Field Evaluation of Dowel Placement in Concrete Pavements

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Presented in this paper are the results of a laboratory and field investigation conducted to determine the effectiveness of the radar device for evaluating dowel bar misalignment and to evaluate the effectiveness of an automatic dowel bar inserter to properly place dowel bars in rigid pavements. The investigation was sponsored by the Demonstration Projects Division of the Federal Highway Administration (FHWA). A commercially available radar system was used. The radar system is capable of locating steel embedded in concrete. The system produces a real-time graphic recording that indicates the location and the relative depth of the embedded steel. Cores are obtained to calibrate the graphic recordings to obtain the actual embedded depth of the steel bars. The laboratory study indicated that dowel bars placed about 5 in. below the concrete surface could be located reasonably accurately by the radar system. In the laboratory, the standard deviation obtained for the differences between actual and measured individual readings was 0.24 in. The field evaluation was conducted during June 1986 along a section of Interstate 86 in the state of Idaho. At this project, an inserter was used to place the dowel bars in the plastic concrete. Dowel placement along 16 transverse joints was evaluated with the radar system. Results indicate that the radar system is capable of determining the location of dowel bars placed in concrete pavements. However, the degree of accuracy is operator dependent and test results must be considered in statistical terms.

Presented in this paper are the results of a laboratory and field investigation conducted to determine the effectiveness of the radar device for evaluating dowel bar misalignment and to evaluate the effectiveness of an automatic dowel bar inserter to properly place dowel bars in rigid pavements. The investigation was sponsored by the Demonstration Projects Division of the Federal Highway Administration.

Current practice for load transfer at joints of rigid pavements is to use round steel dowel bars. Bar diameter is generally 1/8 of slab thickness, dowel spacing is 12 in., and dowel length is 18 in. Dowel bars are placed at pavement mid-depth and require care in placement to minimize the detrimental effects of misalignment.

Dowels may be placed using wire-basket support assemblies or inserted directly into plastic concrete by an automatic dowel bar inserter (implanter). Use of the inserter has not been widespread because of concern with obtaining accurate dowel alignment. Recently, several new dowel bar inserters have been introduced. These new inserters are being promoted as being capable of accurate placement of dowels and of correctly finishing the concrete after dowel insertion without disturbing the dowels.

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To ensure satisfactory long-term performance of rigid pavements, it is required that the dowel bars be placed as parallel as practical to the longitudinal axis and the horizontal plane of the pavement. The reason for placing limits on dowel placement tolerance is to minimize the problems associated with locked joints. Pavement slabs should be free to expand and contract with changes in slab temperature and moisture. Resistance to movement is provided by subbase friction and locked joints. For slabs up to 20 ft, resistance due to subbase friction is not a major problem. The magnitude of restraint caused by locked joints depends on the degree of dowel misalignment, number of misaligned dowels, and dowel corrosion. Locked joints may result in transverse cracking, corner breaks, and spalling at the concrete face around the dowel. Once a spall occurs around a dowel, load transfer effectiveness of the dowel may decrease. The different categories of dowel misalignment and their possible effects on pavement behavior are illustrated in Figure 1.

In the past, a maximum allowable alignment error of 1/4 in./18 in. length of the dowel was specified. Recently, many state agencies have been revising the allowable tolerance levels. For example, the Georgia Department of Transportation specifies an allowable tolerance of 3/8 in./ft in both the horizontal and vertical directions, and several other state agencies specify an allowable tolerance of 1/4 in./ft in both the horizontal and vertical directions.

