BDI 208802 Multi-Depth Deflectometer Installation Guide

RAW DATA. REFINED RESULTS
TECHNICAL NOTES
Document No.: 208802

Contents

208802 Multi-Depth Deflectometer

MULTI-DEPTH DEFLECTOMETER (MDD) SENSOR INSTALLATION

Document Revision History

Rev	Date	Changes
	9/19/2022	Initial release document

notification.

INTRODUCTION

1.1 ABOUT THE MULTI-DEPTH DEFLECTOMERTOR

BDI's Multi-Depth Deflectometers (MDD) are used to measure in-situ elastic deformation and/or permanent deformations in the various layers of a pavement test section. The MDD system is a series of vertical rods located in a 50 mm (2") or 75 mm (3") diameter test borehole. The vertical rods are anchored at various depths inside the MDD tube wall. Each rod, starting from the bottom hydraulic anchor, passes up to the reference head where linear potentiometers measure rod (depth anchor) movements
relative to the road surface.

The advantage of BDI's MDD is that it comes prefabricated to the client's subsurface soil depth dimensions allowing for rapid on-site installation (up to 3 per day). All electronic sensors are contained in a surface-flush road box, keeping electronics above the water table and readily accessible. Additionally, sensors being located at the surface also allows for re-setting potentiometer stroke if excessive rutting occurs. Typical configurations are 4-, 6- and 7-positions for depths up to 4 meters.

1.2 ABOUT THIS GUIDE

This guidance document explains the installation of the Multi-Depth Deflectometer (MDD). The following highlighted message blocks will appear throughout the manual and contain important information that the user should be aware of.


STOP: This symbol and corresponding message represents information regarding the device that if not followed could lead to damaging the device! Pay close attention to this message.


WARNING: This symbol and corresponding message represents vital information and is critical for the device operation and/or the operational settings/configuration.

INFORMATION: This symbol and corresponding message represents general information and/or tips on successfully operating/configuring the device.

PREPARATION FOR INSTALLATION OF THE MULTI-DEPTH DEFLECTOMETER (MDD)

Successful installation of an MDD requires coordination between the client and BDI to assure preparation is complete. Delegation of responsibilities is usually broken down as follows:

2.1 CLIENT RESPONSIBILITIES

- Provides dimensions for fabrication of MDD
- Reviews installation procedure
- Chooses site location for installation
- Coordinates dates for installation with BDI
- Arranges services of a local driller
- Provides coring of holes for road box installation
- Provides saw cutting of pavement for lead wire exit to shoulder
- Seals lead wires in saw cut slit trench (unless BDI is performing installation)
- Provides data acquisition system (BDI can provide this system upon request)
- Connects sensors to data acquisition system (dependent on application)
- Provides a geotechnical representative to log the borehole (if soil classification is required)

2.2 DRILLER RESPONSIBILITIES

- Provides drill rig
- Usually provides coring and core bits
- Must provide split spoons (either 2-inch or 3-inch diameter required) for borehole
- Water

2.3 BDI RESPONSIBILITIES

- Fabricates and ships MDD and sensors
- Ships all backfill material
- Provides all installation tools
- Performs or trains in installation (if requested)
- Installs and seals road box (if contracted for installation)
- Routes sensor wires in slit trench to shoulder (if contracted for installation)
- Installs and verifies the operation of sensors (if contracted for installation)

The above delegation of responsibilities is typical but can be changed through mutual agreement. It is provided as a checklist to assure all responsibilities are covered.

INSTALLATION OF MULTI-DEPTH DEFLECTOMETERS (MDD)

This text provides a summary overview of the preparation for and installation of a prefabricated MDD. This assumes a semipermanent installation (up to several years) in an existing pavement section to a depth of about 6-7 feet.
The location should be free of subsurface utilities such as water, electrical, gas, etc. Overhead obstructions such as electrical lines or bridges should also be taken into consideration when selecting the appropriate drill rig for installation.

3.1 INSTALLATION INSTRUCTIONS

1. A 5-1/4-inch diameter corehole is made to a depth of just over 1 inch in the pavement surface. This creates a seat for the top lip of the road box depicted in Figure 1 below.
Concentrically within the initial corehole, a 5-inch outside diameter (OD) core is removed from the pavement to a depth of just over 3 inches for the MDD. This will allow for the positioning of the road box and reference head assembly as shown in Figure

1. The coreholes should be slightly oversized (1/8-1/4”) from the road box to allow for placement of grout after final installation.

