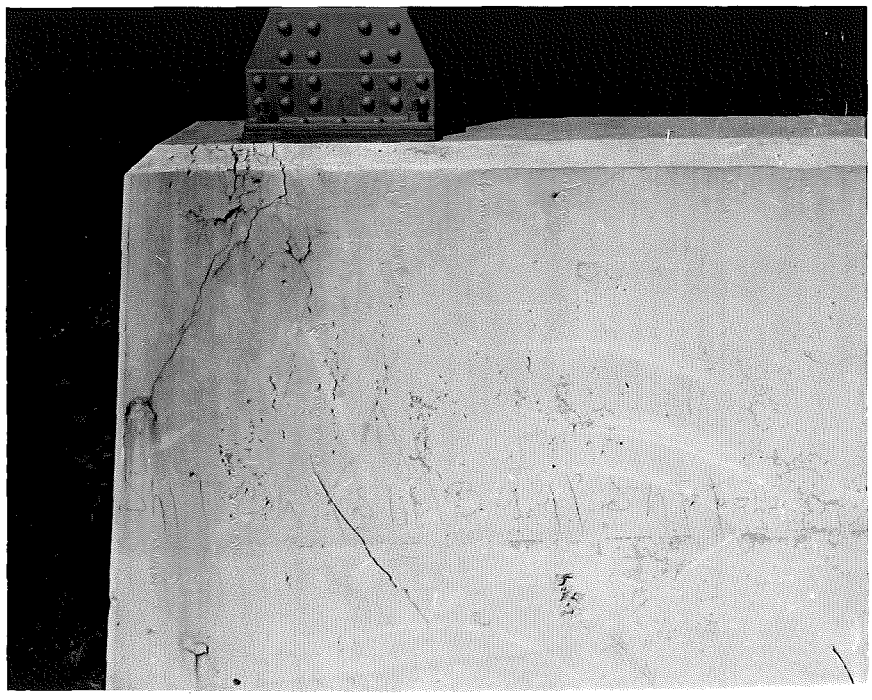

Figure 2. View of one wall of grade separation structure on US 16 near Lansing Airport. Specked areas are spots where the paint has begun to peel on the southern face. Note also incipient disintegration at upper left.

paint was applied with bristle brushes after washing down the walls with plain water. A second coat was applied after the first had hardened and cured for at least 12 hours.

The results to date have not been satisfactory on any of these jobs, although the types of failure observed are probably due to the smooth texture of the concrete surface and possibly insufficient curing of the film. The painted surface in all cases has weathered unevenly leaving brush marks of contrasting color plainly visible, which seems to indicate the non-uniformity of a film which is brushed too thin. Figures 3 and 4 are photographs showing respectively a general view and closeup of one of the walls of the Manistee bridge. The overall appearance is pleasing but at closer range the mottled effect is unsightly. There is a tendency to brush out the paint too thin on smooth concrete surfaces, and this is particularly true when a hair bristle paint brush is used in the usual way instead of scrubbing the paint on with an appropriate stiff brush as recommended by the manufacturer.

At Howell, in addition to the effects described above, there is also a tendency of the paint film to flake off on some areas, especially those adjacent to cracks in the concrete (Figures 5 and 6). This is an indication of poor adhesion which probably is due to inadequate preparation of the concrete surface prior to painting. Smooth, dense surfaces should be acid washed, lightly sand-blasted or dry rubbed with coarse abrasive stones before painting in order to provide "tooth" for the paint. The present (1942) bridge specifications of the Department call for a rubbed finish on new structures to be obtained by the use of a medium coarse carborundum stone with portland cement mortar followed by a fine carborundum stone with water, leaving the paste thus forced in the surface voids of the concrete. Such a surface will not hold a

Figure 3. General view of bridge at Manistee. Painted in 1945 with Peerless portland cement paint.

