MICHIGAN
STATE HIGHWAY DEPARTMENT
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State Highway Commissioner

PLACEMENT OF DOWELS BY THE

FLEX-PLANE MECHANICAL DOWEL BAR INSTALLER

ON PROJECT M8-31, C1

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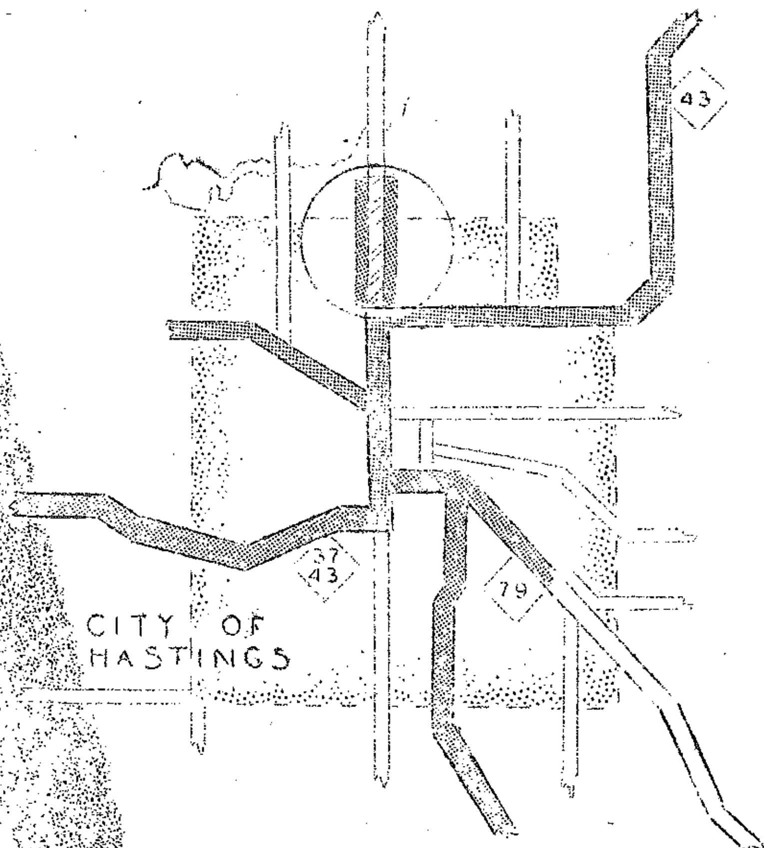

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PLACEMENT OF DOWELS BY THE FLEX-PLANE MECHANICAL DOWEL BAR INSTALLER ON PROJECT M8-31, C1

The development of a machine to install dowel bars mechanically in concrete pavements to eliminate the use of metal baskets or other holding devices has attracted the attention of highway equipment manufacturers for some time. This is the second undertaking by the Department to try out mechanical dowel bar installing equipment. The first experiment was made in 1938 on Project 75-31, C1 on US-2 in the Upper Peninsula. In this case the dowel-installing device was hand operated. It rested on the forms and held the dowels in proper position and alignment during placement of the concrete, after which the dowels were released, the machine removed and carried to the next joint location. The device was not successful in holding the dowels in correct alignment and consequently was not recommended for use.

This report covers observations on the placement of dowel bars by the Flex-plane Mechanical Dowel Bar Installer on Construction Project M8-31, C1 located on County Road extending north from M-43 in Hastings approximately one-half mile. (See cover). The experimental work was initiated by the Construction Division who requested that the Research Laboratory establish the experiment as a research project.

The concrete pavement on Project M8-31, C1 is 22 feet wide and 8 inches thick with contraction joints at 50-foot intervals. In this case 52.5-pound steel reinforcing mesh was used. Transverse dowels consisted of 1-inch by 15-inch round bars spaced at 12-inch centers. The longitudinal tie bars were 1/2-inch by 48-inch rods spaced at 40-inch centers. The Contractor was Ray Sablain of Lansing, Michigan.