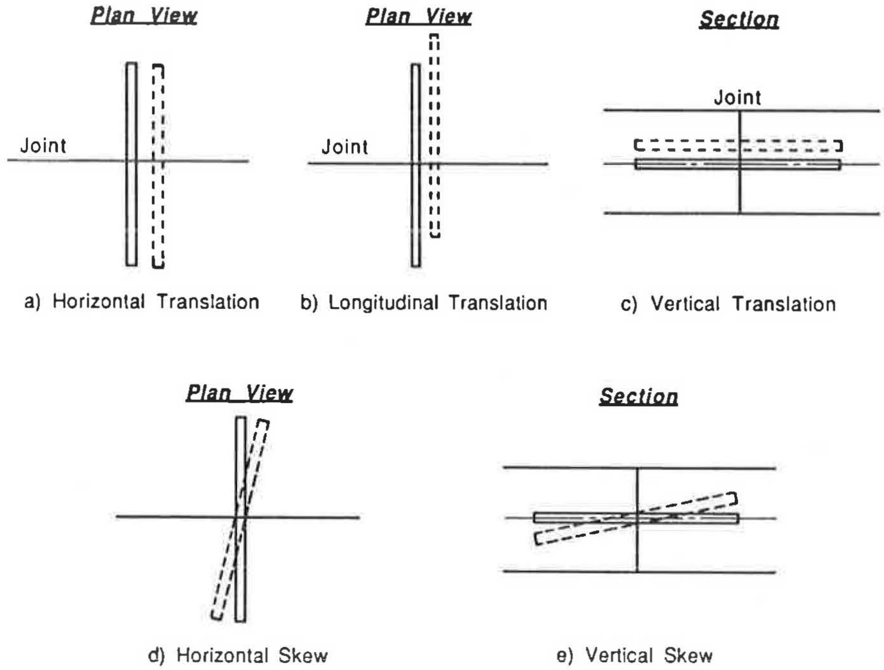
It should be noted that no clear consensus exists on the level of practical limits on dowel-placement tolerances. A detailed discussion on dowel-bar-placement tolerances for rigid pavements is given elsewhere *(1)*. In addition, it has been a slow process in the past to determine levels of misalignment once the pavement was constructed. Dowel bar misalignment was formerly measured by using a pachometer and taking partial-depth or full-depth cores near the ends of the dowel. More recently, ground-penetrating radar devices are being used to determine dowel placement accuracy.

OBJECTIVES AND SCOPE OF WORK

The investigation was sponsored by the Demonstration Projects Division of the Federal Highway Administration. The objectives of the investigation were as follows:

1. To evaluate the effectiveness of the radar technique for measuring dowel bar misalignment in the field; and
2. To evaluate the effectiveness of an automatic dowel bar inserter to correctly place dowel bars in rigid pavements.

The scope of the work consisted of a preliminary investigation in the laboratory and field evaluation of the dowel bar inserter using the radar technique.



Type of Misalignment	Effect on		
	Spalling	Cracking	Load Transfer
a	-	-	Yes*
b	-	-	Yes*
c	Yes	-	Yes*
d	Yes	Yes	Yes
e	Yes	Yes	Yes

*Effect will depend on amount of translation

FIGURE 1 Effects of dowel misalignment.

LABORATORY STUDY

A preliminary laboratory investigation was conducted to refine the application of the radar technique to locate dowel bars in hardened concrete. A commercially available radar unit owned and operated by the Construction Technology Laboratories (CTL) was used. The radar unit allows quick and easy location of reinforcing bars and other embedded steel objects in concrete.

The radar system is routinely used by CTL to locate reinforcing bars in concrete structures. The embedded steel is located accurately enough for structural-evaluation purposes. However, there is some variability associated with each measurement and therefore its application to determining dowel bar misalignment needs to be considered carefully. The variability aspect of the radar measurements is discussed later in this paper.

Radar Rebar Locator

The radar system owned by CTL includes the following items:

1. Radar control unit
2. Transducer
3. Graphic recorder
4. Transducer control cable
5. Remote marker switch

High-frequency electromagnetic pulses are sent into the concrete by the transducer, which may be hand held. The pulses are reflected by the reinforcing bars (or other embedded steel) back to the transducer and are then sent to the radar control unit for signal processing and fed to a line-scan graphic recorder. As the transducer is moved along the concrete surface a graphic recording is automatically generated showing the location and relative depth of all the steel along the transect line. Cores or known steel bar depths are used to calibrate the graphic recordings to obtain the embedded depth of the steel bars.

Variability Associated with Radar Measurements

The embedment-depth measurement provided by the radar system is not an absolute measurement. Because of factors such as operator experience, quality of calibration, and equipment operation, there is a variability associated with each measurement.

Assume, for example, that based on field measurements the following data are developed:

Mean difference between radar measurements and actual dowel depth at a point = 0 in.
Standard deviation of the difference between radar measurement and actual dowel depth at a point = s in.

Then, the standard deviation, s_d, associated with the difference in readings, Δ_χ, between two points along a dowel bar is given as follows:

$$s_d^2 = 2s^2$$

and

$$s_d = 1.414s$$

The probability of a dowel being misaligned, given an allowable level of misalignment, can then be calculated using statistical procedures. The probabilities for s of 0.125 and 0.25 in. are given in Table 1.

