BRIDGE PIER STAINING

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The Arkansas Highway Department studied bridge pier staining to determine the cause of stains, their effects on structures, and the best methods of preventing and cleaning stains. A letter survey of other states and tests on Arkansas bridges were included in the study. Runoff from the bridge deck is the primary cause of bridge pier stains. Arkansas stains contain the elements normally found in soil, rust, and tires. No significant structural damage was found in Arkansas, but some damage, primarily from salt, was reported in the other states. Methods suggested to prevent runoff water from bridge piers include use of continuous spans, expansion joints placed away from piers, preformed seals, and abutment drains. Three-fourths of all bridge stains can be removed by washing. Rust stains and graffiti, however, can be removed only by costly chemical procedures or sandblasting.

•A STAINED or discolored bridge can look old before its time and will give the appearance of being dirty or unkept. Stains also may indicate deterioration of the bridge structure. In an effort to find solutions to the problem of bridge pier staining, the Arkansas Highway Department funded a study to determine the following (1):

1. Cause of bridge pier stains,
2. Effects of stains on structures,
3. Methods of preventing stains, and
4. Methods of cleaning stains.

SURVEY OF STATES

A letter survey on bridge stains was sent to the 49 states other than Arkansas, and the District of Columbia. The survey asked for the states' experiences on composition, origin, effects, and prevention of bridge pier stains. Forty of the states replied, and 5 of the replies reported that they had no information to offer.

Most reports stated that most stains were composed of iron and salt. Rust was the most common stain, but weathering of iron pyrite in aggregate also was reported. Salt from roadway deicing was the second most common cause of stain.

Stains also were reported from fungus, bird droppings, waterborne minerals, petroleum products, dust, clay, marine growth, calcium carbonate, concrete or grout salts, and joint sealants.

Leakage of expansion joints was reported to be the most common source of stain. Weathering of concrete and paint breakdown also were reported as being common.

Fifteen of the respondents reported only aesthetic damage; 8 reported serious deterioration in some cases. Four of the 8 reporting damage listed salt or salt wastes as the cause. From the remaining 4, 1 blamed scaling and spalling, 1 blamed drainage, 1 blamed weathering, and 1 did not list a cause. The remaining respondents considered structural damage as a minor problem only.

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Most suggestions to prevent stain or discoloration are to eliminate water through the joints. Designing more effective drainage systems, sealing all joints, and eliminating joints by use of continuous-span bridges were suggested. Other preventive measures include using waterproof membranes to seal concrete and galvanizing exposed anchor bolts and bearing plates. Where weathering is involved, limiting the amount of iron pyrites and shale in aggregates is suggested.

Only 2 systems of treating bridges that already were stained were suggested. One respondent suggested removing stains with muratic acid and then treating them with a 50 percent-50 percent solution of boiled linseed oil and mineral spirits. The other suggested either sandblasting and treating the caps with epoxy paint or biannually washing areas and then treating them with a solution of linseed oil and mineral spirits.

ARKANSAS STUDY

Stain Composition

Three general types of concrete stains were found in Arkansas: rust stain, graffiti, and broad red or gray stains. These stain types account for more than 99 percent of all discoloration on bridge piers, aprons, and supporting members.

Composition of the stains was determined by qualitative chemical tests, combustion, and x-ray analysis. Rust stains (those directly traceable to metal rust) contained iron compounds and were the familiar burned red or rust color. The broad red and gray stains contained compounds of iron, sulfur, potassium, aluminum, silica, and calcium (Figure 1).

Stain Origin

Rust stains resulted from rusting steel in the bridge structure. Rust stains occurred at the anchor bolts, bridge expansion joints, and bridge piers and on the apron at the end of bridges. Several examples of rust stains that occurred before the bridge deck was placed were found on concrete aprons. Almost all of the rust stains on bridges were below places on the bridge that are difficult or impossible to paint.

Red and gray stains were the result of weathering and surface runoff. The stains occurred in areas where runoff from bridges wet concrete surfaces. In addition, the composition of the stains (iron, silica, aluminum, and sulfur) indicated that soil and road grime were the origin. The presence of sulfur is not surprising because it is used in the manufacture of tires (1 to 1.5 percent by weight) and occurs naturally in asphalts (usually less than 1 percent by weight). Inspection trips during and just after showers confirmed that areas of red and gray stains were wet by surface runoff.

Extent of Stains

No significant structural damage as a result of stains was found on the Interstate bridges during the inspection trips. Stains were superficial and did not penetrate the concrete or accompany a deterioration of aggregate. A small amount of deterioration was present, however, above the rust stains. Rocker arms, anchor bolts, and bearing plates were the most frequent cause of rust stains.

