OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

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To: L. T. Oehler
Engineer of Research

From: C. J. Arnold

Subject: Bridge Deck Construction
Research Project 73 TI-138. Research Report No. R-875.

The subject investigation was undertaken at the request of the Design Division to determine whether the use of shoring under stringers during deck placement provided a significant difference in the accuracy of the location of deck reinforcement.

The original request contained a list of 45 structures that had been designed with temporary supports. However, only seven of the structures had been completed. A subsequent listing from the Design Division provided seven more structures, similar in design, that had been built without supports. These 14 structures were checked for depth of steel.

Steel depth measurements were made at 4,198 locations, including 2,701 locations on 23 spans constructed without shoring and 1,497 locations on 15 spans constructed with shoring. Results of the measurements are shown in the attached table. Remarks include reference to isolated cracking of the decks, but in no case was the cracking of sufficient extent to indicate trends related to support conditions during deck construction. Only five of the structures were open to traffic (the first and last listed under "Structures without Supports," and the last three of "Structures with Supports"). Deck cracking generally increases with age, and, therefore, would not be expected to be very extensive on new decks as surveyed here.

The largest concentration of surface cracking was found on Span 1, S33 of 82123. These cracks were of the type normally associated with shallow cover, running transversely, directly above the bars. Note that this span had the least cover of any deck in the survey. This type of cracking is quite prevalent throughout the state on structures that have a small amount of concrete cover. It is caused by localized shrinkage of the mortar immediately above the bar, and would not be affected as readily by dead-load compressive stresses as would the more general mass-shrinkage cracking that occurs in some decks as they age.

The six cracks noted in Span 4, S09 of 82293, were relatively short cracks near corners of the deck running at an angle to the steel. Evidently, these were due to some sort of restraint in the deck or to a greater amount of shrinkage in localized areas, or both.

The average amounts of cover, and standard deviations shown in the table, do not indicate any significant differences in accuracy of steel placement for the two methods of deck placement. It seems evident from the results, that other uncontrolled factors are more significant. Therefore, based on the results of this limited survey, it does not appear that the cost of shoring can be justified on the basis of accurate steel placement. However, there are other benefits of shoring, such as the addition of compressive dead load stress in the finished deck, and greater control over the position of stringers during deck placement. The recent resurgence of transverse deck finishing may reduce the need for shoring on some structures. Two-span continuous structures obviously will require special treatment in any case.

Our experience with bridge stringer deflection measurements has shown them to be quite variable, even when stringers are of the same size, and similarly loaded. Therefore, the results of this limited investigation should not be considered full justification for discontinuance of shoring. The other considerations may be worth the investment, regardless of the lack of demonstrated effect on placement of deck steel.

TESTING AND RESEARCH DIVISION

C. J. Arnold

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CJA:bf

STRUCTURES WITHOUT SUPPORTS

Bridge No.	Type of Finish	Number of Spans	Pachometer Data [1]												Average for Complete Deck			Remarks
			Span 1			Span 2			Span 3			Span 4			Total			
			N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	
S33 of 82123	longitudinal *	2	102	(1.1-2.1) 1.70	0.24	96	(1.9-2.2) 2.35	0.19	--	--	--	--	--	--	198	(1.1-2.2) 2.01	0.21	Shrinkage cracks in span 1 [3]
S07 of 82293	longitudinal	4	72	(2.5-3.2) 2.96	0.22	144	(2.7-3.5) 3.00	0.19	144	(2.6-3.5) 3.08	0.18	64	(2.4-3.5) 2.84	0.19	424	(2.4-3.5) 2.97	0.20	No visible cracking [3]
S18 of 82293	longitudinal	4	77	(2.2-3.2) 2.82	0.21	119	(2.4-3.2) 2.89	0.22	119	(2.4-3.4) 2.97	0.18	63	(2.0-3.4) 2.73	0.22	378	(2.0-3.4) 2.85	0.21	Isolated shrinkage cracks in spans 2 and 3 [3]
X02 of 82293	longitudinal	4	80	(2.4-3.2) 2.69	0.17	150	(2.2-3.5) 2.78	0.20	140	(2.4-3.2) 2.80	0.20	110	(2.5-3.4) 3.01	0.20	480	(2.2-3.5) 2.82	0.19	Shrinkage cracks in spans 3 and 4 [3]
S09 of 82293	longitudinal	4	207	(2.1-3.2) 2.62	0.24	153	(2.4-3.4) 2.87	0.23	153	(2.6-3.5) 3.21	0.22	198	(2.4-3.5) 3.15	0.29	711	(2.1-3.5) 2.96	0.24	6 cracks in span 4 [3]
S14 of 82293	transverse	3	30	(2.5-3.5) 3.00	0.28	209	(2.0-3.5) 2.74	0.33	47	(2.0-3.4) 2.54	0.38	--	--	--	286	(2.5-3.5) 2.76	0.33	No visible cracks [2]
S12 of 63103	transverse *	2	119	(1.5-2.9) 2.26	0.31	105	(1.7-2.9) 2.33	0.27	--	--	--	--	--	--	224	(1.5-2.9) 2.29	0.29	Isolated shrinkage cracks in span 2 [3]