TABLE 1 PROBABILITY THAT A DOWEL BAR IS MISALIGNED

s, in.	s_d, in.	Measured Misalignment, in.	Probability that Dowel is Misaligned, Percent
0.125	0.177	0.00	15.8
		0.25	50.2
		0.50	92.1
		0.75	99.8
		1.00	100.0
0.250	0.354	0.00	47.8
		0.25	57.8
		0.50	67.8
		0.75	92.1
		1.00	98.3

NOTE: Allowable misalignment is assumed to be 0.25 in. over 12 in. of dowel length. Measured misalignment is over a length of 12 in. s, s_d are defined in the text.

Laboratory Test Details

A small test slab section was constructed in the laboratory. The test section was 12 ft wide, 4 ft long, 8 in. thick, and incorporated a joint at mid-length. Dowels, 1¹/₄-in. in diameter and 18 in. long, were placed along the joint. The dowels were positioned to provide different levels of misalignment and were generally placed so that the top of the dowel at mid-length was about 4¹/₂ in. from the slab surface to simulate placement depth in a 10-in.-thick slab. Figure 2 shows the misaligned dowels placed in the test section.

Dowel placement was then determined with the radar device at regular intervals starting about 6 hours after concrete placement. Passes were made with the transducer on each side of the joint centerline along a line 6 in. away from the joint centerline. Thus, the measured misalignment obtained was over a length of 12 in.

The actual (as-constructed) levels of dowel placement and the measured levels are given in Table 2. It should be noted that, as discussed previously in this paper, there is variability

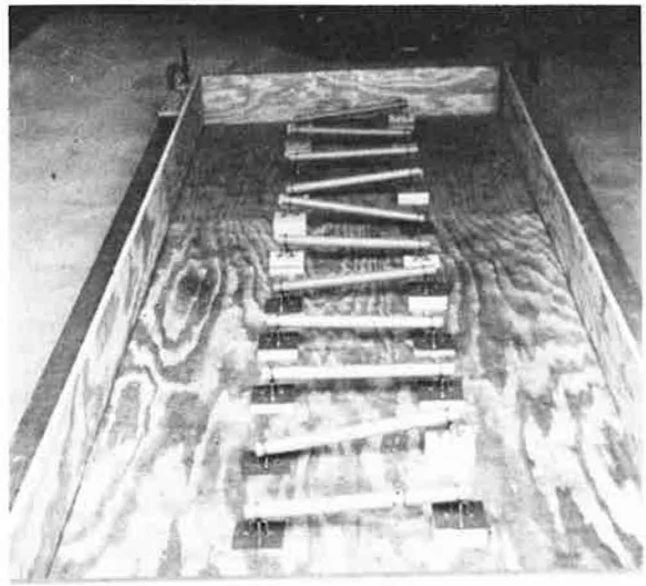


FIGURE 2 View of misaligned dowels.

associated with each individual measurement or estimation of dowel bar depth. This variability is because of the variability associated with the test equipment and procedure and that associated with the interpretation of the graphical data. The larger the variability, the smaller is the degree of confidence for estimating the level of misalignment using the radar device.

The laboratory test data indicate that the standard deviation for the differences between actual and measured individual readings, s, is 0.24 in. based on a total of 33 measurements. Statistically, it indicates that there is a 95 percent probability that the actual misalignment over the measured length of the dowel bar is within ±0.67 in. of the measured misalignment level.

FIELD EVALUATION

A field evaluation of an automatic dowel bar inserter and the radar technique for locating the position of the dowel bars was conducted during the first week of June 1986 along a section of Interstate 86 in the state of Idaho.

Project Details

An 11-mi section of Interstate 86 in Idaho is under construction (summer 1986) between Raft River and the Rockland junction west of American Falls. The first phase is construction of two eastbound lanes with construction proceeding eastward from the west end of the project. The pavement design prepared by the Idaho Department of Transportation requires a 10-in.-thick plain concrete pavement to be placed over an existing asphalt-treated base. The pavement is 38 ft wide and incorporates an