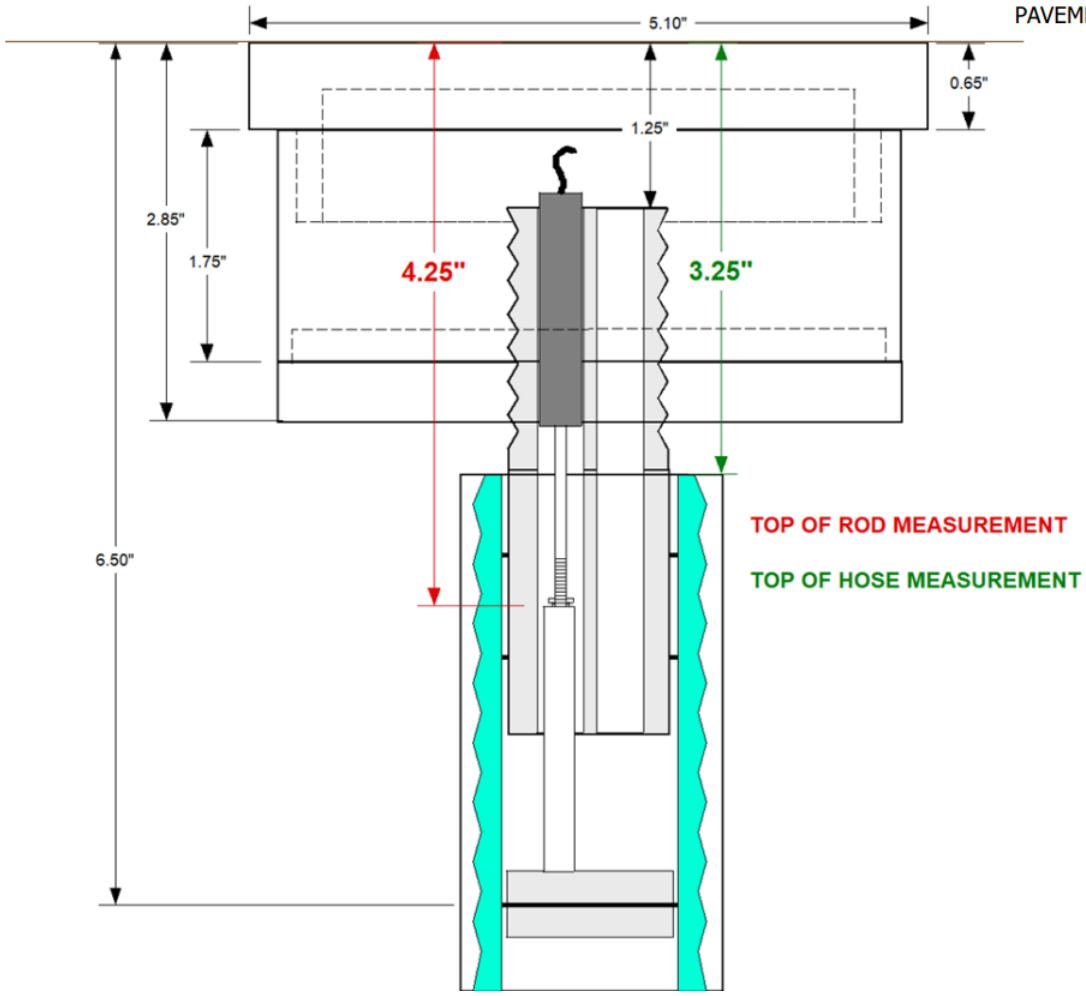

Figure 1: Road box sitting on top of reference plate/head assembly

2. A 2-inch deep slit is cut into the pavement from the edge of the cored hole to the shoulder of the road. The trench must be at least 1/4 inch in width. This trench provides a means for the sensor lead wires to exit the MDD installation to the side of the road. Figure 2 below shows a trench being cut.

   Also, the trench should be flared outward and downward when it meets the larger corehole. This is to accommodate the stacking of the sensor cables as they exit the roadbox through the cable exit hole. See Figure 3 and Figure 4 below for a depiction of where the trench meets the corehole.