The Flex-plane Mechanical Dowel Bar Installer was made by the Flexible Road Joint Machine Company of Warren, Ohio. The machine was capable of installing both transverse dowels and longitudinal joint tie bars. A general view of the equipment is shown in Figure 1. The approximate weight of the machine is 9500 pounds. It is understood that equipment manufactured by the same company has been used with considerable success on airport work where pavement design called for 20-foot contraction joint spacing and no reinforcement in the slab. We also understand that the machine has been used to a limited extent in Texas on normal highway paving work. The operation of the machine is rather simple. The dowel bars are supported in proper position above the surface of the slab, as shown in Figures 2 and 3, and then subsequently forced down into the fresh concrete by the dowel-placing fingers through direct pressure and vibratory action of the members supporting the fingers. The machine also contains a steel dummy joint cutting bar which descends when the transverse dowel bars are placed to displace the aggregate and thereby facilitate subsequent placement of the bars which form the contraction joint groove. Figure 4 shows the condition of the pavement surface upon removal of the transverse and longitudinal dowel-placing fingers and also the dummy joint cutting bar. These demarcations in the fresh concrete are readily removed by the longitudinal float which follows this machine. Figure 5 shows the method of placing steel templates to mold contraction joint grooves. Figure 6 shows two uncovered transverse dowel bars after placement.

Efficacy of Machine in Placing Transverse Dowels

On August 4, 9, and 10 measurements were made by the authors with a striding level to check the alignment of the dowel bars immediately after their placement in the concrete. The measurements obtained and presented in Table 1 indicate that the dowel bars varied considerably from specification tolerances of 1/4-inch slope per foot maximum. The figures in Table 1 indicate vertical displacement of the dowels, from a position parallel to the longitudinal surface or grade line of the pavement. The figures are given in sixteenths of an inch. A positive number indicates that the bar was tilted upward with respect to grade and a negative number indicates that the bar was tilted downward.

Theoretically the machine should place the dowels at the proper depth and parallel with the longitudinal surface of the pavement. All dowels which were tilted more than 1/4 inch, or 4/16, were examined for cause of displacement by carefully removing the concrete from above them. The following conditions were noted:

1. In every case where the dowels were tilted as much as one inch or more, it was observed that one end of the bar was resting on a transverse wire of the reinforcing mat. This condition caused the dowel to rotate in a vertical plane about the adjacent dowel-placing finger, forcing its opposite end to a greater than normal depth in the concrete. When this condition was first recognized an attempt was made to have the mesh placed so that the wires would not come in contact with the dowels. However, in the pressure of actual production, apparently the mesh cannot be laid with enough accuracy as to vertical position in the slab or spacing at joint locations to guarantee always sufficient clearance for the dowels.

Two other conditions inherent in the concrete mixture itself which, apparently, caused similar misalignment of the dowels were: (1) the presence of large pieces of aggregate directly under a dowel end which would offer greater resistance than the concrete at the other end and (2) heterogeneity of the concrete mix. In several cases the concrete appeared more dense at one end of a bar than at the other end. When this occurred the end of the dowel in the less dense concrete would come to rest lower in the slab.

This rotary movement of the dowels is due to the fact that the dowel-placing fingers which force the dowels into the concrete are spaced only 11-3/8-inches center to center, whereas the dowel bars are 15 inches long. Thus, the ends of the dowels extend 1-5/8 inches beyond the outside edge of the fingers. It can readily be seen that a fixed object under either of the extreme ends of a dowel would cause a rotary motion about the adjacent placing finger which acts as a fulcrum thus resulting in considerable vertical rotation and consequent misalignment of the dowel. In some instances it was observed that the dowels were considerably off in horizontal alignment as well as vertical alignment. This is due to the fact that once the dowel has dropped a very slight distance below the stabilizing influence of the notch in the placing finger, it is free to rotate horizontally. The greater the amount of vertical displacement, the greater the horizontal displacement can become. These conditions can no doubt be easily corrected by making changes in the spacing and design of the dowel-placing fingers.

In case of the longitudinal tie bars any internal resistance encountered in their downward travel from aggregate particles, very dense concrete, or from the reinforcement would result in bending of the bars. It is imperative that the steel mesh be placed uniformly and at proper depth, at all times.

Furthermore, it was observed that the vibration process involved in placing the dowels resulted at times in considerable puddling of the concrete in the joint area. In some instances it reduced the concrete to a fluid consistency. Such a condition of the concrete would be undesirable from the standpoint of uniform strength and subsequent durability. This condition can no doubt be successfully overcome by changes in the technique of placing the dowels perhaps using less vibration, more pressure, and possibly slower insertion speeds.

It will be observed in Table 1 that the dowels in contraction joint at Station 1+25 were in exceptionally good alignment. The concrete at this point had been poured just prior to the lunch period of the paving crew and the dowels were inserted about 1 hour after pouring when the concrete had reached a relatively thick consistency. Very little puddling of the concrete occurred from vibration during installation of the dowels. This might indicate the desirability of using as little vibration as possible in placing dowels to minimize any local disturbance to the concrete.

