EXTERNAL INFLUENCE OF MIT T2 NONDESTRUCTIVE THICKNESS TESTING
RESULTS | CASE STUDY AND RESOLUTION

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ABSTRACT

In 2014, S.T.A.T.E. Testing, LLC conducted a validation study for the Illinois Tollway to determine the effectiveness of several non-destructive thickness testing methods in advance of the Tollway’s Performance Related Specification (PRS) for concrete pavement construction. Through this study it was determined that the MIT T2 non-destructive measuring device was suitable for use.

When the first project calling for MIT T2 use began paving, it was immediately discovered that the device was not providing reliable, repeatable thickness data in the field. Through a series of diagnostic and forensic efforts, it was determined that the device was working as it should and that the cause of the problems were inherent to the project location rather than a device malfunction or operator error. The starting area of the project site is densely populated with high and standard voltage power lines. Additionally, there is a large power transformer farm located adjacent to the site. There are also at least 3 significant radio and microwave antennas in the project right-of-way or adjacent to it.

Working with MIT and their US sales and service representative, S.T.A.T.E. Testing was able to implement a field fix which updated the MIT T2 firmware to include additional signal filtering to allow the signal noise induced by the harsh electromagnetic environment and allow the MIT T2 to function properly and produce accurate, repeatable data. Validation testing was conducted across the overall project to ensure no further problems would be encountered.

Keywords: MIT T2, Non-Destructive Testing, External Influence, Radio Interference, Electrical Interference
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BACKGROUND
Illinois Tollway I-90 Reconstruction/Widening Project
The Illinois Tollway is in the process of a massive reconstruction and widening program for the Jane Addams Tollway (I-90) which extends west from O’Hare Airport in Chicago, IL to Rockford, IL. Approximately 2 years were spent reconstructing and widening the existing road from Elgin, IL to the intersection of I-39 in Rockford. The current two year build cycle will reconstruct the portion of the Jane Addams from O’Hare Airport to Elgin, IL. The primary cross section of the roadway includes a 13-inch thick jointed plain concrete pavement.

As part of the current build cycle, the Illinois Tollway has implemented its newly developed Performance Related Specification (PRS) for concrete pavements. The PRS includes incentives and disincentives for a variety of pavement metrics, including thickness. In order to ensure that sufficient thickness data could be gathered to provide sound statistical representation and accurate pay factors, the decision was made to use non-destructive testing (NDT) thickness measurement for the PRS. This process allows a large number of measurements to be made without undue burden on quality control or quality assurance personnel and preserves the pavement condition by eliminating or limiting the number of core holes cut into new pavement.

Illinois Tollway Non-Destructive Thickness Testing Feasibility Study
In order to determine most appropriate NDT thickness measurement device for the Illinois Tollway PRS program, S.T.A.T.E. Testing, LLC conducted a literature review and feasibility study on behalf of the Illinois Tollway. The literature review and industry study, two candidates were selected for evaluation, the MIT T2 thickness scanning device, and the MIRA ultrasonic tomography scanner (unpublished data).

The MIT T2 device uses magnetic imaging tomography to precisely determine the depth to calibrated plates placed on grade in advance of the concrete paving. The device outputs a single number thickness measurement for direct recording.

The MIRA device uses ultrasonic tomography to locate the interface between disparate materials or lifts of a single material. The device produces complex files which must be analyzed separately to determine the thickness of interest.

A field study was performed on selected sites during the construction of the 11 ¼” nominal thickness PCC pavements for the I-90 project in 2014. Both devices performed well in the field. Care needed to be taken to ensure that the measurement plates were placed well away (approximately 12”) from other steel sources such as tie bars and dowel bars in order to get precise, reliable data from the MIT T2. The MIRA device was not significantly impacted by the presence of other steel sources (unpublished data)(1).