Figure 2: Cutting slit trench into the pavement

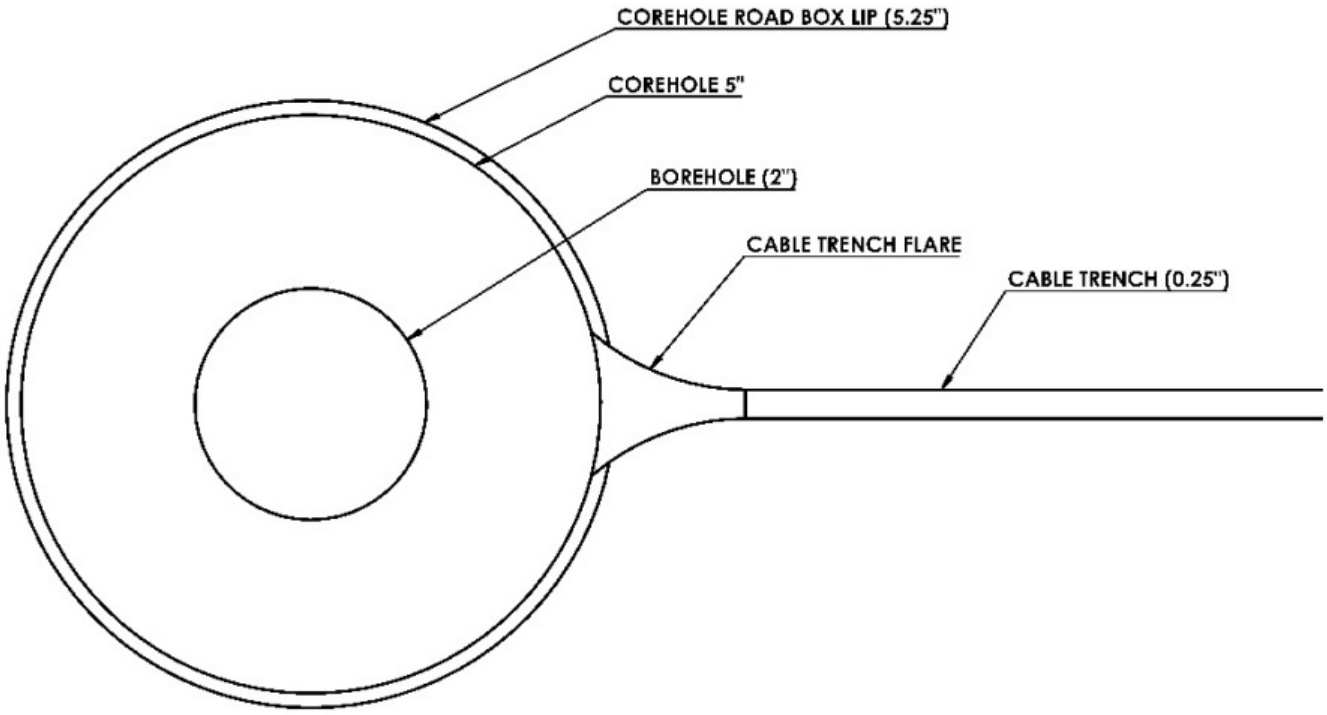

Figure 3: Flared slit trench meeting corehole, plan view **(depiction)**

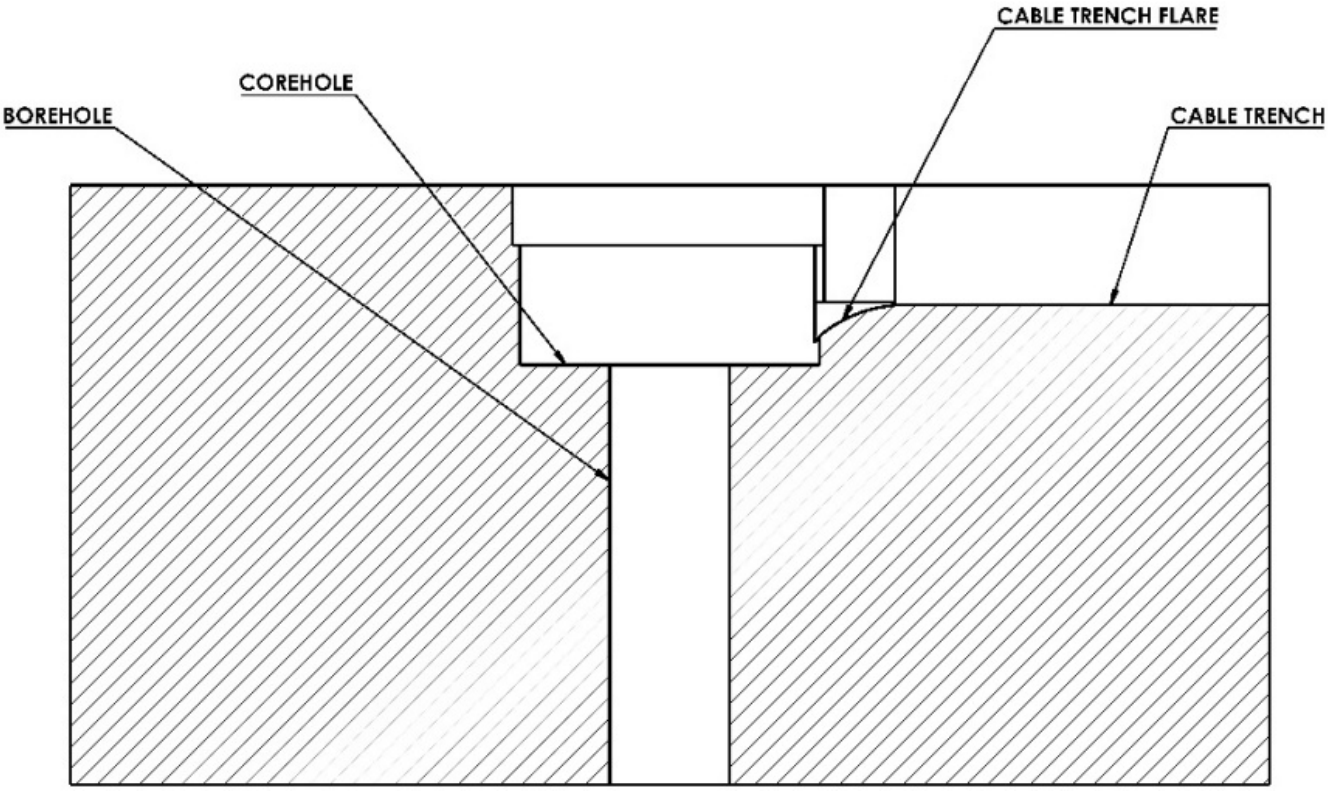

Figure 4: Flared slit trench meeting corehole, elevation view (depiction)

INFORMATION: Before boring the hole for the MDD, it is recommended to fabricate annular pieces of wood, as seen in Figure 5. The inside diameter (ID) of the wood spacers should be approximately 1/4" larger than the split spoon being utilized (2" or 3"), and the outside diameter (OD)(should be slightly smallerhan the diameter of the corehole (~5"). These are to be placed at the bottom of the corehole while the split spoon is operating, to keep the borehole concentric with the corehole.

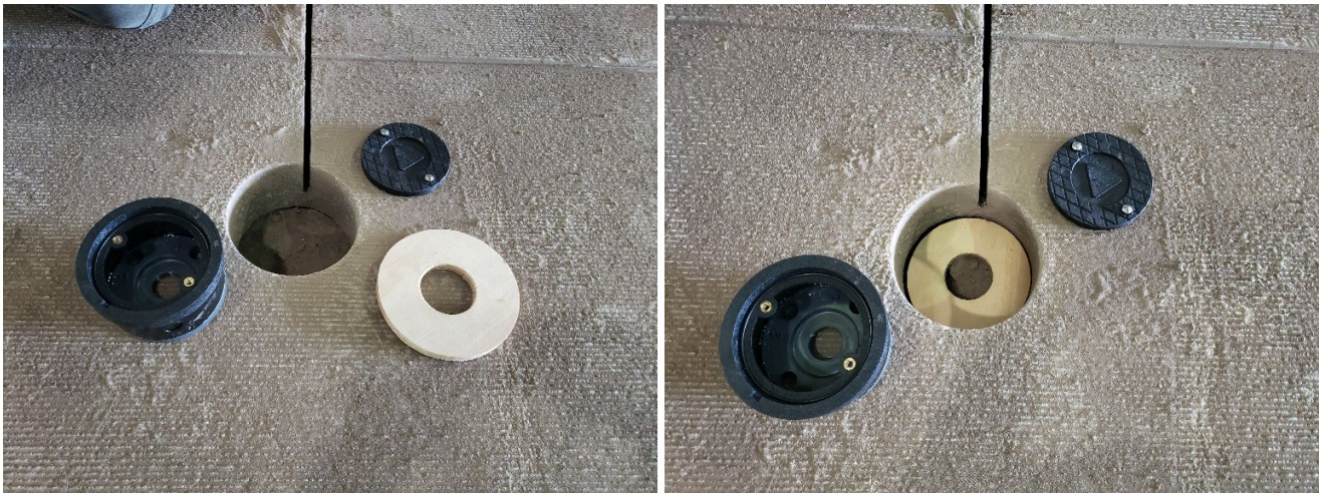

Figure 5: Roadbox and annular piece of wood sitting next to corehole

WARNING: A split spoon MUST be used to create the hole for the MDD, as this sensor requires a smooth

borehole for installation. An auger or drill will leave the walls of the borehole too rough, making the insertion of the MDD infeasible.