The data in Table 1 also shows a preponderance of negative values which would indicate a general downward tipping of the dowels toward the mixer. We have reason to believe that this condition was due to the fact that the vertical axis of the dowel-placing assembly, including the supporting member and dowel-placing fingers, was not perpendicular to the grade. The construction of the machine is such that a very slight deviation of the vertical axis of the supporting member with respect to the axes passing through the centers of the wheels which ride on the forms can cause a magnifying error in dowel alignment. Measurements taken on the first day, but not included in Table 1, indicated that the whole dowel-placing assembly was tilted with respect to the grade approximately 1/4 inch. This matter was called to the attention of the manufacturer's representative present who supposedly corrected the condition by proper adjustments.

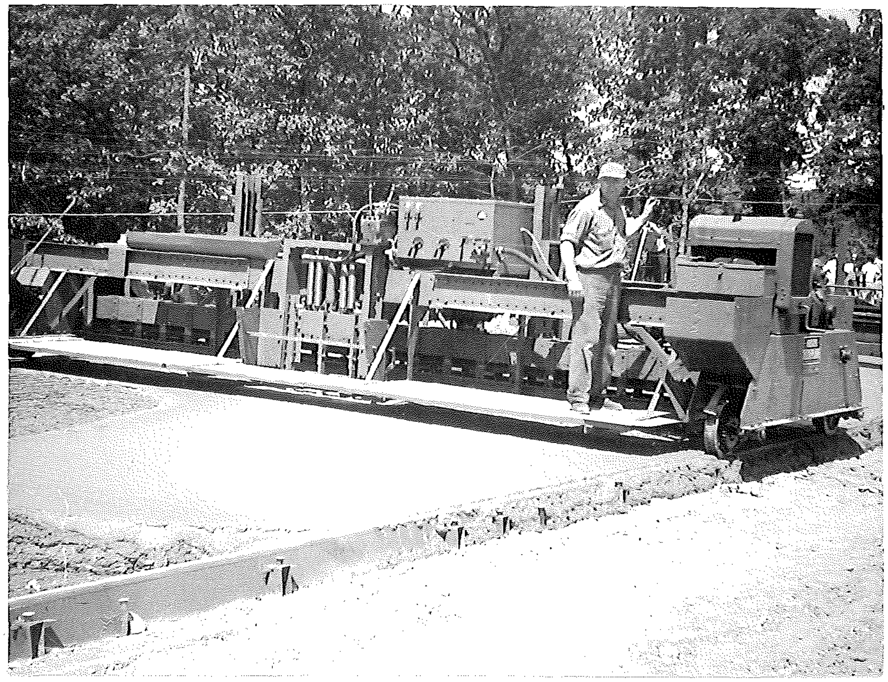

Figure 1. General View of Flex-plane Mechanical Dowel Bar Installer

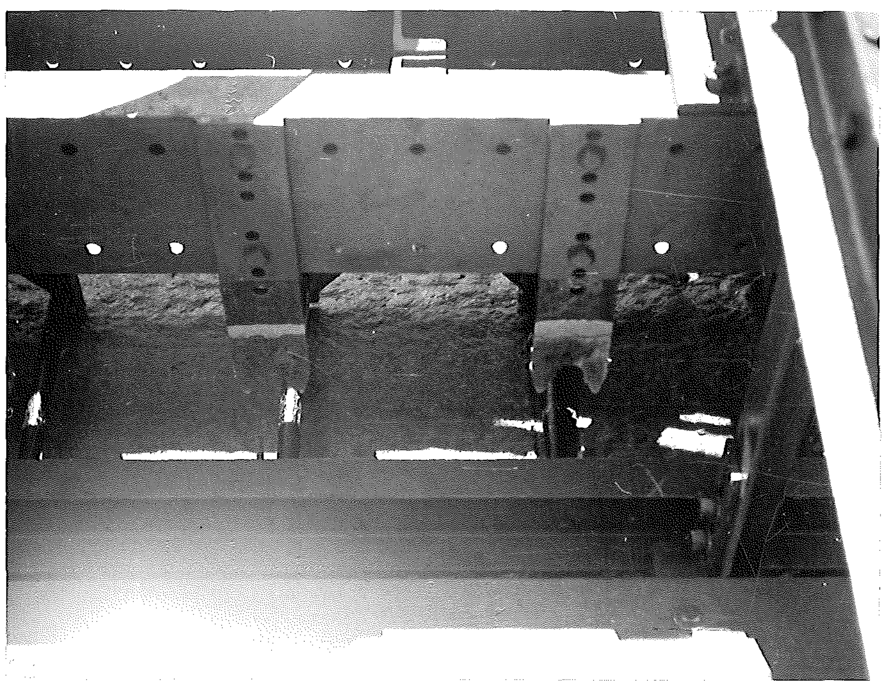

Figure 2. Showing Transverse Dowel Bars in Place ready to be pushed into concrete by dowel-placing fingers directly above them.

