STATE OF CALIFORNIA

DEPARTMENT OF TRANSPORTATION

DIVISION OF
ENGINEERING SERVICES

MATERIALS ENGINEERING
AND TESTING SERVICES

OFFICE OF RIGID PAVEMENT
AND STRUCTURAL CONCRETE

5900 Folsom Boulevard
Sacramento, California 95819

FINAL REPORT

METHOD TO DETERMINE PAVEMENT THICKNESS USING RECOMMENDED TECHNOLOGY

August 2007

METHOD TO DETERMINE PAVEMENT THICKNESS USING MAGNETIC TOMOGRAPHY TECHNOLOGY

This is report contains a draft of the California Test Method for thickness measurement using magnetic tomography technology. Included in this report is a white paper summarizing the current non-destructive methods of measuring pavement thickness, and a copy of the presentation on the MIT (Magnetic Imaging Technology) Scan-T2 system. The contents do not necessarily reflect the official views or policies of the State of California.

This report does not constitute a standard, specification, or regulation. The Caltrans Office of Rigid Pavement and Structural Concrete and their consultants, Applied Research Associates, Inc., are responsible for the accuracy of the information and data presented in this report.

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Task Order

This task order was issued to Applied Research Associates, Inc (ARA) by Caltrans under Contract #59A0499. The Notice to Proceed on this task order was issued in February 2006 with the main objective of providing Caltrans with a draft test method for thickness measurement and preparing a power point presentation for training Caltrans on this new test method. The scope of work for the original task order is included in Section 1 of this report.

Project Deliverables

The project deliverables as per the revised task order scope and their status is shown in table below.

Project deliverable	Status	Section
Literature search	Complete	Section 1
Perform demonstration	On-going	Not included
Recommendation of the new technology	Complete	Section1
Draft test method for thickness measurement	Complete	Section 2
Power point presentation	Complete	Section 3

Contents of this Document

This document consisted of 3 sections. Section 1 contains the white paper summarizing the current industry test equipment available to measure pavement thickness. This white paper includes the advantages and disadvantages of each method. The recommended technology is included at the end of the report. Section 2 contains a draft of a California Test Method for measuring pavement thickness using the MIT-Scan T2 recommended. Section 3 contains the power point presentation for training Caltrans personnel on the new test method.

SECTION 1—COMMERCIALLY AVAILABLE DEVICES WHITE PAPER

EVALUATION OF NONDESTRUCTIVE TESTS FOR THICKNESS MEASUREMENT OF CONCRETE PAVEMENT AND DEVELOPMENT OF DRAFT TEST METHODS FOR MEASURING THICKNESS

Introduction

The accurate measurement of concrete pavement thickness is an important aspect of any quality control / quality assurance (QC/QA) process. Traditionally, this measurement has been performed by taking cores and measuring the height of the cored PCC. Because coring is a time-consuming and destructive process, only a small number of cores are taken to evaluate thickness of in-place concrete. Because of the small number of cores that can be practically taken to evaluate PCC thickness, the average thicknesses of the cores may not be representative of the pavement thickness. The goal of this research is to evaluate existing nondestructive test methods and technologies for measuring thickness of in-place concrete and to identify the pros and cons with respect to the effectiveness (precision, accuracy, and repeatability), efficiency, cost, functionality, applicability, ease-of-use, and user-friendliness of each technology for Caltrans.

Current Technologies

Several technologies have been developed or are currently under development for measuring thicknesses of hardened concrete pavements. The following is a brief summary of these technologies.

<u>Eddy Currents in Measurement Reflectors</u>

The two devices that use measurements of eddy currents for determining PCC thickness are the Isoscope MP30 Road, manufactured by Fischer®, and the MIT-SCAN-T, manufactured by MIT. These devices work by analyzing the eddy current in the measurement reflectors that are produced as a response to the pulsed magnetic field generated by the device as illustrated in figure 1. The primary disadvantage of using this technology is that the readings are affected by other metallic features in or near a pavement including dowel bars, tie bars, reinforcing steel, guardrails, and safety shoes. MIT recommends a minimum distance of 4 ft from guardrails, 8 ft from parked vehicles, and 2 ft from adjacent reflectors.