3. A 2- or 3-inch diameter split spoon sampler is used to bore a hole in the center of the corehole to the required depth. The coring operation through a wooden doughnut is shown in Figure 8 below. Split spoon samples can be discarded as spoils or logged and collected for geotechnical investigation.
   Having multiple split spoons aids in the installation time as one can be cleaned while the other is being used.
   It is also important that the split spoons contain soil retention cups on the inside to keep the soil from falling back into the borehole when pulling out the split spoon.

Figure 6: Split spoon heads used to create the borehole for the MDD

Figure 7: Left- operators cleaning the dirt from the split spoon, Right- operators putting the split spoon back onto the rig in preparation for another plunge

Figure 8: Wooden doughnut being used to guide the split spoon through the center of the corehole

4. The depth of the hole from the road surface must be made equal to the length of the MDD assembly plus 6 inches. This extra length is to accommodate the check valve at the bottom of the MDD assembly and any potential soil particles that may fall ack into the borehole. It is suggested that even when the proper depth is achieved, the split spoon should be run back down the hole again immediately before insertion of the MDD tube assembly to assure the hole has not 'swelled' closed and to leave the hole with a smooth wall.

INFORMATION: As noted above in Step 4, the walls of the borehole will attempt to move inward over time, so it is best practice to insert the MDD into the borehole as soon as possible following the drilling. This makes for much smoother insertion and a reduction in the jamming and possible damage to the sensor.

5. Remove the thumb screws from the head unit. Follow these steps directly before, and during the insertion of the MDD to ensure proper anchor depth is set.

   a. Install the setting tube onto the head unit. Turn the setting tube until the mark on the utside of the tube is flush with the top of the head unit.

   b. Insert the MDD with the attached setting tube into the borehole. The head unit should be approximately 2 inches below the road surface at this point.

   c. Using the setting tube, gently pull the whole assembly upward until the second set of holes in the setting tube is flush with the road surface (the first set of holes being the set of holes closest to the head unit). A connecting rod from the installation kit can be used to ensure that the holes are flush with the road surface by feeding the

connecting rod through the second set of holes and resting the connecting rod on the road surface. It must be noted that the stop nut must contact the top of the head unit to ensure that the anchor is at the proper depth. The setting tube with the connecting rod being inserted at the proper height can be seen below in Figure 9.

Figure 9: Connecting rod being inserted into the setting tube, in preparation for setting the hydraulic anchor

d. Once the connecting rod is resting against the road surface, and the stop nut is against the top of the head unit, attach the free end of the hydraulic tubing to the hydraulic hand pump from the installation kit. Begin filling the bladder of the anchor.

e. The bladder will accept hydraulic fluid as it expands- this can be seen by executing a full stroke of the pump lever, and then observing the pressure decrease as the pump lever is held stationary. Continue pumping until the pressure indicated by the dial gauge begins to spike (approximately over 700 psi threshold) and decreases quickly with the pump lever held stationary. Once the dial indicator begins extending passed this threshold with each pump, and the pressure no longer decreases when the pump lever is held stationary, it can be assumed that the bladder has expanded sufficiently and is now set.

f. Give the setting tube a firm (but not excessive, approximately 10 pounds of pull) tug upwards to make sure that the anchor is set and not going to shift.

6. With the anchor set and the head unit held in place by the setting tube and the connecting rod, gently feed the copper tube of the water pump into the borehole alongside the MDD as deep as the borehole will allow.
7. Remove the connecting rod from the setting tube, then gently unscrew the setting tube from the head unit.

INFORMATION: Give the threaded rod attached to Measurment Location 1 (ML1) a gentle but firm downward push, to confirm that the anchor has expanded and is holding the MDD in position. It is important not to knock any debris into the sensor holes of the MDD at this stage.

8. Adjust the two 10-32 nuts from the ML1 rod so that they are sitting precisely 1 inch higher than their previous position, and then reinstall the setting tube onto the head unit, threading down to the mark (just as in Step 5. c.). This is to allow the head unit to move exactly 1 inch away from the set anchor.