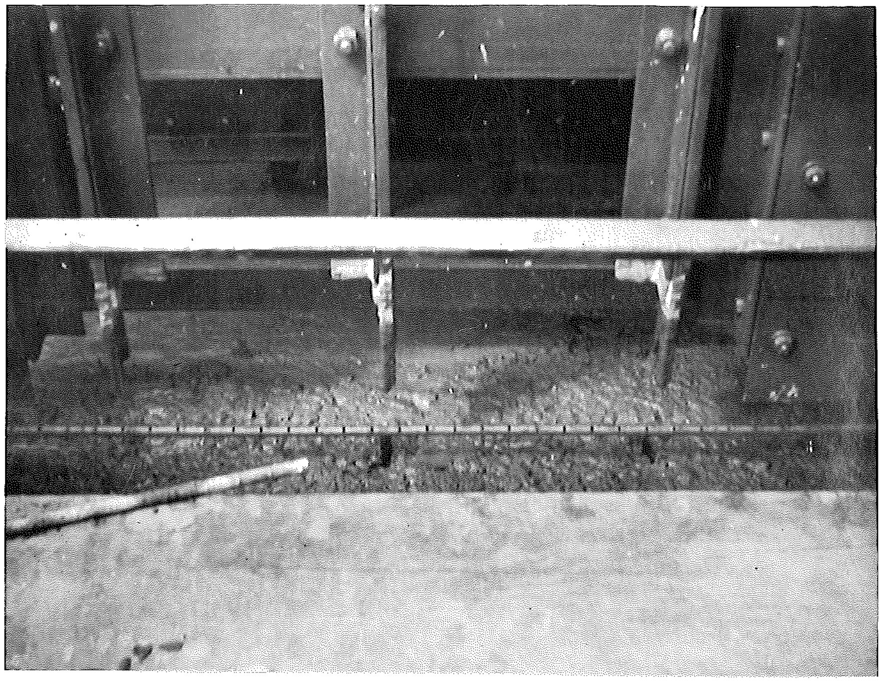

Figure 3. Showing Longitudinal Tie Bars in place ready to be inserted in fresh concrete by dowel-placing fingers.

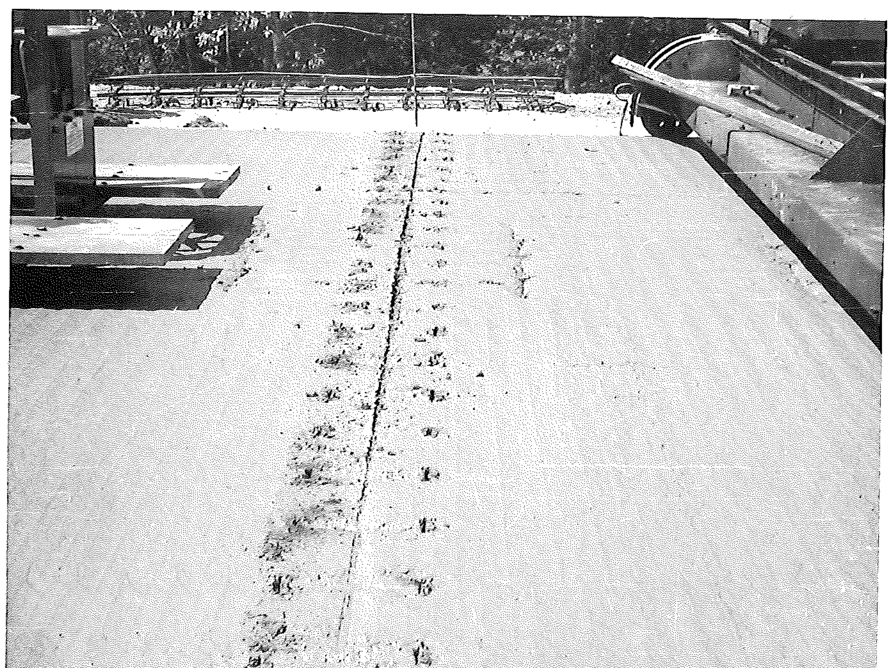

Figure 4. Condition of pavement surface upon removal of dowel-placing fingers and dummy joint-cutting bar.

Figure 5. Method of placing steel template to mold contraction joint groove.