Ultimately, the decision was made to implement the MIT T2 because the data was reliable and easy to interpret, the device was cost effective, and there was regional and national precedent for its use to help allay contractor concerns about its use in determining pay factors. Most of the regional contractors had seen the device demonstrated during a visit from the FHWA Mobile Concrete Laboratory. The only significant concerns expressed at that time were due to movement of the plates. To address this, S.T.A.T.E. Testing, LLC incorporated nailing of the plates to the stabilized subbase paving platform as part of the feasibility study. No plates were found to have moved.
**MIT T2 Acquisition**

S.T.A.T.E. Testing acquired a new MIT T2 in February of 2015 in advance of the 2015 construction season in order to provide NDT thickness measurement for the Illinois Tollway. This testing is provided by S.T.A.T.E. Testing, LLC as part of our role as Independent Assurance for the I-90 corridor. The device was delivered and tested at the laboratory in East Dundee, approximately 1 mile from the I-90 project site. Initial testing was performed by using the device to scan atop standard steel plates using Styrofoam blocks as a standoff to provide elevation. These tests showed the device to operate similarly to the FHWA loan program device used in the earlier feasibility study. No issues were noted and the device was securely stored until it would be needed for the I-90 project in the summer of 2015.

**CASE STUDY**

The first 13-inch PRS concrete pavement construction began on May 18th, 2015. The project area was westbound I-90 extending west from Beverly Road and continuing on to approximately Illinois Route 25. Due to the configuration of the project, subsequent paving days would progress from west to east, and the jump to the eastbound side of the project and commence from approximately Illinois Route 25 west towards Beverly Road.

![Project Paving Area of Concern](image)

**Figure 1: Paving Project Area**

S.T.A.T.E. Testing placed standard 30-cm diameter steel plates at predetermined random positions prior to the day of the pave. A total of 6 plates were placed per sublot, with each sublot being approximately 1000-ft long by 1 lane wide. The contractor elected to pave this portion of the project 2-lanes wide. Due to site logistics, the contractor decided to nail the dowel baskets to the stabilized subgrade paving platform ahead of the paver in the space between the rubber-tire concrete belt placed and the slip-form concrete paver. The litany of prep work, foot traffic, skid steer operation and ready-mix concrete truck traffic did cause some
distortion of a few of the plates. The decision was made to switch to longer nails driven with a powder-actuated nail gun to improve hold on the pavement platform and the contractor was instructed to take care when working atop the thickness plates.

**Initial Field Experience**

Within a few days of paving, S.T.A.T.E. Testing, LLC was on site to begin the NDT thickness scanning using the MIT T2 device. The initial tests produced erratic results. The initial comment back to the engineering staff from the field technicians was that they were concerned that the plates had been deformed during paving and that the readings were erratic as a result. Another possible concern was that the device had not been properly charged or perhaps the wrong target plate settings had been selected. The field crew brought the unit back to the office for charging and examination overnight.

When attempting to survey the thickness points again the following day after verifying all the settings, the crew again encountered difficulty getting consistent measurements. The readings on the MIT device would vary by upwards of 2 inches when repeating a scan over a plate in the same direction at times, though not consistently. The average of a large number of readings would generally fall within the expected range of 13-in to 13 ½-in, however it was obvious that something was wrong. Paving continued and S.T.A.T.E. Testing staff monitored the paving operation to be sure that the plates were not being warped or moved during paving. No significant issues were found.

The device was brought back to the office for inspection. The device appeared to be operating normally and checked out when operated over a dummy-plate in the parking lot of the S.T.A.T.E. Testing lab.

**Initial Investigation**

Joe Pitlik and Sarah Kilroy from the S.T.A.T.E. Testing engineering staff took the MIT T2 unit out to the project site to confirm the field crew findings. They confirmed that the device was properly setup but was producing erratic and inaccurate results. With paving progressing almost daily, it became critical to develop a solution so that deadlines for reporting of data to the Illinois Tollway and the contractor under PRS could be met going forward.

At this point the engineering staff at S.T.A.T.E. Testing, LLC initiated contact with Kessler Soils Engineering Products, Inc. (KSE) to discuss the matter. No issues with device setup or field practice could be determined. S.T.A.T.E. Testing, LLC had the KSE reference/loaner device express shipped to the lab so that the unit could be examined side by side with a unit known to be functioning properly.