WARNING: When performing Step 10 below, make sure not to overextend the head unit when applying the stretch to the MDD. This can cause the tops of the measurement rods to become disconnected from the bottom of the head unit, which can be extremely difficult to guide back into proper placement.

9. While very gently pulling on the setting tube, the head unit must be stretched exactly 1 inch from its previous position. The bottom set of holes (the ones closest to the head unit, along the setting tube) must be made flush with the road surface. It is extremely important at this step not to overextend the head unit above 1 inch; the bottom set of holes in the setting tube must never be pulled above flush with the road surface. While holding the connecting rod flat against the road surface, feed the rod through the bottom set of holes to hold the setting tube in place. See Figure 10 below for a proper setup.

Figure 10: Connecting rod inserted into the setting tube, through the bottom set of holes (this example excludes the threaded rods in each measurement position)

10. Using Table 1 for reference, gradually insert backfill material into the annular space between the MDD and the walls of the borehole. To allow the material to filter down past the ribbed sides of the MDD, carefully shift the head of the MDD back and forth, making sure not to lift the setting tube and connecting rod above their current set position.

    Table 1: Backfill volume approximate volumes

MDD OUTER TUBE DIAMETER, IN	BOREHOLE DIAMETER, IN	ANNULARSPACE, INA2	BOREHOLE DEPTH, IN	ANNULAR SPACE VOLUME, INA3	6″ BOTTOM OF HOLE VOLUME, INA3	TOTAL VOLUME OF MIX
1.40	2.00	1.60	84.00	134.60	3.	138
2.40	3.00	3.	84.00	214.	7.	221
1.40	2.00	1.60	96.00	154.	3.	157
2.40	3.00	3.	96.00	244.	7.	251
1.40	2.00	1.60	108.00	173.	3.	176
2.40	3.00	3.	108.00	275.	7.	282

    Backfill mix suggestions:

    • Soft Clay – Benseal

    • Medium Strength Clay – 1 pt. Benseal, 1 pt. Sand

    • High Strength Material – 2 pt. Benseal, 1 pt. Cement

11. Once no more backfill material can be placed into the hole, begin injecting water with the water pump to activate the backfill material, moving the copper tubing upwards approximately 1 foot at each water injection. Repeat until the copper tubing has been retrieved from the hole. Add more backfill as necessary as the copper tube is pulled from the hole.
12. Using side-cutters or a similar tool, snip the hydraulic line as close to the hole as possible.
13. At this point, the head unit will be relatively stationary. Remove the setting tube and the connecting rod. Remove the threaded rods from the measurement positions and place tape or something similar over the top, making sure to cover the measurement holes.
14. For any remaining void around the head unit, use material from that surrounding level or something as similar as possible to create a level fill around the top of the duct hose of the MDD. Fill this material to approximately 0.5 inches below the top of the duct hose, as seen in Figure 11 below.

Figure 11: Head unit covered and layer material placed around the top of the duct hose

15. Remove the covering tape, then screw the roadbox onto the head unit. The lid of the roadbox should be removed so that the cable exit hole can be aligned with the trench. See Figure 12 for reference. Place the protective tape back over the exposed measurement holes. If the cable exit hole does not align perfectly with the trench, the roadbox can be screwed down another revolution. It is important that the roadbox is at least at the height of the road surface, however, it can be slightly lower if need be.

Figure 12: Roadbox screwed onto the head unit, protective tape replaced over measurement holes

16. Mix a small batch of non-expanding, fast-setting Quikcrete ® , and carefully pour it through the annular space between the outside of the roadbox and the pavement. Do this until the Quikcrete ® contacts the underside of the roadbox, and this can be confirmed through the holes in the underside of the roadbox. Do not overfill, then

allow the Quikcrete ® to set.

INFORMATION: The roadbox should be rigidly stationary at this point, with the underside making full contact with the Quikcrete ® floor and the cable exit feeding directly into the trench. Using an implement, stir the Quikcrete ® through the holes in the bottom of the roadbox. This is known as “rodding” and will allow the Quikcrete ® to spread and set properly on the bottom of the roadbox.

17. For each individual sensor, hook up the sensor readout box and evaluate the functionality of each sensor. If the sensor is operating properly, the box will display approximately 5 volts, then decrease in a linear fashion when the sensor is compressed. See Figure 13 below for sensor testing. Note that in Figure 13, the sensors have already been fed through the cable exit. Sensors should be checked twice in the field. Once before installation to verify sensor functionality and once again after running the cables through the cable exit and trenching to verify that the cables were not damaged. Final sensor compression readings are obtained after setting sensors into the reference head and seated against Measurement Location (ML)rods.