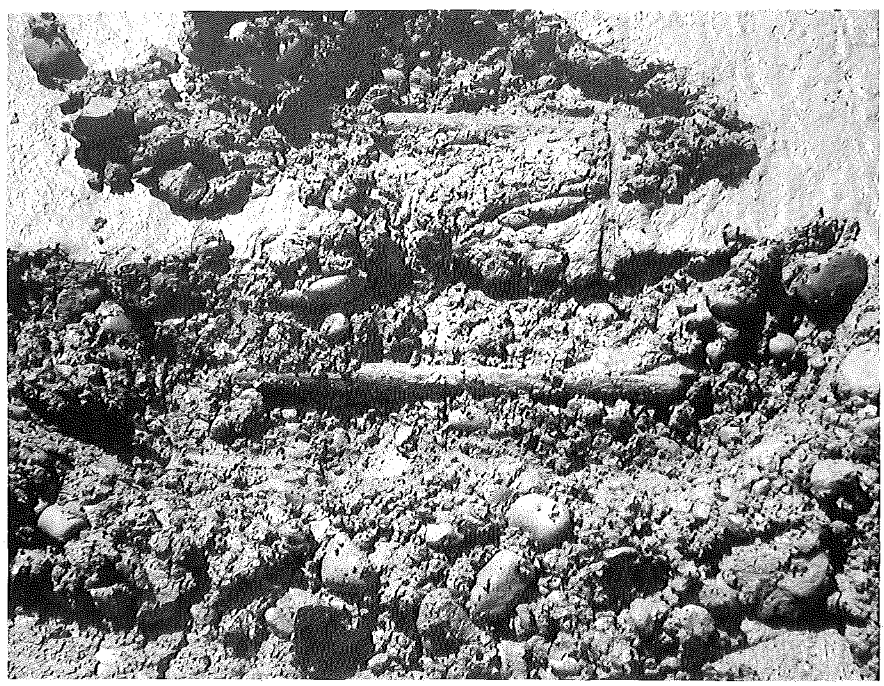

Figure 6. Two uncovered dowel bars after placement

TABLE I

SUMMARY OF ALIGNMENT MEASUREMENTS ON DOWEL BARS
INSTALLED BY FLEX-PLANE MECHANICAL DOWEL INSTALLER
HASTINGS - PROJECT M 8-31, C1

STATION	(Left)										DOWEL BAR NUMBER										(Right)		NO. OF DOWELS OVER 1/4"	PER CENT
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
14 + 55	-2	6	6	6	2	2	3	3	3	0	-2	8	-26	-30	-6	0	-24	-10	-4	-8	6	2	11	50
14 + 05	-4	0	8	-1	-4	-11	-4	2	1	-5	-7	-4	0	-1	-19	-2	-2	-4	-4	-3	-4	2	5	23
13 + 55	-2	-2	-5	-3	-11	-5	-4	3	-1	-11	-1	1	-31	-11	-17	-23	-15	1	-7	-1	6	3	11	50
5 + 75	-4	3	-1	-4	-2	-1	0	-11	-19	-7	5	-1	0	-12	-11	-9	-4	-3	-1	-4	5	-4	8	36
5 + 25	2	-15	-2	-1	-9	-1	-1	0	1	-18	0	1	-1	3	0	-1	-1	-2	0	-3	-1	-2	3	14
4 + 75	-9	1	-2	-7	-10	-6	-20	-19	-6	-6	-22	1	-1	-20	-20	-19	2	-1	-1	-1	-2	-4	10	45
4 + 25	3	6	5	-18	1	4	0	2	No Readings Taken						-23	-3	-1	-1	-1	-1	-15	-4	5	23
3 + 75	-2	1	-4	-27	-31	-4	-22	-6	-6	2	-10	-22	-6	-12	-2	-32*	-2	-7	-13	-6	-4	-4	13	59
2 + 75	7	6	-2	-7	0	-1	-18	-3	1	-4	3	3	4	-32*	-1	-2	-3	2	-2	-4	-1	-1	5	23
2 + 25	5	-1	-5	-2	-18	-13	-7	-20	-11	-6	-7	-2	-2	-5	-5	-13	-1	-11	-11	-6	-3	-8	16	73
1 + 75	-1	1	5	-4	1	-5	0	-7	-4	-12	-5	3	0	2	-4	1	3	1	0	-4	3	-6	6	27
1 + 25	1	0	2	3	3	1	-11	-3	-11	0	-6	1	2	2	1	-1	0	0	0	-1	-1	-3	3	14

NOTE: Values given are in 16ths of an inch. Maximum specification tolerance is 4/16 of an inch.

* Beyond limits of level which is 2 inches.