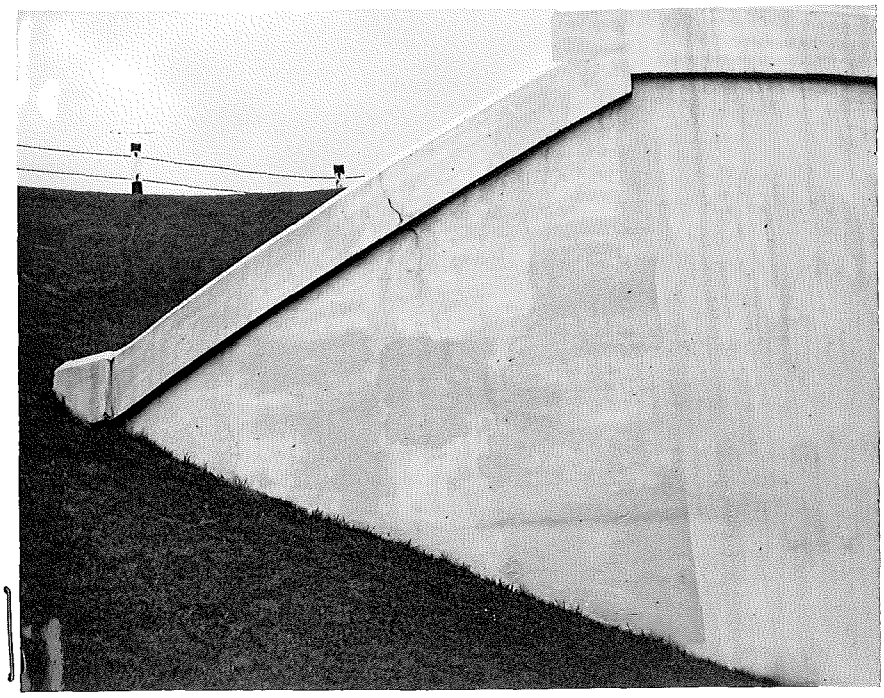

Figure 4. Closeup of one wall of the Manistee bridge showing mottled effect produced by uneven weathering of the paint film.

Figure 5. Chipping and scaling of portland cement paint film on underpass east of Howell on US 16. Painted in 1944.

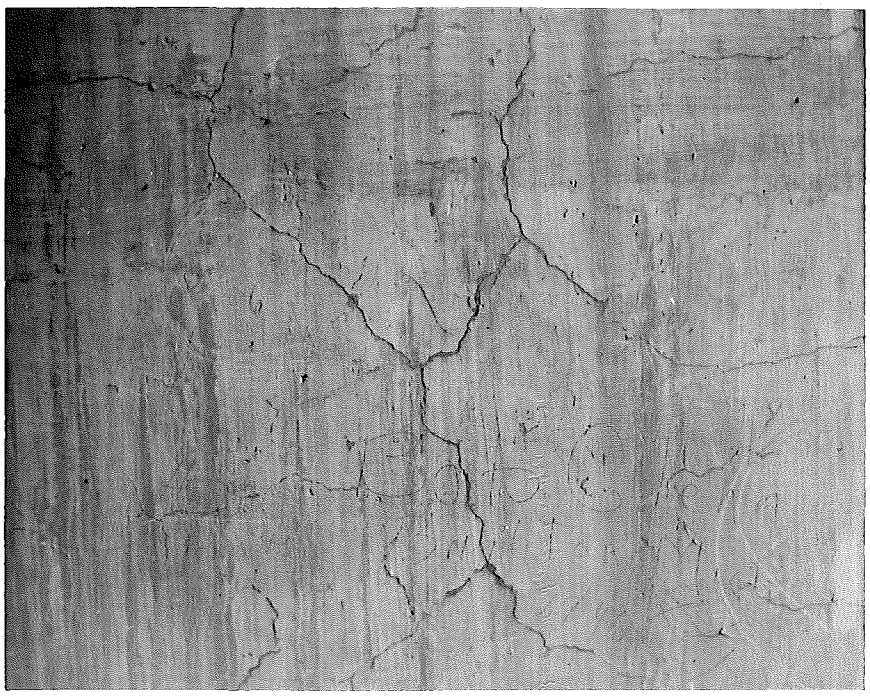

Figure 6. Crazing cracks showing through portland cement paint coat at Howell. Paint is starting to flake off at crack edges.

paint film as well as one which has only been cleared of projections and rubbed with a dry course stone after pointing the cavities with mortar. Proper preparation of the concrete surface of existing structures to receive a paint coating necessarily requires roughening by one of the methods mentioned above to secure adequate bond and a durable finish.

It is apparent from even this limited survey that greater emphasis should be placed on certain related construction factors in order to increase the durability of bridge concrete. Figures 2 and 7, which are photographs taken at the Lansing airport and Howell structures respectively, illustrate the accelerated weathering by freezing and thawing which occurs as a result of water dripping on the wall from above, which is probably aggravated by intermittent application of loads and vibration and which may also be partly due to the fact that the quality of standard concrete at top of abutment walls is sometimes questionable due to segregation and water gain. In such case the water stains are clearly visible in the cracked areas.

The use of an air-entraining agent in the concrete of the structure to reduce its permeability should prevent or at least greatly delay this type of deterioration.

Crazing and cracking of the types shown in Figures 6 and 8 are not serious in themselves except insofar as they allow entrance of water to cause scaling or spalling later on. Horizontal cracking at the plane of weakness between successive lifts of concrete seems to be a common phenomenon. These two types of cracking also should be prevented or minimized by the use of an air-entraining agent or an admixture to reduce segregation and water gain.

Figure 7. Another example of accelerated weathering of concrete indicated by network of cracks near the top of the wall, US 10 east of Howell.