[1] N = number of readings
[1] $\bar{x}$ = depth to lateral steel reinforcement in inches (range given in parentheses, average appears beneath)
[1] σ = standard deviation of depths in inches
[2] Bridges with main steel above longitudinal steel cover over No. 6 bars = 1-3/4 to 2-1/4 per specification.
[3] Bridges with main steel below longitudinal steel cover over No. 6 bars = 2-1/4 to 2-3/4 per specification.
* Open to traffic

STRUCTURES WITH SUPPORTS

Bridge No.	Type of Finish	Number of Spans	Pachometer Data[1]												Average for Complete Deck			Remarks
			Span 1			Span 2			Span 3			Span 4			Total			
			N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	N	$\bar{x}$	σ	
S01 of 82293	longitudinal	4	42	(2.1-3.0) 2.47	0.22	132	(2.1-3.2) 2.62	0.29	138	(2.2-3.2) 2.67	0.24	42	(2.4-3.8) 2.92	0.39	354	(2.1-3.8) 2.67	0.29	No visible cracks[2]
S16 of 82293	longitudinal	1	144	(2.6-3.5) 2.98	0.20	--	--	--	--	--	--	--	--	--	144	(2.6-3.5) 2.98	0.20	No visible cracks[2]
S01 of 50061	longitudinal	2	60	(2.4-3.2) 2.80	0.22	60	(2.0-2.9) 2.49	0.21	--	--	--	--	--	--	120	(2.0-3.2) 2.64	0.21	No visible cracks[2]
S14 of 63103	longitudinal	2	60	(2.2-3.0) 2.65	0.20	60	(2.2-2.9) 2.57	0.16	--	--	--	--	--	--	120	(2.2-3.0) 2.61	0.18	No visible cracks[2]
S01 of 63191	transverse *	2	162	(1.8-3.2) 2.49	0.29	155	(1.6-2.8) 2.36	0.24	--	--	--	--	--	--	317	(1.6-3.2) 2.42	0.26	No visible cracks[2]
S29 of 82123	longitudinal*	2	153	(2.1-3.4) 2.71	0.28	153	(1.9-3.5) 2.66	0.32	--	--	--	--	--	--	306	(1.9-3.5) 2.68	0.30	Various shrinkage cracks[3]
S31 of 82123	longitudinal*	2	68	(2.0-3.4) 2.38	0.29	68	(2.0-3.3) 2.49	0.29	--	--	--	--	--	--	136	(2.0-3.4) 2.43	0.29	Various shrinkage cracks[3]

[1] N = number of readings
[1] $\bar{x}$ = depth to lateral steel reinforcement in inches (range given in parentheses, average appears beneath)
[1] σ = standard deviation of depths in inches.
[2] Bridges with main steel above longitudinal steel cover over No. 6 bars = 1-3/4 to 2-1/4 per specification.
[3] Bridges with main steel below longitudinal steel cover over No. 6 bars = 2-1/4 to 2-3/4 per specification.
*Open to traffic