Prior to paving, the reflectors are positioned at marked or specified locations. After placing the probe on the pavement above the reflector, the instrument registers the decrease in electromagnetic field generated by the eddy currents in the reflectors, which is then used by the device to compute the distance between the probe and the reflector. A summary of the two devices based on information provided by the manufacturers is shown in table 1. Figure 2 and figure 3 show photographs of typical usage of the Isoscope MP30 Road and the MIT-SCAN-T, respectively.

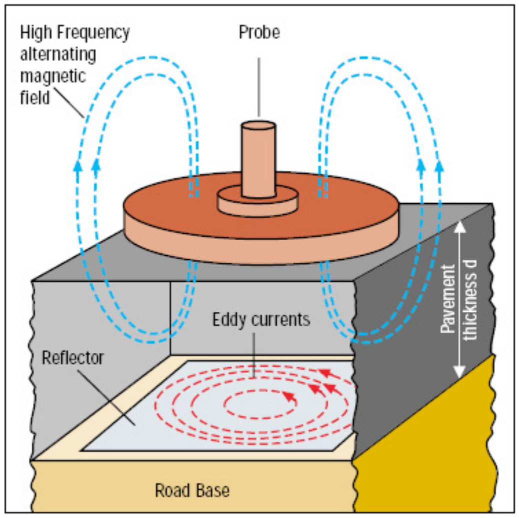

Figure 1. Illustration of principle of evaluating pavement thickness using eddy current measurements (Fischer® brochure).

Table 1. Summary comparison of Isoscope MP30 Road and MIT-SCAN-T.

	Isoscope MP30 Road	**MIT-SCAN-T**
Total Weight	55 lbs (as shipped with measurement cart)	7 lbs (hand held device only)
Measurement range	1.2 to 12 in	0 to 17.5 in
Calibration	Corrective calibration with standard set required	Not required
Reflector	Self-adhesive foil (12 × 28 in) – can be calibrated to 6 additional reflector sizes	3 to 12 in dia. 0.6 mm thick galvanized sheet steel circular disks. Possible to use reflectors with other dimensions.
Accuracy	± 0.5%	0.04 in ± 0.5%
Temperature	41 to 104 ºF	23 to 112 ºF
Data storage capacity	10,000	16,384
Additional features	Digital measurement reading on LC display Acoustic signal for detecting approximate reflector positions Interface for data transfer Measurement cart or carrying belt for working flexibility Probe has to be centered above reflector	Digital measurement reading on LC display Search mode to quickly determine approximate reflector position Light, handheld device Precise position of reflector not required (can be at a distance of 6 in from center of reflector) 8 hour usage time (based on fully charged battery)

Figure 2. Using the Isoscope MP30 Road: (1) placing the reflector prior to paving, (2) Device placed on top of the measurement cart, (3) measuring pavement thickness with probe hung from the measuring cart, and (4) measuring pavement thickness holding the probe with a carrying belt (Fischer® brochure).

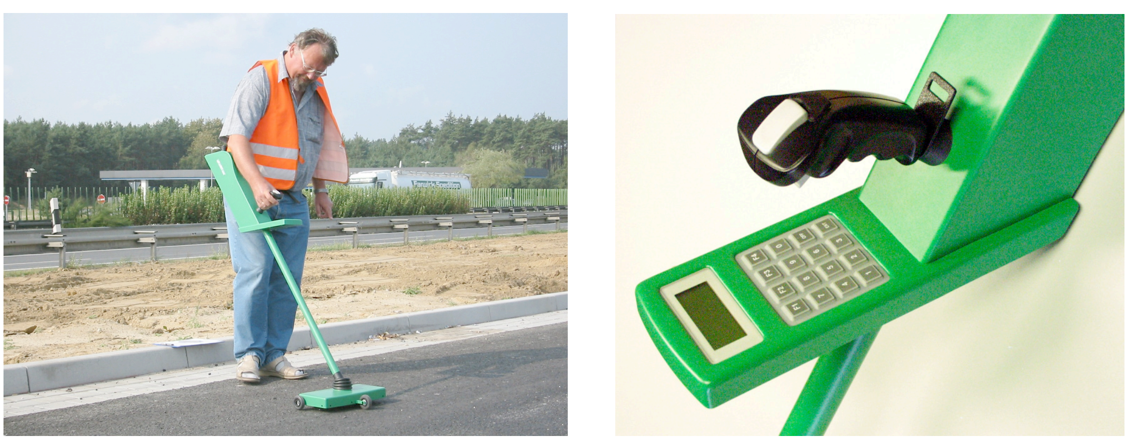

Figure 3. Using the MIT-SCAN-T: (1) measuring pavement thickness with probe and (2) close-up of control panel (MIT brochure).