Cleaning

Graffiti and rust stains were difficult to remove. Sandblasting is an effective method of stain removal, but it removes part of the concrete. When repeated often, sandblasting removes the concrete matrix. Derrington, Stowe, and Miller (2) recommend using

Figure 1. Composition of broad red and gray stains.

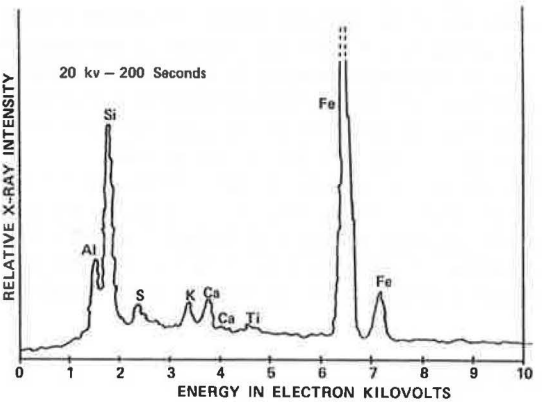
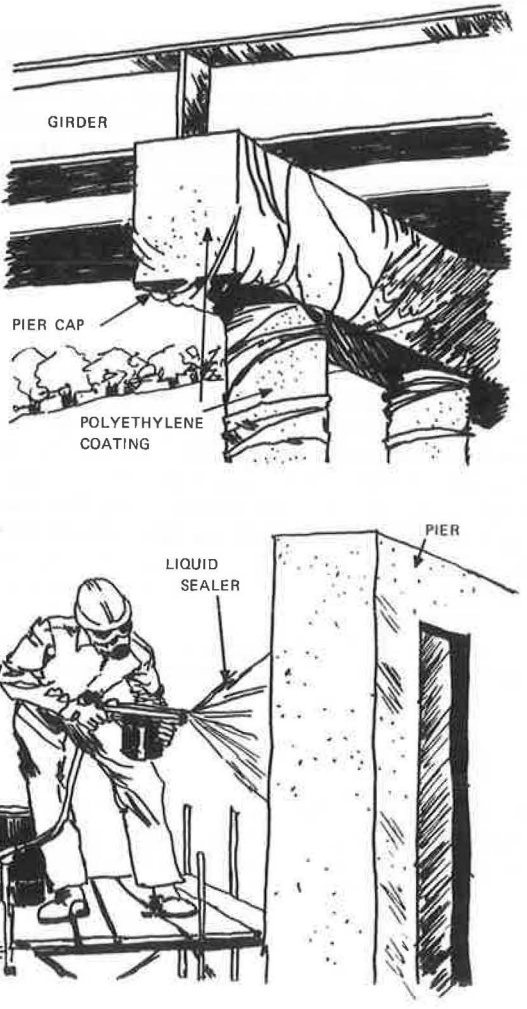


Figure 2. Temporary stain protection.



a combination of sodium citrate and sodium hydrosulfite for removing iron stains. This method, however, is expensive and time consuming.

Red and gray stains, which make up more than 75 percent of the stains on most bridges, were relatively easy to remove. An estimated 95 percent of these stains were removed from the Seventh Street overpass of I-40 in North Little Rock, Arkansas, by washing with a brush, cleaning agent, and rinse water. Use of a dry brush alone removed 60 percent of the stain. Application of Removox, a mixture of hydrochloric acid, gluconic acid, 9-10 molar ethylene oxide nonionic, 12-15 molar ethylene oxide nonionic, and an inhibitor, also removed 90 to 95 percent of the stain with or without brushing. This cleaning agent, because of the acid it contains, also removes some of the concrete matrix.

Prevention of Stains

Prevention of stains, other than graffiti, is accomplished by keeping water off the concrete. The most effective method is to use continuous-span bridges or to place the expansion joint away from the bridge piers. Elimination of expansion joints over bridge piers, however, is not always economical.

A 1973 Georgia Department of Transportation study (3) of bridge expansion joints concludes that joints can be sealed by sealing the vertical curb face at construction joints. Specifying use of sliding plate joints, preformed seals (with high solids adhesive), and armored joints could be discontinued.

Coatings and sealers are effective in preventing stains over short periods of time (Figure 2) (4). Polyethylene and vinyl can effectively prevent stains during the construction period before the bridge deck is poured. With time, however, coatings and sealers break down and expose the concrete to stains.

A sloping abutment with drain (Figure 3) is effective for eliminating stains from bridge ends (4). Drip pans, also shown in Figure 3, are only moderately successful because the wind that accompanies storms will blow water on the bridge piers.