**Testing Against Reference Device**

The KSE loaner device was received on Friday, May 22nd and immediately put into service. The KSE device is older, but functioned identically to the FHWA loaner unit and the S.T.A.T.E. Testing unit, so no additional training was needed. Both units were taken to the project site and tested over the existing plates. Both units showed the same erratic behavior. Significant spread between readings was found, even when using identical scan paths on the same plate. Time was short and the project site was congested with construction traffic. It was decided to regroup and experiment further over the weekend.

**Second Field Investigation**

Joe Pitlik and Sarah Kilroy from S.T.A.T.E. Testing returned to the project site on Saturday, May 23rd. Both the S.T.A.T.E. Testing MIT T2 and the KSE MIT T2 were brought out along the S.T.A.T.E. Testing MIT BT 2 dowel bar scanner. By this time, more than 4000 feet of two lane wide mainline 13-in PCC pavement had been placed. The two T2 devices were used to check measurements along the length of the area. No consistency could be found in the readings for either device. While the initial measurements from the feasibility study in 2014 had shown that no more than 6 mm of difference could be found between readings for a plate placed well away from other embedded steel, the field measurements for this project were...
producing more than 50 mm of variation between scans, regardless of orientation. The MIT BT 2 performed well and dowel bar scanning of many locations along the pavement were successfully analyzed in the field.

The work over the course of the day had taken the crew from east to west across the project. Rather than haul the gear back to the starting point near Beverly Road where the vehicles were parked. Joe Pitlik hiked back to get a vehicle to collect the equipment. While slowly driving through the construction site back to get Sarah Kilroy and the gear was when the realization of the likely source of the problem occurred. The vehicle in use has a good radio and typically has no trouble tuning in stations. Two of the stronger radio stations in the Chicago area, WBEZ and WXRT, which can both be tuned in easily at the S.T.A.T.E. Testing lab approximately 1 mile north of the project site were both filled with static and very difficult to listen to.

This brought to mind anecdotal evidence from past projects and the development of the Illinois Tollway dowel alignment specifications that overhead power lines could cause signal interference in the data. These anecdotes of outside electromagnetic interference from power lines had not previously caused a problem for Mr. Pitlik on projects across the nation, however. It was at this point that Mr. Pitlik took a careful look at the project surroundings. The photos below show the views from the center of the project.

![Representative Images from Ground Level near Middle of Site](image1)

![Representative Images from Ground Level near Middle of Site](image2)

The ground level shots clearly show the congestion of various high tension/voltage long distance transmission lines as well standard service electrical lines. Also shown are three separate radio/cellular/microwave antennas. The image below shows the likely interference sources highlighted on an aerial image from Google Earth.
Working with Manufacturer and US Representation

Fortunately, Garry Aicken from KSE, MIT’s US representation, was able to pass through the project site on May 26th as part of a previously scheduled trip to other locations. Because there was no likely cause of the problems when Mr. Aicken departed his office in Virginia, he had brought along an alternate plate type to see if the problem could be resolved using a difference size plate designed for thicker airfield pavements. Ultimately this approach was never attempted.

S.T.A.T.E. Testing, LLC demonstrated the problem in the field to Mr. Aicken from KSE using both of the MIT T2 units on hand at that time. By comparing the performance in on the project site against performance at the S.T.A.T.E. Testing lab and other adjacent job sites, they were able to determine that both MIT T2 units were performing properly and that the problem was isolated to the project site in question. At that time, paving had not commenced on any other Illinois Tollway projects, so testing was performed using Styrofoam blocks over plates resting on grade. Both units performed well when used approximately 1 mile in either direction of the project site.
The presence of the external electromagnetic interference was demonstrated clearly using the MIT T2’s search function. In this mode, the display screen shows a bar graph of the readings for each of the 4 sensors in the scan head. When significant external interference is present, the bar graph is highly unstable and erratic. This effect is magnified when the scan head is aimed up into the air rather than down into the pavement.

Search screen shown with no interference. Note the steady low readings for all 4 sensors.