TABLE 2 RESULTS OF LABORATORY STUDY

Dowel Number	Actual Depth from Surface, in. East Side	Center Line	West Side	Measured Depth from Surface, in. East Side	Center Line	West Side	Misalignment Over 12 in. Center Actual	Measured
1	3.96	4.44	5.29	4.07	4.37	4.89	-1.33	-0.82
2	4.83	4.44	4.17	4.51	4.44	4.14	0.66	0.37
3	4.21	4.44	4.54	4.07	4.29	4.37	-0.33	-0.30
4	3.83	4.44	5.17	4.07	4.44	4.82	-1.34	-0.75
5	5.50	4.44	3.50	4.96	4.44	3.99	2.00	0.97
6	4.83	4.44	4.17	4.66	4.44	4.36	0.66	0.30
7	3.91	4.44	5.03	4.07	4.44	4.67	-1.12	-0.60
8	4.66	4.44	4.28	4.59	4.44	4.36	0.38	0.23
9	4.44	4.44	4.44	calibration		--	--	--
10	3.50	4.44	5.50	4.00	4.51	4.97	-2.00	-0.97
11	3.91	4.44	5.03	4.00	4.44	4.74	-1.12	-0.74
12	4.44	4.44	4.44	4.44	4.44	4.44	0	0

NOTE: 1. Standard deviation for the differences between actual and measured individual reading, s = 0.24 in. (for n = 33).
2. Standard deviation for difference between actual and measured misalignment levels = 0.34 in.

8.5-ft-wide tied concrete shoulder and a 3.5-ft-wide inside shoulder. The required random joint spacing is at 13, 15, 16, and 14 ft, requiring four joints every 58 ft.

Project specifications required use of epoxy-coated 1¼-in.-diameter and 18-in.-long dowel bars. A maximum allowable misalignment level of ¼ in./12 in. of the dowel bar length was specified. Project specifications allowed use of dowel bar assemblies or a dowel bar inserter manufactured by Guntert and Zimmerman or approved equal.

Study Details

Paving on the project started on June 3, 1986. The initial 400 to 500 ft were placed using dowel basket assemblies because of grade requirements. During the afternoon of June 3, several hundred feet of pavement were placed using the Gomaco dowel bar inserter, shown in Figure 3.

During the first day of operation, the inserter did not work as it was supposed to. Dowel bar placement was not carried out as consistently as specified. During the night of June 3, 1986, the contractor modified and adjusted the inserter mechanism to ensure better placement of the dowel bars.

On June 4, 1986, the radar device was used to locate dowel bars at selected joints of concrete paving placed on June 3, 1986. Joints were randomly selected for evaluation and only a small number of dowels per joint were located because of time constraints.

On the same day, a longer length of concrete paving was laid with dowels placed by the adjusted inserter. Dowel placement appeared to be proceeding smoothly. On June 5, 1986, the radar device was used to locate dowel bars at 16 joints of the concrete paving placed on June 4, 1986. During the radar evaluation, several cores were obtained at locations of dowel bars identified by the radar device. These cores and core holes were used to measure the depth of dowel bars from the pavement surface. The dowel bar depth measurements obtained from cores were used for calibration. Figure 4 shows a dowel bar in two core holes. The bar was located by the radar device.

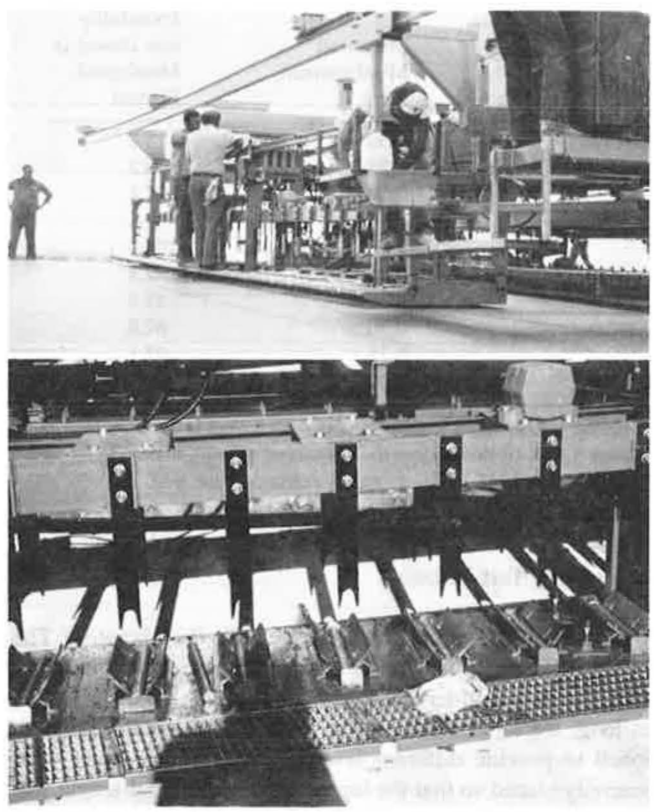


FIGURE 3 Gomaco dowel bar inserter, full and close-up views.

