Survey Technique and Iowa Experience

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• IOWA investigated bridges in the winter and spring of 1961. This investigation was limited only to the decks of the interstate bridges then open to traffic. All of the bridges are fairly new. The oldest in this survey were constructed in 1957. Most of the bridges have seen service for at least two winters.

The survey was conducted at the request of the Bureau of Public Roads. As much information as possible concerning decks was included in the survey. The investigation included all types of disintegration, not just scaling. At that time deterioration of decks was not considered a major problem. Following this survey it is not now considered a serious problem, comparatively speaking.

The survey was conducted in this manner:

1. The district materials engineer and the resident maintenance engineer inspected all interstate bridge decks in their area making notes relevant to the present condition. This survey included 210 structures.
2. A three-man committee digested these reports choosing 124 structures with reported objectionable defects for personal investigation and a few with no defects reported as standards for comparison. This committee represented 78 years of highway engineering experience.

HRB Special Report 30 was studied along with other pertinent literature. It was necessary to have agreement of classifications among the committee members, but this discussion in Washington was not anticipated at the time of the survey. The following definitions were made:

Scaling. — The removal of surface mortar. This was classed as surface scale and light scale. Surface scale was usually considered as $\frac{1}{8}$ in. or less, though it is not easy to measure accurately. Light scale was $\frac{1}{8}$ to $\frac{1}{4}$ in. Other serious scaling was classified to include areas commonly referred to as raveling or spalling. The section or sections of the floor having scaling were noted. The location of the scaling was noted such as general scaling and scaling near curb. The scaled area was neither measured nor estimated, but described in such terms as small amount and large amount.

An attempt was made to determine the cause of some of the serious scaling, which indicated a serious need for corrective action. This was in line with the goals of this survey.

Pitting. — The damaging of the finished surface over an area by removal of individual aggregate particles. Generally, it is thought to be due to unsound aggregate in the smaller sizes.

Potholing. — In this survey, a surface spall caused by unsound aggregate at or near the surface. This may be weathering of shale very close to the surface or an expansive aggregate (such as chert) that may break some depth of sound concrete. At any rate, this problem can be traced to an unsound aggregate particle. Some refer to this defect as a popout.

Cracking of bridge floors was divided into three types:

1. Structural cracks. —Negative moment cracks occurring when structural action under a live load puts the deck in tension.
2. Plastic shrinkage cracks. — Cracks occurring when loss of moisture causes shrinkage during hardening.
3. Pattern cracking. — Cracking that traces the pattern of reinforcing in the concrete to some extent.

Disintegration of Concrete. – A general deterioration into small fragments or pieces. There are other categories for defects which could have been included but were not. This was a limited survey with a goal of finding and correcting defects resulting from construction procedures. Considerable effort was spent on evaluating the data. In all cases imperfections were confined to relatively small areas of the deck, and in no case was the entire deck found to be deficient.

SUMMARY OF DATA

Scaling

Some instances of scaling were found. In 49 of the 124 decks some local surface scaling appeared. Ten of the 49 decks had light scaling locally. Four of the 10 decks with light scaling were serious enough to cause the committee to recommend careful watching. Two decks had serious scaling or raveling. One had been repaired with latex mortar.

Each of the decks was constructed under the same general specification using air-entrained concrete.

It was accepted that both salt and finishing techniques may have had a strong influence on the scaling. Where light scaling was found, it was thought that an unusual thickness of mortar had been floated into place to bring a low spot to the proper elevation. In at least one case it was thought that concrete near the proper elevation had partially hardened before additional concrete was placed to obtain the proper elevation, leaving a plane with inadequate bond. These conclusions were made after examining the project reports or diaries and represent the best judgment of the committee.

On one deck the curing burlap apparently was disturbed, and some of the concrete adhered to the burlap causing an appearance of scaling.

Surface scaling is very difficult to evaluate. It is impossible to determine whether it will be progressive or not. On most of the bridge decks with surface scaling in small areas, it was thought that another year or two under traffic may cause the evidence of scaling to disappear leaving a surface with the appearance of abrasion only.

There is an indication from this survey that more effective curing may be justified.

