*BRIDGE DECK
SCALING SURVEY*

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*Joint
Highway
Research
Project*

*PURDUE UNIVERSITY
LAFAYETTE INDIANA*

by

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Technical Report

BRIDGE DECK SCALING SURVEY

To: K. B. Woods, Director
Joint Highway Research Project

June 19, 1964

File: 5-8-25

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-37Y

Attached is a report entitled "Bridge Deck Scaling Survey" by S. J. Hanna and C. F. Scholer, Research Assistants, Joint Highway Research Project. The survey was made at the request of the Advisory Board to determine the severity of concrete bridge deck deterioration on structures built since 1947. Approximately fifty-four percent of the structures built between 1947 and 1963 were surveyed. All districts were included in the sample.

Respectfully submitted,

H. L. Michael/jm

H. L. Michael, Secretary

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Attachment

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Technical Report

BRIDGE DECK SCALING SURVEY

by

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and

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Joint Highway Research Project

File: 5-8-25

Project: C-36-371

Purdue University
Lafayette, Indiana
June 19, 1964

BRIDGE DECK SCALING SURVEY

INTRODUCTION

This investigation was conducted for the purpose of determining the condition of exposed bridge surfaces with respect to scaling of the portland cement concrete. Bridges in the Indiana Primary, Secondary and Interstate Systems were investigated. The exposed surfaces checked were approaches, deck, curb, gutter and sidewalk areas. Bridges constructed from 1947 to the fall of 1963 were inspected. The year 1947 was chosen as a starting point since 1947 was the first year in which air-entrained concrete was in general usage.

The tabulation of bridges in the State Highway System of Indiana compiled by the Bridge Department of the ISHC and dated June 30, 1962 was used as a basis for determining the number and location of bridges on the Primary and Secondary systems. Strip maps were used to locate Interstate bridges and hence the total count of Interstate structures could not be determined with the same accuracy. However, a large fraction of the total number of Interstate bridges was included in the survey.

All bridges on record were located on a state map using map pins. Routes were then selected in a manner so as to give uniform coverage of the state.

This investigation was not intended to inventory all structures in the state but rather to obtain a representative sample throughout the state so as to evaluate the magnitude of the scaling problem in Indiana.

METHOD OF RATING

The bridges were visually inspected by Mr. C. F. Scholer and Mr. S. J. Hanna. The bridges were rated on the spot using the Structure Scaling-Inspection Report form shown on page 3. Visual estimates of the percentage of the area scaled were recorded along with other pertinent information such as whether or not the deck was resurfaced. A note was made of the popouts and was recorded as none, slight, moderate or heavy.

A number rating system was then used for initial tabulation purposes. This system was later modified to None, Moderate to Light and Severe ratings. Ratings were also given to the condition of the bridge with respect to overall scaling and also with respect to the degree of scaling in the localized area of the structure most acutely affected.

Rating of 5:	0%	None
Rating of 4:	0 - 15%	Moderate
Rating of 3:	15 - 40%	
Rating of 2:	40 - 70%	Severe
Rating of 1:	70 - 100%	

TABLE 1

Summary of Bridges Statewide (by number)

Total Number of Bridges	1449
Number Surveyed	786
Number Not Surveyed	663
Sample Size, percent of total	54%
Total Number of Widening, PPS* and PCS*	161
Number Surveyed	67
Number Not Surveyed	94
Sample Size, percent of total widening, PPS and PCS	42%
Total Number Analyzed (1449-161)	1288
Number Analyzed Surveyed	719
Number Analyzed Not Surveyed	569
Sample Size, percent of total analyzed	56%

*PPS - Precast Prestressed Concrete Slab

*PCS - Precast Concrete Slab

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STRUCTURE SCALING--INSPECTION REPORT

Road and Section _____ County _____ Structure No. _____

Page Number in the June 30, 1962 Bridge Book _____

Date Inspected _____ By _____

DESCRIPTION

	Yes	No
Concrete Approaches	_____	_____
Bituminous Approaches	_____	_____
Concrete Deck	_____	_____
Concrete Deck Patched	_____	_____
Concrete Deck Resurfaced	_____	_____
Other _____	_____	_____

AREA SCALED

%

Approaches	_____
Roadway	_____
Gutter Area	_____
Curb	_____
Sidewalk	_____

Popouts: _____

Remarks: _____

BRIDGES SURVEYED—BY SYSTEM

P- PRIMARY
S- SECONDARY
I- INTERSTATE

TOTAL BRIDGES
SURVEYED

RESULTS OF THE BRIDGE DECK SCALING SURVEY

Table 2 presents a statewide summary of bridges investigated. The total number of bridges differs for the various locations due to the various types of resurfacing that has occurred since initial construction. For example, a structure may have been resurfaced completely from curb to curb or just the roadway resurfaced with the concrete in the gutter area still exposed. The number of bridges surveyed which fall into the various ratings are tabulated.