Expansion joints between sections of bridges can effectively be sealed in 1 of 3 ways (Figure 4). Where expansions are large, as in finger joints, the neoprene or conveyor-belt trough is effective. Veral Pinkerton of the Arkansas Highway Department has stated that care must be taken to ensure that the belt trough has sufficient room to flex so that it will not become clogged. Intermediate movements can be absorbed with angle troughs, and small expansions can be absorbed with compressible, preformed joint sealers. Compressible joint sealers must be installed with care or leaks will develop.

CONCLUSIONS

Stains on bridges in Arkansas were not damaging to the structures.

Natural stain, that is, all stains except graffiti, were the result of weathering and and surface runoff.

Natural stains, other than rust stains, can be removed effectively by sandblasting; washing with soap, water and a brush; or applying certain acids and rinsing. These stains will recur, however, unless their source is found and corrected.

Bridge pier stains can be reduced greatly by preventing rainfall runoff from reaching the concrete below the bridge deck.

ACKNOWLEDGMENT

I would like to thank the Belthehem Steel Corporation for their permission to use the drawings shown in Figures 2, 3, and 4 (4).

Figure 3. Abutment protection and drip pan.

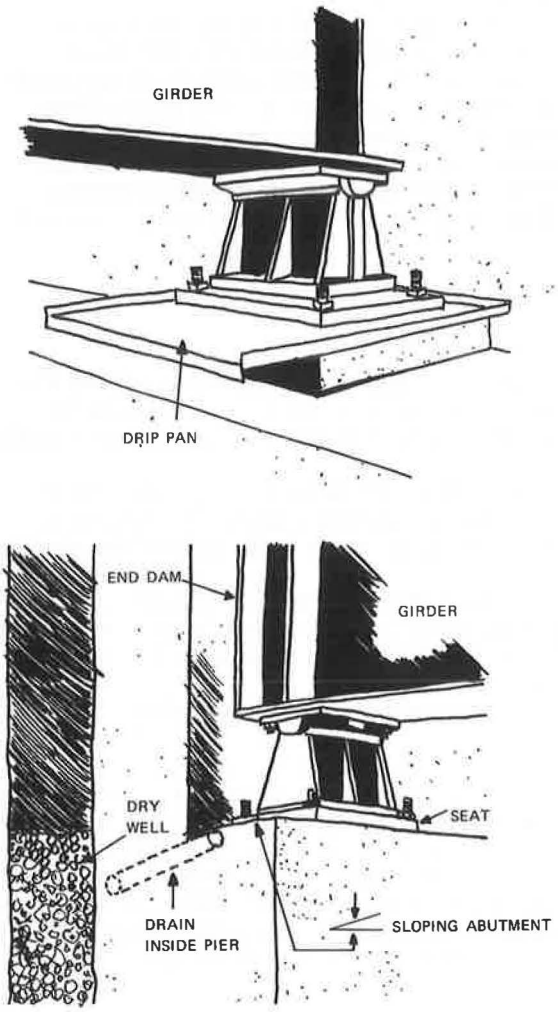
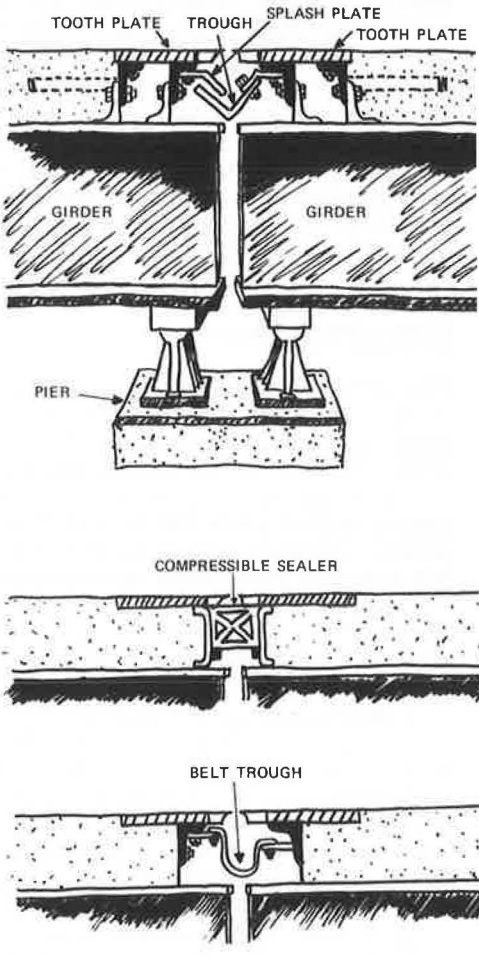


Figure 4. Expansion joint protection.



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