Ghosting and arrows demonstrate degree of instability in search mode when interference is present.

Figure 4: Signal Variability in Search Mode With and Without Interference.
Due to the time difference between the project site and the MIT offices in Dresden, Germany, we were unable to confer with the manufacturer in real time about the matter. Mr. Aicken summarized our field findings and arranged to discuss the issue with MIT after they had reviewed the findings. No record of similar issues could be found in the US. Underground power lines had occasionally been an issue, but only affected the immediate area, according to KSE.

Fortunately, MIT concurred with our findings that some combination of the influence of the various electromagnetic interference sources was wreaking havoc on the signal the MIT T2 uses to analyze pavement thickness. This type of issue had been encountered in the development of the device and digital signal filtering had been applied to clean up the signal prior to analysis and counteract the effects. Because the bulk of the work to develop the device was performed in Europe, European sites provided most of the testing grounds. As a result, the majority of the signal filtering that was developed occurred in the 50 Hz band generated by European electricity. North American electrical systems use a 60 Hz cycle rate and therefore require different signal filters to fully scrub the signal. MIT was able to quickly adapt their 50 Hz signal filters to 60 Hz filters and issue a firmware update for the S.T.A.T.E. Testing MIT T2 unit.

Mr. Aicken was able to install the new firmware version on the S.T.A.T.E. Testing MIT T2 unit on the morning of May 27th. Field testing confirmed that the S.T.A.T.E. Testing MIT T2 unit was producing accurate data on the project site as well as at the S.T.A.T.E. Testing lab, while the KSE MIT T2 unit was still producing faulty data at the project site, as it had not had the firmware update performed. MIT stated that new calibration files for the targets would not be required with the new signal filtering. Off-site testing between the updated and non-updated units bore this fact out.

**FOLLOW UP**

Even with the filtering in place, the search mode for the device still shows erratic behavior when significant interference is present. However, this did not seem like a sufficient means of identifying problem areas. A more quantifiable method was required.

After the furious effort to resolve this MIT T2 issue on this project, S.T.A.T.E. Testing elected to build a more stable reference block to provide regular validation of the MIT T2 function. Plates were permanently installed in the parking lot to provide an easy point of reference for bench testing. The reference block was constructed out of lightweight foam insulation board in layers to create a 13 3/8-in thick block. The lightweight of the setup allows it to be used in the office or transported to the jobsite for comparison between units or validation that unit will perform on site. To date, this has not been found.

![Figure 5: S.T.A.T.E. Testing MIT T2 Reference Block and Plate](image)
The reference block was then used with a plate on grade at points along the entire paving corridor to determine whether additional problems were likely to be encountered so that any additional filtering or contingency plans could be in place prior to paving. When significant variation between readings or variance from actual thickness is encountered, alternate measurements or additional filtering will be required. No issues have been found, however. Stable accurate readings were obtained on the reference block, even when testing in the relatively harsh environment surrounding O’Hare Airport where significant electrical, radio, and radar signals are present.

CONCLUSIONS

The MIT T2 continues to perform well in the field for the Illinois Tollway, providing rapid, frequent measurement of the pavement thickness. The issue of major, above ground electromagnetic interference was heretofore unreported in North America. The MIT signal filtering appears to have fully resolved the issue and the remaining thicknesses for the project area have been measured without incident.

The use of non-destructive testing can provide valuable information about paving materials and structures, but care should be taken to ensure that the methods are reliable within the project limits. The process of validating these measures, as has now been done for the MIT T2 on the I-90 corridor, are straightforward and easy. Whenever possible, this validation should occur in advance of use.

This problem had not previously encountered using the MIT T2 and no sign of it was encountered during the earlier feasibility study. We do not suspect the problem is widespread, but we have not isolated the precise cause of the problem. While some combination of the electrical components and radio towers is likely at fault, at this time, on-site validation against a known thickness remains the best way to test for reliability. We recommend that the new MIT 60Hz filters be implemented for North American MIT T2 units and that MIT T2 users pre-validate project sites which may be subject to electromagnetic interference.
REFERENCES