The evaluation of the depth of dowel placement was done by making a pass with the transducer along a line 6 in. away from each side of the joint, as shown in Figure 5. Thus, the difference in dowel bar depth between two corresponding readings gave the misalignment over a length of 12 in. For the pavement placed on June 4, 1986, every other joint was evaluated between the second and thirtieth joint. In addition, the

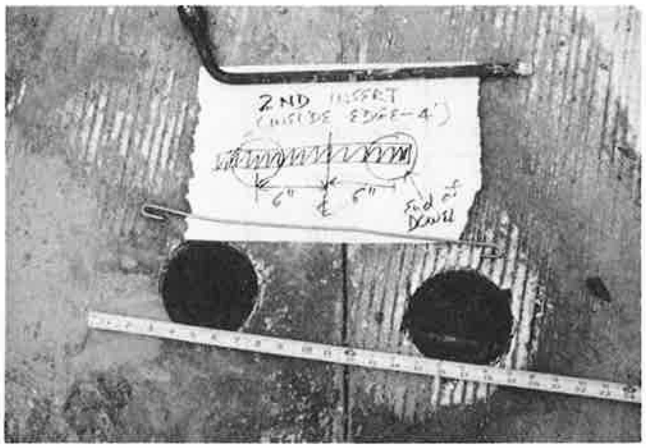


FIGURE 4 Location of a dowel.

FIGURE 5 Field testing in progress.

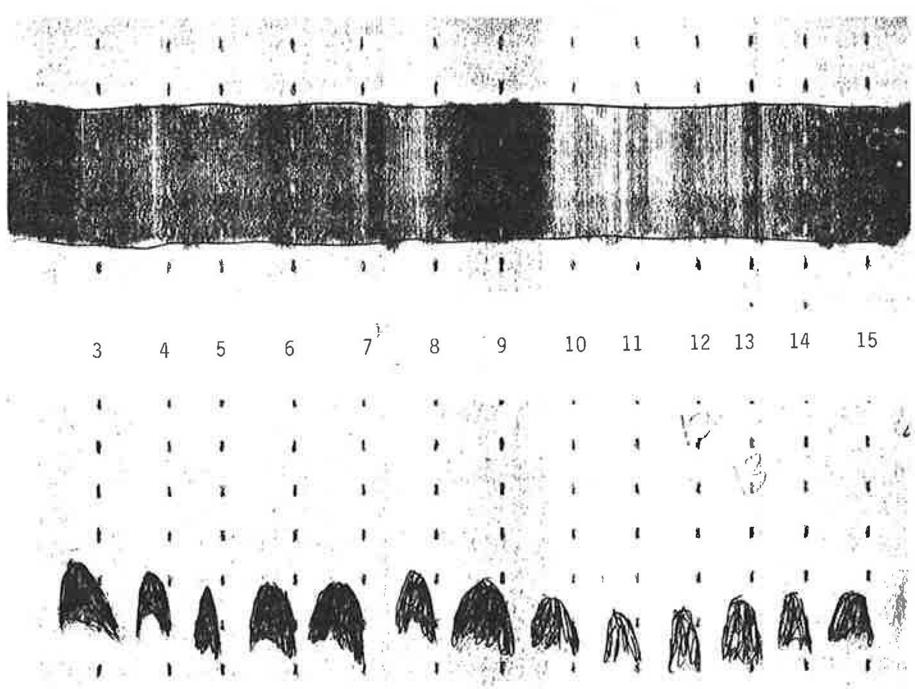
evaluation alternated between the joint in the inside and the joint in the outside lane. A typical graphical record of a pass along a joint is shown in Figure 6.

Test Results

Because of inserter problems on the first day of paving, data are not presented for joints evaluated from the first day's paving. Test data are presented only for 6 joints from the second day's paving. When joints along the outside lane were evaluated, passes were made with the transducer between the shoulder joint and the pavement centerline for a distance of about 14 ft. Generally, 12 dowel bars were located at about 2 ft to about 13 ft from the shoulder joint.

When joints along the inside lane were evaluated, passes were made with the transducer between 3 ft and 16 ft from the free edge of the inside shoulder. Generally, 14 dowel bars were located at about 3 ft to about 16 ft from the inside shoulder edge. Results of the radar testing are given in Tables 3 to 8 for the 6 joints of the pavement placed on June 4, 1986.