Impact Echo

Three devices that use the impact echo method for determining PCC thickness are the DOC-500, manufactured by Germann Instruments, the IEI-C manufactured by Impact-Echo Instruments, and the Concrete Thickness Gauge CTG-1T, manufactured by Olson Instruments, Inc.

These devices work by analyzing the reflected compression waves from the bottom of the structural member or from any hidden discontinuity as illustrated in figure 4. An instrumented hammer or an impactor is used as a source to generate compression waves which are sensed by a receiver after being reflected. The IE systems can also be used to detect presence of cracking or delaminations, presence of voids, determination of crack depth, and also strength of concrete.

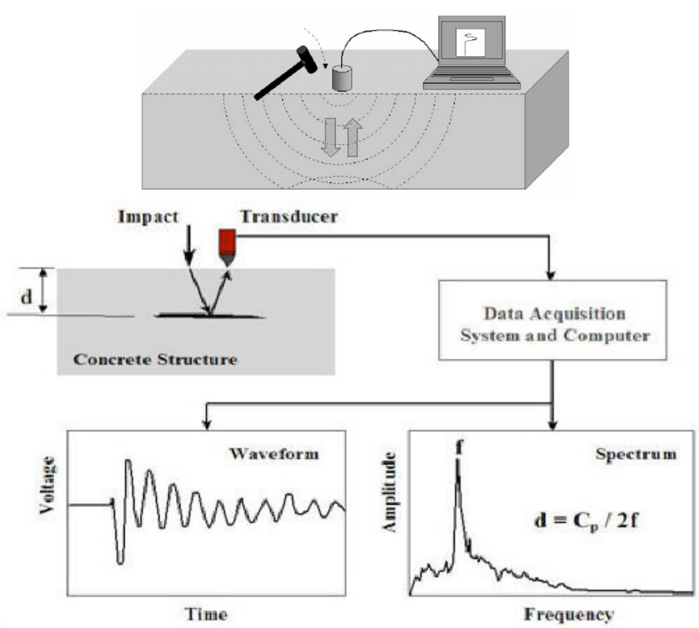

Figure 4. Principle and schematic of testing with impact echo (www.force.dk website).

The advantage of using impact echo technology is that reflectors are not required and the signals are not affected by the presence of steel reinforcing bars. The primary disadvantage of using this technology is that the accuracy is 3 to 5% of the thickness. For a 10 in concrete pavement the errors can be as high as 0.5 in, which may not be acceptable for QC/QA purposes. The errors could be reduced to 0.2 in if the equipment is first calibrated using a representative core from the pavement. Where void/debond areas exist, the thickness echo peak is often shifted to a lower frequency causing the slab to appear thicker as a result of a later arrival time around the void/debond area. Another disadvantage of using impact echo is that measuring concrete pavement thickness on stiff base may provide erroneous results because the device may not be able to distinguish between the layers. Figures 5 through 7 show the DOC-500, the IEI, and the CTG-1T, respectively. The costs of the three systems are $7,900, $9,500 and $4,000, respectively.

Figure 5. DOC-500 System: (1) testing equipment and (2) measuring pavement thickness (computer not included).

Figure 6. IEI-C System: (1) testing equipment (computer not included) and (2) measuring pavement thickness with pistol grip transducer.

Figure 7. CTG-1T System: (1) testing equipment and (2) measuring thickness of concrete slab.

Impact Echo with Measurement of Wave Velocity

Four devices that use the impact echo method and measurement of wave velocity for determining PCC thickness are the C-570 Impact Echo System, manufactured by DGSI, the IEI-B manufactured by Impact-Echo Instruments, the Portable Impact Echo System (PIES), manufactured by Qualitest™, and the DOC-1000, manufactured by Germann Instruments.