TABLE 2

Statewide Summary of Scaling Ratings in All Systems

Number of Bridges

<u>Location</u>	<u>Rating</u>		
	<u>Severe</u>	<u>Moderate to Light</u>	<u>None</u>
Approaches	4	31	352
Roadway	7	78	361
Gutters	24	151	299
Curbing	17	118	420
Overall Scaling Rating	15	190	349
Localized Area Rating	91	131	299

A percentage breakdown as to type of deck (portland cement concrete or bituminous concrete resurfacing) is shown in Table 3. Where a structure was resurfaced it was not possible to rate the approaches or the deck, however, gutters and curbs were rated when possible. On those structures

that were resurfaced, the overall scaling rating and the localized rating were based on those areas of exposed portland cement concrete.

TABLE 3

Statewide Summary of Scaling Ratings on

All Systems by Surface Type, in Percent

(based on 439 bridges)

(based on 213 bridges)

Portland Cement Concrete

Bituminous Mixture

Location on Deck	Severe	Moderate to Light	None	Severe	Moderate to Light	None
Approaches	1	8	91	N/A	N/A	N/A
Roadway	2	16	82	N/A	N/A	N/A
Gutters	4	32	64	8	30	62
Curbing	1	22	7	7	19	74
Overall Scaling	1	36	63	7	29	64
Localized Area	9	26	55	13	21	66

A breakdown by State Highway Districts is shown in Table 4. An interesting and expected trend can be seen in the tabulation. Under column N in both the Primary and Secondary Systems the percent of bridges which have no scaling increases as one proceeds from the northern to the southern districts. The converse is true in column M-L which shows that the problem of scaling is more severe in the northern portion than in the southern portion of Indiana. This trend is not so evident in the Interstate System due to the small number of Interstate bridges in the LaPorte, Ft. Wayne, Crawfordsville and Vincennes District, (see page 4). The 14% value for severe overall scaling in the Ft. Wayne district represents one bridge out of a total of seven bridges surveyed. It can be seen from the statewide average and the Greenfield and Seymour Districts that the Interstate

TABLE 4

District Summary of Overall and
Localized Sealing Ratings, in Percent

	Primary System						Secondary System						Interstate System					
	Overall			Localized			Overall			Localized			Overall			Localized		
	S	M=L	N	S	M=L	N	S	M=L	N	S	M=L	N	S	M=L	N	S	M=L	N
LaPorte	0	56	44	15	46	39	5	55	40	26	53	21	0*	80*	20*	0*	100*	0*
Ft. Wayne	2	43	55	24	34	42	12	36	52	9	50	41	14*	72*	14*	86*	0*	14*
Crawfordsville	0	31	69	12	21	67	0	45	55	25	25	50	0*	100*	0*	50*	50*	0*
Greenfield	1	33	66	12	18	60	4	29	67	20	15	65	2	33	65	20	19	61
Vincennes	0	10	90	0	7	93	0	0	100	0	6	94	0*	0*	0*	0*	0*	0*
Seymour	9	17	74	10	15	75	8	13	79	17	4	79	0	38	62	17	35	48
Statewide	2	35	63	14	28	58	5	29	66	16	24	60	2	38	60	23	24	53

* Number of Interstate Bridges Surveyed was very small in this district.

** Represent 3 out of 33 bridges, two which were constructed in 1947.

S Severe

M=L Moderate to Light

N None

System is no less susceptible to scaling than is the Primary or Secondary Systems. Approximately 40% of all bridges surveyed showed obvious signs of scaling deterioration.

Photographs 1-8 show examples of severe scaling observed at various bridge locations within Indiana.

1 — Severe Scaling on One-Lane of Approach to Recently Constructed Bridge (18-K-4518)

2 — Severe Scaling Along Outside of Bridge Approach. This was Built in 1960. (3-O-4872)

3 — Severe Scaling on Deck of Bridge Built in 1950. (39-O-3627)

4 — Severe Scaling on Bridge Deck Built in 1961.
The Adjacent Gutter has not Scaled (41-K9-2235 S.B.)

5 — Severe Scaling in the Gutter of the Same Bridge
Shown Above but at Another Location.
(41-K9-2235 S.B.)

51-41

6 and 7 — This Resurfaced Deck Apparently has Considerable Scaling. The Photo with the Shadow Indicates that Scaling has Continued After Resurfacing. (221-C-4040)

8 — A Typical View of Scaling in a Portion of a Gutter. The Adjacent Pavement has Little Scaling at this Location. (18-K-4518)

POPOUTS

As noted previously, the condition of the surfaces with respect to popouts was also rated. For structures with exposed concrete decks 55 were rated heavy, 247 rated moderate and 238 rated as light or none. A further breakdown as to district is presented below.

	<u>Severe</u>	<u>Moderate</u>	<u>Light or None</u>
LaPort	1	22	31
Ft. Wayne	24	34	29
Grawfordsville	3	32	6
Greenfield	25	124	85
Vincennes	0	6	42
Seymour	<u>2</u>	<u>29</u>	<u>45</u>
Total	55	247	238

Photographs 9-11 on the following page illustrate various conditions of structures as to the intensity of popouts. Photograph No. 9 shows a structure with curb, sidewalk and rail heavily pitted with popouts. Photograph No. 10 shows a structure on I-465 which was rated as moderate with respect to popouts. Photograph No. 11 shows a structure on U. S. 41 in Vigo County which was rated as heavy with respect to popouts.