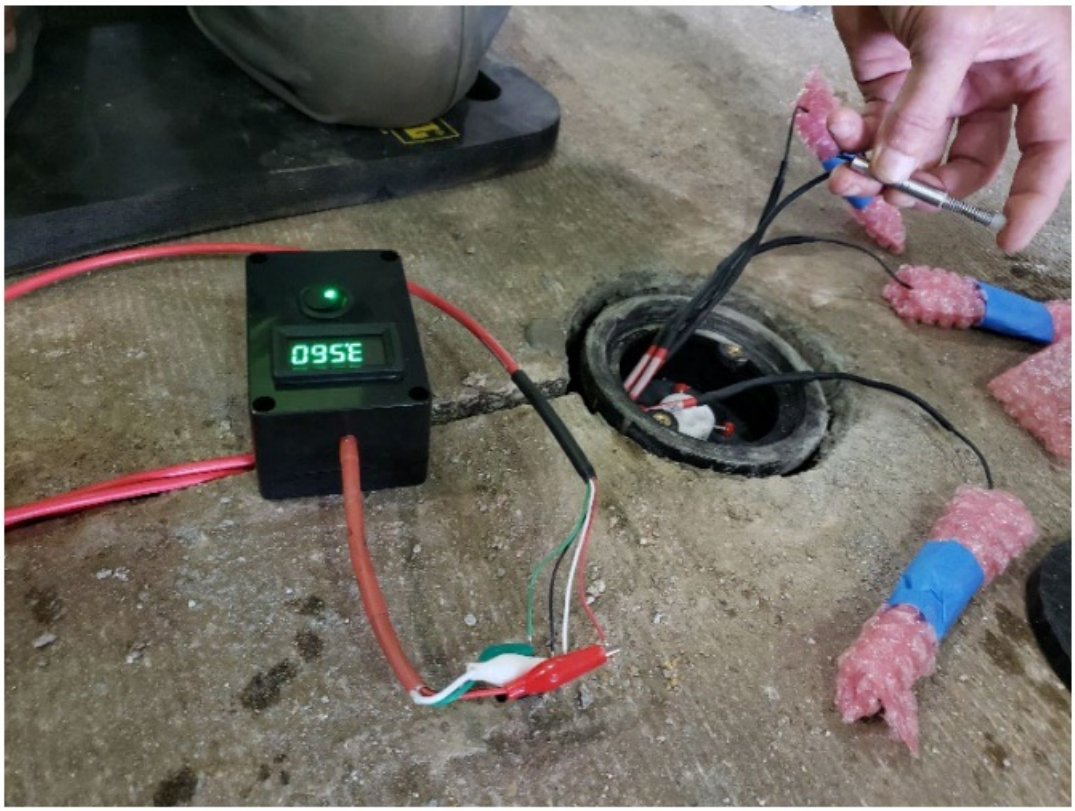

Figure 13: Sensor hooked up to the readout box, and displaying a reasonable voltage when compressed

18. Next, feed the sensor cables through the cable exit and the trench. See Figure 14.

Figure 14: Sensor cables fed through the cable exit and along the trench

19. Once fed through, wrap each of the cables with butyl rubber and form the butyl rubber stopper into the cable exit hole of the roadbox. This is to make a water-tight seal and discourage water ingress into the roadbox.

Figure 15: Butyl rubber stopper placed into the cable exit, while also surrounding each sensor cable

20. Place the thumb screws into the head unit, making sure that the ends of the screws do not intrude into the sensor cavities.
21. Install each sensor into its respective position through the following steps:
    a. Once again, hookup the sensor to the readout box.
    b. Place the sensor into the proper sensor cavity.
    c. Using the readout box for reference, tighten the respective thumb screw while holding the sensor in an ever-so-slightly compressed position. The readout should only change approximately 0.3 volts.
    d. Ensure that the thumb screw is snug and that the sensor cannot shift.