A conventional impact echo device needs to be first calibrated using concrete of known thickness with properties identical to the slab being tested. This calibration is used to compute the wave velocity in the concrete. However, the wave velocities can also be estimated by using two transducers as specified in ASTM Standard C 1383-98a – "Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method." This standard has since been replaced by ASTM C 1383-04. The time difference between arrivals of the first P-wave running on the surface to the two transducers is recorded and divided into the distance between the transducers to provide an estimate of the wave speed as shown in figure 8.

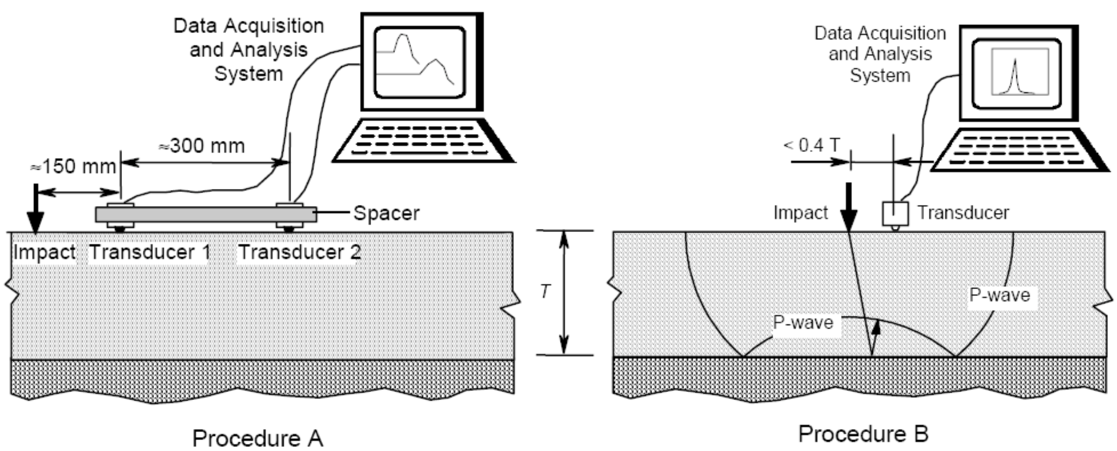

Figure 8. Two step procedure for measuring plate thickness using ASTM C1383: Procedure A is to estimate the P-wave speed which is then used in Procedure B to determine slab thickness (from National Institute of Standards and Technology [NIST]).

The advantage of using impact echo technology with measurement of wave velocity is that reflectors are not required and the signals are not affected by the presence of steel reinforcing bars. Calibration using a representative core is not required. The primary disadvantage of using this technology is that the errors can be as high as 3% of the thickness. For a 10 in concrete pavement the errors can be as high as 0.3 in, which may not be acceptable for QC/QA purposes. The errors could be reduced if the equipment is first calibrated using a representative core from the pavement.

Figures 9 through 12 show the C-570 System, the IEI, the PIES, and the DOC-1000, respectively. The costs for the four systems are $12,850 for C-570 (computer not required), $11,500 for the IEI-B (computer not included), $16,995 for the PIES (handheld iPaq included), and $11,900 for the DOC-1000 (computer not included).

Figure 9. C-570 System: (1) testing equipment and (2) measuring thickness of concrete slab.

Figure 10. IEI-B System: testing equipment (computer not included).

Figure 11. PIES System: (1) testing equipment (2) close-up of hand-held device, and (3) measuring thickness of concrete slab (handheld PDA included).

Figure 12. DOC-1000 System: testing equipment (computer not included).

Impact Echo with Spectral Analysis of Surface Waves (SASW)

Two commercially devices are available that combine impact echo with spectral analysis of surface wave analysis. These include the CTG-1T-SW, manufactured by Olson Instruments and the Portable Seismic Properties Analyzer for Pavements (PSPA-P), manufactured by Geomedia Research and Development (GRD).

The SASW method uses the dispersive characteristics of surface waves (Rayleigh waves) to determine the variation of the shear wave velocity (stiffness) of layered systems with depth. Two receivers are used to measure the properties of the concrete layer. Two receivers are placed on the surface and a hammer or impactor is used to generate the wave energy. A signal analyzer is used to collect and transform the receiver outputs. Figure 13 shows the setup for SASW tests.