Pitting and Potholing

Pitting and potholing were not serious problems. No case of objectionable pitting was found. In practically all decks in certain areas, some potholing was found. The potholing was anticipated, but in general it was not found serious. Availability of coarse aggregate in Iowa precludes the elimination of all potholing.

Cracking

Structural cracks, which are negative moment cracks, were found to occur generally on continuous steel structures and frequently on prestressed concrete structures. These cracks were found to be well distributed and usually small. This cracking was not considered to be a serious defect.

Plastic shrinkage cracks were found in 41 structures. Usually they were hairline cracks in no particular pattern. In one case, some extended through the deck. Nine of these 41 cases were judged severe enough to cause early maintenance.

Several cases of plastic shrinkage were coupled with pattern cracking such that the result was a combination of the two.

Most of the severe shrinkage cracks occurred on deck sections poured under winter conditions, indicating a need for better techniques, more careful controls, or elimination of deck pours in the winter.

Several cases of radial shrinkage cracks were found, indicating that a heater could have been placed directly below this location when the concrete was placed in the winter.

Pattern cracking was found in some decks. Usually it was in combination with shrinkage cracks, and they were difficult to classify in a positive manner. Five cases appeared to be related definitely to steel placement.

In some other cases it appeared that reinforcing had been disturbed after the concrete had begun to harden. This was particularly true near the end of skewed sections with staggered joints. Perhaps effective precautions were not always taken to prevent disturbance of the bars extending outside the section being poured.

Pattern cracking did not occur frequently, but a study of construction techniques could minimize it.

Deterioration of the Concrete

One section was found to have an area with deteriorated concrete, but it was impossible to determine the cause. Because the section was poured during the winter, it could be presumed that some freezing may have occurred.

Minimizing Scaling

In Iowa, pavements and bridge decks placed after October 15 on roads that are salted are treated with a linseed oil emulsion. Each gallon of the emulsion has the following ingredients:

Boiled linseed oil	0.054 gal
Kerosene	0.054 gal
Soap powder	0.03 lb
Trisodium phosphate	0.04 lb
Water	0.892 gal

The soap powder and trisodium phosphate are mixed in a barrel of water. About 50 gal of water are placed in a 500-gal distributor. The soap solution is added to this 50 gal. The kerosene and linseed oil are added to the distributor and the remainder of the water is added in a forceful spray. The material is continuously circulated during this process.

This emulsion is applied to dry concrete in two applications (0.15 and 0.10 gal per sq yd) with ample drying time between applications.

CONCLUSIONS

The survey committee agreed that because scaling was generally confined to small areas, it is not now a serious problem in Iowa, but it could become serious. The committee was quick to realize that finishing, curing, and inspection techniques should be improved. It was recognized that scaling potential is hard to define, but that better finishing and curing techniques and better inspection should contribute to the solution of the scaling problem.

A program has been initiated to put the committee's conclusions into use:

1. Controlling the amount of mixing water closely to prevent either excessive or deficient slump. Limits of 3 to 4 in. were suggested.
2. Banning absolutely the addition of water on the surface of concrete before or during the finishing process.
3. Avoiding excessive working of the concrete by
   a. Requiring a better mechanical speed;
   b. Permitting only sufficient vibration to consolidate the concrete; and
   c. Eliminating belting and substituting a burlap drag.
4. Requiring the use of retarders when indicated by weather conditions or pouring sequence.
5. Eliminating artificial heating of concrete floors.
6. Encouraging the casting of continuous decks using retarders.
7. Considering possible methods to reduce loss of surface moisture which results in plastic shrinkage cracks.
8. Provide an additional quality control inspector to assist the regular bridge inspector during pouring operations.

In addition to these eight points the committee recommended a system of educational meetings with bridge contractors and inspectors to improve construction practices.

The committee further recommended that the survey be made annually on all primary and interstate bridges under traffic for $2\frac{1}{2}$ to $3\frac{1}{2}$ years.

The committee felt that scaling generally was not a separate problem. There are several problems that could be improved by better construction techniques. This overall improvement should help to minimize the scaling problem.