Results in Tables 3 to 8 are given only for misalignment in the vertical direction. Because the transducer is pulled along the pavement surface manually, the horizontal scaling on the graphical record is not very accurate, as seen from Figure 6. In addition, the signal from the dowel bar is spread out and therefore the horizontal location of the point of measurement cannot be estimated accurately enough. However, it is possible to grossly estimate horizontal misalignment. For more accurate estimation of horizontal misalignment a mechanized tracking system should be used to pull the transducers along the pavement surface and increase the speed of the graphical recorder. The higher speed of the graphical recorder, however, can result in a large amount of paper record.



NOTE: Joint No. 23, inside lane; pass along east side of joint. Numbers indicate distance in feet from inside shoulder edge.

FIGUE 6 Typical graphical record of a pass made with the radar transducer.

TABLE 3 RESULTS FOR JOINT NO. 6: OUTSIDE LANE

Distance from Shoulder Joint, ft	Dowel Depth, in. West Point	Dowel Depth, in. East Point	Misalignment over 12 in., in.	Probability of Misalignment, %
2.00	5.18	4.70	0.48	65.00
3.00	5.56	4.94	0.62	78.00
4.00	5.47	4.99	0.48	65.00
5.00	5.14	4.80	0.34	60.00
6.00	5.09	4.75	0.34	60.00
7.00	5.04	4.70	0.34	60.00
8.00	4.99	4.70	0.29	58.00
9.00	4.99	4.70	0.29	58.00
10.00	5.04	4.80	0.24	57.00
11.00	5.09	4.80	0.29	58.00
12.00	5.08	4.89	0.19	56.00
13.00	5.32	4.84	0.48	65.00

NOTE: 1. Probability of misalignment is based on standard deviation, *s* of 0.25 in.
2. Probability value indicates the probability that the dowel is misaligned more than allowable.

TABLE 4 RESULTS FOR JOINT NO. 8: INSIDE LANE

Distance from Shoulder Edge, ft	Dowel Depth, in. West Point	Dowel Depth, in. East Point	Misalignment over 12 in., in.	Probability of Misalignment, %
3.00	NS	4.67	-	-
4.00	4.58	4.80	0.22	58.00
5.00	4.80	4.76	0.04	50.00
6.00	4.76	4.76	0.00	48.00
7.00	4.71	4.80	0.09	51.00
8.00	4.80	4.76	0.04	50.00
9.00	4.72	4.76	0.04	50.00
10.00	4.81	4.85	0.04	50.00
11.00	4.85	4.85	0.00	48.00
12.00	4.85	4.85	0.00	48.00
13.00	4.85	4.85	0.00	48.00
14.00	4.85	4.85	0.00	48.00
15.00	4.85	4.85	0.00	48.00
16.00	4.89	NS	-	-

NOTE: 1. Probability of misalignment is based on standard deviation, *s* of 0.25 in.
2. Probability value indicates the probability that the dowel is misaligned more than allowable.
3. NS = No sign recorded.

TABLE 5 RESULTS FOR JOINT NO. 12: OUTSIDE LANE

Distance from Shoulder Joint, ft	Dowel Depth, in. West Point	Dowel Depth, in. East Point	Misalignment over 12 in., in.	Probability of Misalignment, %
2.00	4.28	4.16	0.12	53.00
3.00	4.20	4.13	0.07	50.00
4.00	4.20	4.16	0.04	50.00
5.00	4.09	4.16	0.07	50.00
6.00	4.05	4.05	0.00	48.00
7.00	4.05	4.09	0.04	50.00
8.00	4.01	4.05	0.04	50.00
9.00	4.05	4.01	0.04	50.00
10.00	4.09	4.09	0.00	48.00
11.00	4.13	4.05	0.08	51.00
12.00	4.09	3.38	0.71	90.00
13.00	4.24	4.05	0.19	56.00

NOTE: 1. Probability of misalignment is based on standard deviation, *s* of 0.25 in.
2. Probability value indicates the probability that the dowel is misaligned more than allowable.