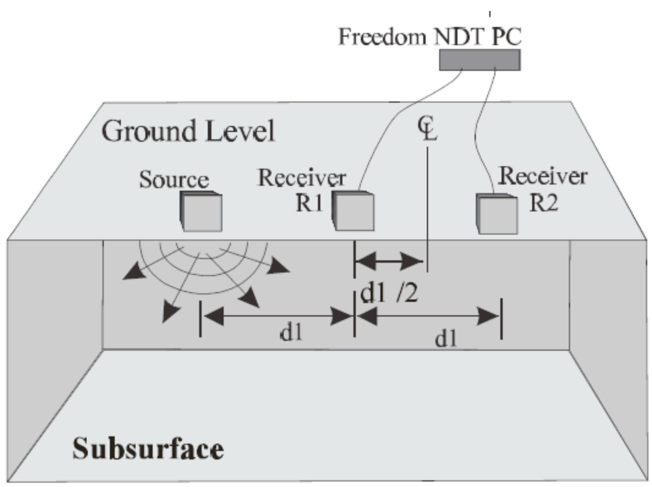

Figure 13. Field setup for SASW tests (from Olson Engineering).

SASW measurements are accurate to within 5% for the determination of thickness and stiffness of the top layer in a pavement system. For a 10 in pavement, the errors can be as high as 0.5 in. A handful of commercially available systems are available that can perform SASW measurements, including SASW-S, manufactured by Olson Instruments and SASW system by GDS Instruments. However, these are not developed specifically for measuring concrete thickness and interpretation and analysis of data may be required. By comparison, the two systems CTG-1T-SW and PSPA-P combine SASW with impact echo testing to improve functionality and reliability. Measurement of the surface wave velocity with the SASW method allows calculation of compression wave velocity for use in Impact-Echo analysis resulting in accuracies of 2 to 3%.

Figures 14 and 15 show the CTG-1T-SW and the PSPA-P systems, respectively. The price for the two systems are $5,500 and $_____ respectively. The CTG line also includes a flaw detection model for an additional $2,500. The PSPA-P system can also be leased from GRD.

Figure 14. CTG-1T-SW System: (1) testing equipment (2) close-up of testing equipment, and (3) measuring thickness of concrete slab.

Figure 15. PSPA system: (1) testing equipment (2) measuring thickness of concrete slab.

Ground Penetrating Radar (GPR)

Several manufacturers produce GPR systems for various applications. Two vendors that have developed devices specifically for pavement evaluation are Pulse Radar Inc. and Geophysical Survey Systems, Inc. (GSSI).

Ground penetrating radar (GPR) systems use electromagnetic pulses to test, characterize, or detect subsurface materials based on changes in electrical and magnetic properties of the subsurface layers. GPR works using short electromagnetic pulses radiated by an antenna which transmits these pulses and receives reflected returns from the pavement layers, as shown in figure 16. Wave pulses are reflected at interfaces have a difference in electrical properties. Many antennas are available ranging in center frequency from 25 to 3,000 MHz. The lower frequencies provide better penetration but less resolution, while the higher frequencies give less penetration but higher resolution.

Two basic types of GPR equipment systems are used depending on the type of antenna employed: (1) Ground-coupled antennas that are in direct contact with the surface and have to be moved slowly by hand or towed slowly by a vehicle at 2 to 4 mph. Ground-coupled radar is most suitable for deeper penetrations and for object detection, and where survey speed is not critical. (2) Air-coupled horn antennas are usually mounted on vehicles with an air gap between the bottom of the radar and the surface to be evaluated. The vehicle with the air-couple radar can gather data at speeds up to 45 to 50 mph.