Figure 16: Sensor being installed into the sensor cavity, using the readout box to ensure that it is installed in a very slightly compressed position

22. Tuck all sensor wires into the roadbox and attach the roadbox cover as seen in Figure 17.

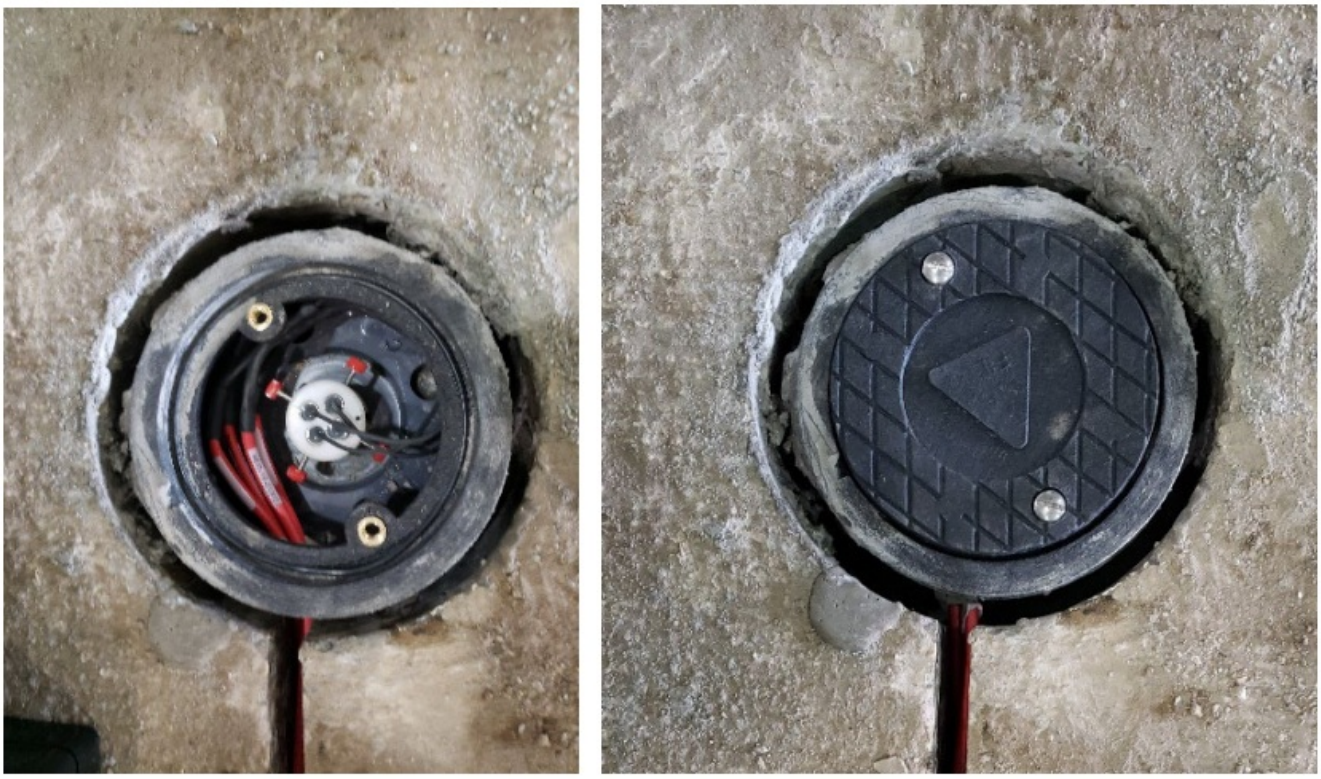

Figure 17: Sensor cables tucked in, roadbox cover reinstalled

23. With the roadbox cover reinstalled, mix more Quikcrete ® and fill the annular space between the roadbox and the pavement. If so necessitated, include black dye in this Quikcrete ® to closely match any asphalt surfaces. See Figure 18 for the completed installation. A small dam may need to be created within the cable trench, to stop the flow of the Quikcrete ®

Figure 18: Annular space surrounding the roadbox filled with dyed Quikcrete ®

INFORMATION: To seal the lid of the roadbox, Vaseline ® or silicone grease can be applied to the lip of the roadbox before the lid is reattached. This will provide further waterproofing and weather sealing.

WARNING: After a minimum of 1-2 days, the MDD should be 'exercised' prior to collecting actual data. This can be accomplished by passing back and forth over the road box with a heavy vehicle to allow for everything to seat properly.

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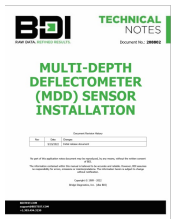
Documents / Resources

	BDI 208802 Multi-Depth Deflectometer [pdf] Installation Guide 208802 Multi-Depth Deflectometer, 208802, Multi-Depth Deflectometer, Deflectometer

References

- Structural Health Monitoring and Structure Diagnostic Testing