TABLE 6 RESULTS FOR JOINT NO. 14: INSIDE LANE

Distance from Shoulder Edge, ft	Dowel Depth, in. West Point	East Point	Misalignment over 12 in., in.	Probability of Misalignment, %
3.00	3.79	4.13	0.34	60.00
4.00	4.09	4.05	0.04	50.00
5.00	4.16	4.08	0.08	51.00
6.00	4.20	4.09	0.11	53.00
7.00	4.24	4.09	0.15	55.00
8.00	4.17	4.09	0.08	51.00
9.00	4.17	4.09	0.08	51.00
10.00	4.20	4.16	0.04	50.00
11.00	4.20	4.20	0.00	48.00
12.00	4.31	4.28	0.03	49.00
13.00	4.13	4.13	0.00	48.00
14.00	4.20	4.12	0.08	51.00
15.00	4.20	4.13	0.08	51.00
16.00	4.09	NS	-	-

NOTE: 1 Probability of misalignment is based on standard deviation, *s* of 0.25 in.
2. Probability value indicates the probability that the dowel is misaligned more than allowable.
3. NS = No sign recorded.

TABLE 7 RESULTS FOR JOINT NO. 24: OUTSIDE LANE

Distance from Shoulder Joint, ft	Dowel Depth, in. West Point	East Point	Misalignment over 12 in., in.	Probability of Misalignment, %
2.00	4.31	4.27	0.04	50.00
3.00	4.35	NS	-	-
4.00	4.23	4.23	0.00	48.00
5.00	4.19	4.19	0.00	48.00
6.00	4.11	4.15	0.04	50.00
7.00	4.15	4.11	0.04	50.00
8.00	4.19	4.27	0.08	51.00
9.00	4.19	4.23	0.04	50.00
10.00	4.27	4.31	0.04	50.00
11.00	4.31	4.23	0.08	51.00
12.00	4.27	4.19	0.08	51.00
13.00	4.23	4.07	0.16	56.00

NOTE: 1. NS = No signal recorded.
2. Probability of misalignment is based on standard deviation, *s* of 0.25 in.
3. Probability value indicates the probability that the dowel is misaligned more than the allowable.

Discussion

Data presented in Tables 2 through 8 indicate that the radar technique is capable of determining the location of dowel bars placed in concrete pavements. The depth of a dowel bar at a point can be measured with a reasonable degree of accuracy. However, the degree of accuracy is operator dependent. During laboratory testing, CTL's standard deviation for differences between actual and measured depths, *s*, was 0.24 in. Based on this standard deviation, it can be stated with 95 percent confidence that the actual depth of a dowel bar at a point is within ±0.47 in. of the estimated depth. Similarly, it can be stated with 95 percent confidence that the actual misalignment of a dowel bar is within ±0.67 in. of the estimated misalignment. The probability that the dowel is misaligned more than the allowable misalignment can then be estimated using statistical procedures.

For the case of *s* equal to 0.25 in. and allowable misalignment of 0.25 in. over a length of 12 in., the following probabilities are obtained from Table 1 for different values of measured misalignment:

Measured Misalignment, in.	*Probability that Dowel Misalignment is Greater than Allowable, Percent*
1.00	98.3
0.75	92.1
0.50	67.8
0.25	57.8
0	47.8

It can be seen from this table that when the measured misalignment is small, it is difficult to ascertain if the dowel bar is actually misaligned more than the allowable level of misalign-

TABLE 8 RESULTS FOR JOINT NO. 26: INSIDE LANE

Distance from Shoulder Edge, ft	Dowel Depth, in. West Point	East Point	Misalignment over 12 in., in.	Probability of Misalignment,%
3.00	NS	4.23	–	–
4.00	4.07	4.15	0.08	51.00
5.00	4.11	4.23	0.12	53.00
6.00	NS	4.23	–	–
7.00	4.19	4.27	0.08	51.00
8.00	4.27	4.27	0.00	48.00
9.00	4.19	4.27	0.08	51.00
10.00	4.11	4.35	0.24	58.00
11.00	4.14	4.35	0.21	57.00
12.00	4.23	4.35	0.12	53.00
13.00	4.15	4.35	0.20	57.00
14.00	4.27	4.35	0.08	51.00
15.00	4.31	NS	–	–
16.00	NS	NS	–	–

NOTE: 1. NS = No signal record.
2. Probability of misalignment is based on standard deviation, s of 0.25 in.
3. Probability value indicates the probability that the dowel is misaligned more than the allowable.

ment. As the measured misalignment becomes large, it is then possible to state with more certainty that the dowel bar is misaligned more than the allowable misalignment.

The certainty of estimation can be greatly improved if the variability associated with the use of the radar device can be minimized. Thus, better estimates would be obtained if the standard deviation for the differences between actual and measured depths, s, was only 0.125 in. instead of 0.25 in.