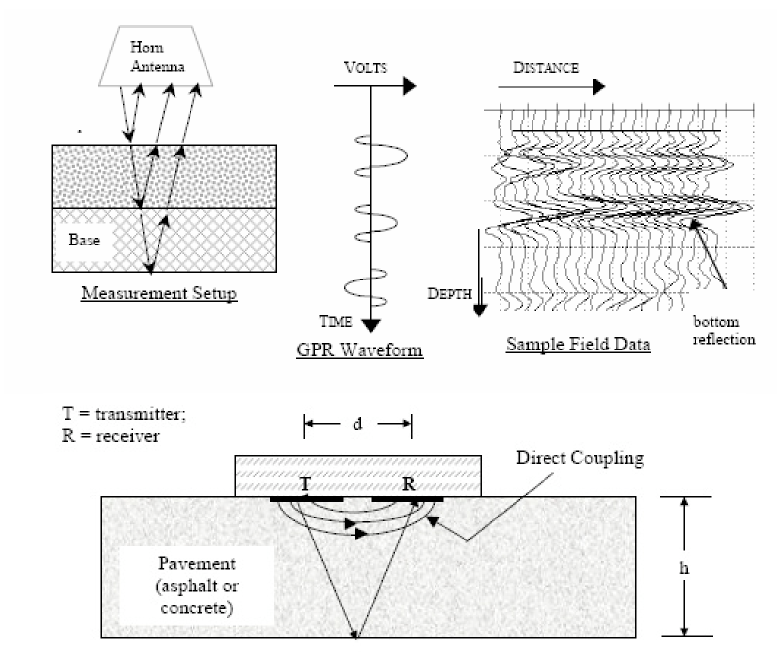

Figure 16. Principle of testing with air-coupled GPR and ground-coupled GPR.

One of the traditional limitations of GPR has been the cost and complexity of the equipment, the need for interpretive expertise, and the requirement for office data processing. Recent developments with GPR hardware have yielded systems which are less expensive and easier to operate, and could overcome the equipment complication. On the data processing side, prototype software for automated on-site processing has been developed and may overcome some of the processing issues.

A more significant issue for using GPR for concrete pavement thickness QC/QA is the accuracy which range from 5 to 10%. For a 10 in concrete pavements, errors can be as high as 1 in. While this may be acceptable for network level evaluation, it is not acceptable for QC/QA purposes. Recent research conducted by Texas DOT suggest that to obtain a resolution of 0.4 in in dry concrete a GPR bandwidth of 5,000 MHz is required. Currently, there is no such commercial GPR available. Also, GPR may not always be able to detect the thickness of concrete pavement if there is insufficient contrast between the concrete and the base layer.

Figures 17 and 18 show the Pulse Radar Inc. and GSSI equipment, respectively. GSSI also manufactures a handheld device shown in figure 18. However, it can be used only for evaluation to depths less than 10 in.

Figure 17. Pulse Radar GPR System: (1) air-coupled horn antennas mounted on van.

Figure 18. GSSI GPR System: (1) air-coupled horn antennas mounted on van (2) ground-coupled antenna mounted on cart, and (3) handheld device.

Summary

A summary table of the various devices for measuring concrete pavement thickness is shown in table 2.

Table 2. Summary of various devices for evaluating concrete pavement thickness.

Device	Technology	Accuracy	Limitations
Isoscope MP30 Road	Eddy Currents in Reflectors	± 0.5%	Reflector required – thickness data cannot be collected where reflector not positioned (requires planned test locations). Affected by nearby metallic objects such as tie bars, dowel bars, etc. Probe has to be centered above reflector. Corrective calibration with standard set required.
MIT-SCAN-T		0.04 in ± 0.5%	Reflector required – thickness data cannot be collected where reflector not positioned (requires planned test locations). Affected by nearby metallic objects such as tie bars, dowel bars, etc.
DOC-500	Impact Echo	± 5% (± 2% when calibrated)	Calibration using representative core from pavement required for better results. Void/debond areas can affect results. Device may not be able to distinguish between layers if stiff base present.
IEI-C			
CTG-1T			
C-570	Impact Echo with P-wave velocity measurement	± 3% (± 2% when calibrated)	Calibration using representative core from pavement required for better results, but can be used without calibration. Void/debond areas can affect results. Device may not be able to distinguish between layers if stiff base present.
IEI-B			
PIES			
DOC-1000			
CTG-1T-SW	Impact Echo with Spectral Analysis of Surface Waves velocity measurement	± 3% (± 2% when calibrated)	Calibration using representative core from pavement required for better results, but can be used without calibration. Void/debond areas can affect results. Device may not be able to distinguish between layers if stiff base present.
PSPA-P			
Pulse Radar	Ground Penetrating Radar	± 5 to 10%	High cost of equipment and mobilization. Cost and complexity of data analysis. Poor accuracy for QC/QA purposes. Device may not be able to distinguish between layers if insufficient contrast between layers.
GSSI			

New research and development projects are currently being conducted for evaluation of pavement thickness such as (1) Pavement Thickness Density Meter (PTDM) for determining pavement thickness and density during construction and (2) laser scanning of base prior to paving. However, these technologies are still under development and are not commercially available.