9 Severe Popouts (67-H-3830)

10 Moderate Popouts on Structure on I-465 over U.S. 36.

11 Severe Popouts on Deck (41-K9-2235S.B.)

SPALLING OF PORTLAND CEMENT CONCRETE PAVEMENT FROM REINFORCING BARS

During the pavement scaling survey, several bridges were noted that had reinforcing bars exposed. In general this was due to spalling of the concrete covering the reinforcement. A total of 32 bridges had such exposed steel. Considering all bridges surveyed in all systems this amounts to $4 \frac{1}{2}\%$ of the bridges. The interstate system shows five bridges or 3% had exposed reinforcing steel.

In many cases the cause of this spalling was no doubt attributable to insufficient lack of cover, (see photograph No. 15). In some cases, however, the cover present should have been sufficient, (see photograph No. 17). Staining of cracks over reinforcing bars was common on bridges experiencing this difficulty. Similar stains were often noted on bridges without spalling being present.

On resurfaced bridges or on those with extensive patching it was not possible to determine if spalling had occurred.

Pavement Spalling Off of Reinforcing Bars

15 Spalling Apparently Due to Shallow Cover (57-H-426)

16 Early Stages of Spalling Built 1956. The Dark Line Crossing the Paint Stripe in the Foreground is a Rust Stain. (2D 2213)

17 Severe Spalling with Cover Greater than 1 inch are Rebars. Overpass over I-65. (Note exposed steel in curbing) (334-C9-4293)

GENERAL COMMENTS

It was noted by the personnel inspecting the bridges that in a number of instances scaling was promoted by poor maintenance. Frequently sand and gravel deposits were allowed to remain in gutter areas and hold moisture. This allowed the concrete to become saturated with moisture in these areas and freeze and thaw damage was severe. On a number of structures over Interstate projects the position of the expansion joint coupled with excessive filler material held material in the gutter area which would normally wash off. These two conditions are illustrated in Photograph Nos. 12 and 13 respectively.

Another condition noted in recent construction was the apparent deterioration of concrete at the junction of sidewalk and rail. This is illustrated in Photograph No. 14. This appears to be a problem of forming and construction practice rather than what is normally thought of as scaling damage.

12 Joint Problem on 46th
Street Overpass over I-465.

13 Sand and Gravel in Gutter
(36-G-3897)

14 Joint Forming Problem (67-H-3830)

The construction records for 56 bridges were reviewed. Twenty-seven (27) bridges were selected to represent bridges with good scaling ratings (most severe rating of 4 or 5). The remaining 29 bridges were selected to represent bridges with poor scaling ratings (most severe rating of 1 or 2).

A majority of the bridges with poor scaling rating are from the four northern districts and, necessarily, the majority of the 29 construction records for poor bridges were from these districts. The 27 bridges with good ratings were selected, insofar as possible, from the same districts as the bridges with poor ratings.

Although the number of bridge construction records reviewed was relatively small, making it impossible to arrive at a firm conclusion, it can be noted that only one "good" bridge deck was poured in the four winter months of November, December, January and February. Severely scaled decks were poured throughout the year with the greatest number occurring in the months of January, June and December.

Air content of the fresh concrete when poured was recorded on 21 of the 56 construction records reviewed. Nine of the 21 bridges were rated as having essentially no scaling, while localized scaling was severe on the other 12. In many of these the air content was apparently determined only once for the entire deck.

The average recorded air content for the 9 "good" bridges was 5.1% based on 17 reported air contents. The average was 4.2% based on 19 reported air contents for the "bad" bridges. A frequency distribution of the air contents is shown in Figure 4. It should be noted that most of the air contents recorded were below the middle of the range currently specified by the ISHC.

FIG.2— DATE OF DECK POUR— "GOOD SCALING RATING"

FIG.3— DATE OF DECK POUR— "BAD SCALING RATING"

(FIG. 4)
FREQUENCY DISTRIBUTIONS
OF RECORDED
AIR CONTENTS

SUMMARY

1. The population of bridges in the state highway system built since 1947 is approximately 1288. Of this total, 56 percent or 719 bridges were surveyed. Over 150 bridges contained no exposed concrete and could not be rated. Practically all of these did have concrete decks that once served as the wearing surface but which were subsequently resurfaced.

2. Of the 500 plus bridges that were given overall ratings, 15 were rated as severely scaled, on 190 scaling was moderate to light and 349 bridges were given an overall rating of "none." Hence scaling was present to some extent in about 40 percent of the bridges that could be rated.

3. A measure of variability of concrete quality, perhaps interacted with exposure conditions, is indicated in Table 2. Although only 15 bridges were rated severe overall, 91 bridges contained significantly large localized areas in which scaling was severe.

4. Severity of the scaling problem increases as one proceeds from southern to northern Indiana.

5. Review of construction records of 56 bridges showed, among other things, that of the 12 bridges for which the deck was poured during the period November 1 - February 28, only one was rated good while eleven were rated as severe.