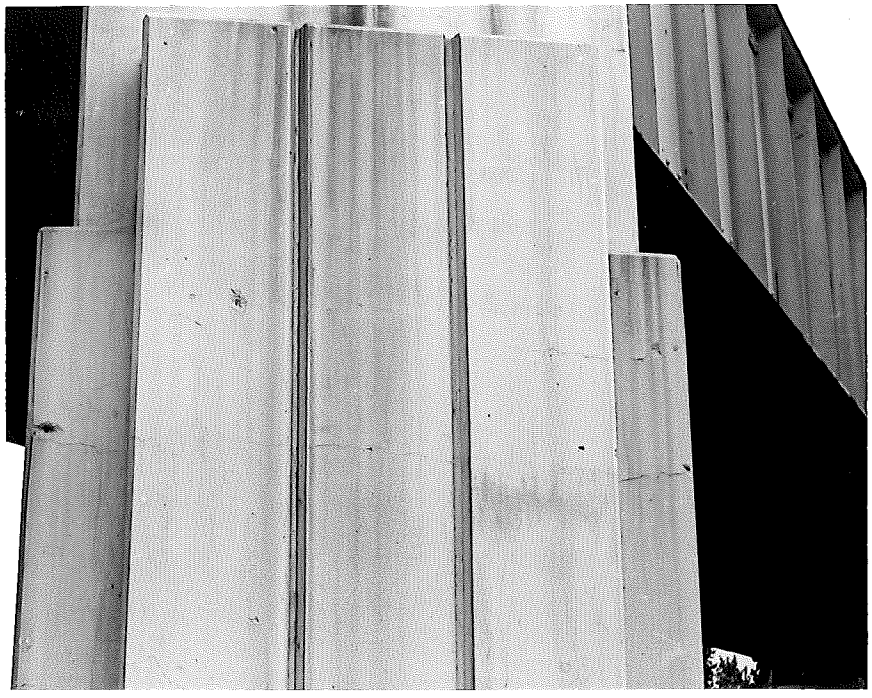

Figure 8. Horizontal cracks and aggregate popouts. US 10 east of Howell.

Economics and Practicability of Painting

In this phase of the study there are two distinct questions to be answered on the following points: (1) Is painting, which initiates additional and continuing maintenance costs and problems, economically justifiable? and (2) are present materials and methods practicable from the standpoint of securing a good job without extraordinary precautions and specially trained personnel?

In order to arrive at an answer to the question in regard to the economic justification of painting as a general policy it is necessary to consider just how much protection against weathering is secured thereby. In other words, will maintenance costs be increased or decreased as a result of painting?

Oil paints probably provide appreciable waterproofing of the concrete when applied to a dry surface under favorable conditions, but it has already been shown that, in general, the adverse moisture conditions found in our type of structure preclude the use of such paints.

Again, portland cement paints, although they will adhere to damp surfaces, offer little protection to concrete of good quality against the destructive natural forces of wetting and drying and freezing and thawing, and have the practical disadvantage of a specialized technique of application.

It is further evident from the condition survey of existing painted structures that treatment with either type of paint neither seals nor hides cracks and other defects in the surface of the concrete as shown by Figures 2, 4, 5, 6, 7 and 8. This fact supports the conclusion that little can be expected from surface coatings in the way of preservation of the concrete against weathering.

A less tangible factor, but just as real, is that of enhancement of eye appeal of the structure. It is hard to set a price on beauty. Although it might be expected to bring a reward in the form of greater volume of tourist business and increased state revenues from various taxes and licenses, it would be extremely difficult to determine just what increment could be directly attributable to the esthetic improvement of our highway system by these means alone. In this connection it is well to point out that the staining and soiling which inevitably occurs whether or not the structure is painted largely nullifies the decorative effect in a comparatively short time. Figure 9 and 10 are examples of what can happen in two years of exposure, regardless of the type of paint used. Painting, once started, must be continued at relatively short intervals if the decorative value is to be maintained. An examination of Table I throws serious doubt on the advisability of assuming such an added burden in view of the fact that benefits to be derived are not commensurate with the costs involved.

SUMMARY AND CONCLUSION

Results of study may be briefly summarized as follows:

1. Painting of the concrete has two intended functions; preservation against weathering, and improvement in appearance. Due to conditions surrounding the use of paints on highway structures, and the inherent qualities of the paints themselves, neither function is adequately fulfilled in the present instance.

2. A general appraisal of the relative merits of the two principal classes of paints used on exterior concrete shows that oil paints, while offering advantages in respect to ease of application and waterproofing efficiency

Figure 9. Staining of paint due to surface water. Lansing airport overpass.

Figure 10. Staining due to surface water. Howell underpass.

are not, in general, applicable to concrete under moisture conditions found in highway structures. Portland cement paints have little protective value on concrete of good quality and are difficult to apply properly.

3. Unsatisfactory condition of existing experimental portland cement paint jobs is believed to be due largely to inadequate preparation of the surface, improper application technique, and possibly insufficient curing of the film.

4. Failures of existing experimental oil paint jobs are probably due to normal weathering and subsequent loss of elasticity of the film.

5. Painting does not seal cracks and other defects in the concrete surface, nor does it prevent the formation of such cracks.

6. Continuing maintenance in the form of repainting at frequent intervals because of staining and soiling would be required in order to preserve decorative value if the practice of painting were once initiated.

The facts presented in the report point to the conclusion that painting of highway structures such as bridges and grade separations is not justified by the expected benefits to be derived therefrom.