Based on the field evaluation of inserted dowels, in the authors' opinion, the automatic dowel bar inserter used on the I-86 project is potentially capable of placing dowel bars in the plastic concrete within the specified limits. However, the inserter as used on the second day of construction (June 4, 1986) was still not performing as expected. There were apparently a few missing dowel bars or displaced dowel bars, as indicated by the lack of signals received at one or both ends of a dowel bar. The measured misalignment at the joints tested generally appeared to be satisfactory. However, as already discussed, the measured data can only be interpreted in statistical terms. Thus, even when the measured misalignment was zero, the probability that the dowel bar is actually misaligned more than the allowable misalignment of 0.25 in./12 in. length is still about 48 percent. Therefore, any conclusions on the effectiveness of the inserter need to be made very cautiously.

It is expected that in the future, as more field experience is gained with the use of the radar device for evaluating dowel bar placement, it will be possible to determine with more confidence the effectiveness of the dowel bar inserter. For example, if the standard deviation for the differences between actual and measured depths, s, could be reduced to only 0.125 in., and the measured misalignment was zero, then the probability that the dowel bar is actually misaligned more than the allowable misalignment of 0.25 in./12 in. length is 15.8 percent.

SUMMARY AND CONCLUSIONS

Based on the field evaluation, it is concluded that the radar device has the potential to be an effective method for evaluating dowel bar misalignment. The technique is suitable, with proper modifications, for rapid assessment of up to a hundred joints per day. Although presently the reliability of measurements for low values of measured misalignments is not high, it is expected that in the future progress will be made in this area to reduce variability associated with the measurements.

Based on a test of selected joints from one day's paving, the inserter appeared generally to be meeting the specified dowel bar placement tolerances. That day of paving was the inserter's second day in use.

It should be emphasized that, as with any other construction equipment, the equipment operator plays a key role in ensuring that the inserter is properly used. Thus, the effectiveness of the inserter may vary from project to project unless consistent specifications are used and regular inspection is performed.

It should also be emphasized that, as the radar technique for determining dowel bar misalignment is improved in the future, better specifications will need to be developed for controlling dowel placement. Items to be addressed should include acceptable misalignment of an individual dowel as well as the acceptable number of misaligned dowels per joint.

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The opinions and findings expressed or implied in this paper are those of the authors, and are not necessarily those of the Federal Highway Administration.

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Montana's Experience with and Strategies for Concrete Pavement Rehabilitation

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The first concrete pavement rehabilitation project in Montana presented a unique challenge for all those involved. Outlined in this paper are the background, planning, and design processes involved in the project and the recommendations made. Although concrete pavement rehabilitation may not be the salvation for all concrete pavement, it does provide solutions and repair strategies for some, when appropriate procedures are followed. Even though concrete pavement rehabilitation was not ultimately selected as the treatment of choice for this project, the process of analyzing the project and sustaining the final decision was valuable and will provide a useful basis for future concrete pavement evaluations. Future projects will be selected and designed based on cost-effective analyses and proven performance of the many techniques now being used, and those yet to be discovered.

In Montana, portions of the Interstate highway system were constructed of portland cement concrete pavement in the 1960s. Montana has 477 lane mi of concrete Interstate and 22 lane mi of concrete primary highway, which have served the state well. However, through the years this pavement has deteriorated to varying degrees owing to increased traffic loading and age, and it has become evident that work will have to be done on "the pavement that should last forever."

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In the spring of 1983, it was apparent that Montana had to begin assessing it rigid pavement needs and proceeding with rehabilitation programs. It was decided to select an Interstate project in and adjacent to Butte as a pilot project. The concrete pavement in this area appeared to be in the worst condition of all concrete pavements in the state. Based on what was learned there, other projects in the state could be developed.

On June 1, 1983, the Federal Highway Administration (FHWA) approved a preliminary engineering program to study this pavement and determine what rehabilitation work would be required to restore the pavement to a condition that would adequately serve the traveling public (see Figure 1 for location).

DESCRIPTION OF PROJECT

The project [Project IR 15-2(49)124, Butte—West and South] begins west of Butte and extends southeasterly to 1.7 mi south of the Continental Drive Interchange. The work involved is on about 5.3 mi of I-15 and 3.1 mi of I-90 concrete pavement.

Also included are the asphalt plant mix surfacing of 2.5 mi of frontage roads and portions of Iron Street, the I-115 spur, grade separations, ramps, and miscellaneous work (see Figure 2).