Recommendations

Based on the information collected about the various devices, the field evaluation of two complementary devices (1) MIT-SCAN-T and (2) CTG-1T-SW is recommended. The MIT-SCAN-T is recommended for its ease of use and no calibration required, resulting in fewer human errors (due to lack of or erroneous calibration). However, the MIT-SCAN-T requires preplanning and placing of reflectors over the base course prior to paving. The results are also affected by other metal in the vicinity, including dowel bars, tie bars, etc. In situations when the MIT-SCAN-T cannot be used, the CTG-1T-SW can be used in its place. While the accuracy of the CTG-1T-SW is not as high as the MIT-SCAN-T, the errors can be reduced if a calibration core is used to calibrate the device prior to thickness measurement.

SECTION 2—DRAFT OF CALIFORNIA TEST METHOD FOR THICKNESS MEASUREMENT OF CONCRETE PAVEMENT USING THE MIT-SCAN T2 EQUIPMENT

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CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read **"SAFETY AND HEALTH"** in Section G of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

METHOD TO DETERMINE PAVEMENT THICKNESS USING MAGNETIC TOMOGRAPHY TECHNOLOGY

A. SCOPE

This method describes the procedure for use of magnetic tomography technology to measure the thickness of a pavement in a non-destructive manner.

B. APPARATUS

MIT (Magnetic Imaging Technology) Scan-T2 system (Figure 1) is commercially available equipment which uses magnetic tomography to detect locations of steel discs placed on the base prior to paving. It consists of the following components.

A. A handheld Sensor Unit
B. A battery charging system
C. A handheld printer (Optional)
D. Magnetic zinc or aluminum coated steel reflector discs.

C. PRINCIPLE OF OPERATION

The sensor unit emits a weak, pulsating magnetic signal and detects a transient magnetic response signal induced in the metal reflector discs placed on the base during construction. The principles of tomography are then used to determine the depths of the discs and therefore thickness of pavement.

D. PLACEMENT OF DISCS

A. Select reflector disc according to Table 1.
B. Select and mark random but representative locations over the section to be paved where reflector discs will be placed.
C. Place reflector discs at selected locations but not closer than 500 millimeters (20 inches) from the edge of another disc.
D. Reflector discs shall not be placed such as to have dowel bars, tie bars, steel reinforcement or other metallic objects within a radius of 900 millimeters (3 feet) from the disc.
E. Secure all reflector discs to cement or asphalt treated bases with PK nails at least 50 millimeters (2 inches) long.

E. THICKNESS MEASUREMENT

A. Charge the scan unit before going to a site.
B. Once onsite, assemble the unit as shown in Figure 2.
C. Select the appropriate reflector type in the SEARCH/MEASUREMENT menu based on the disc placed at the site during construction.
D. Locate the reflector disc by using the SEARCH function to ensure that the disc has not moved from planned location.
E. To avoid incorrect readings due to interference, clearance distances as provided in Table 2 and Figure 4 must be ensured.
F. Input the site and reflector disc location information in the LOCATION SETTINGS menu for future records.
G. Place the unit about 300 millimeters (12 inches) before the approximate location of the edge of reflector disc and start measurements.
H. Move the sensor unit in a straight line at a steady rate for about 1.5 meters (5 feet).
I. If required, verification of reflector disc material and dimensions may be conducted from the RESULT menu after completion of a measurement and driving the sensor over the disc twice in two mutually perpendicular directions.

The data so collected is analyzed in real time and results can be seen on the display at the end of the analysis. The recorded results contain the details of the measurement including the location, date and time of measurement and pavement thickness along with reflector disc parameters.

Accuracy of measurement is within ± (0.5% of measured value + 1 millimeter).

To obtain reliable results the surface of the joint to be scanned must be free of any metallic objects. Any metal objects within proximity of the scan unit may influence the measurement results. Items such as keys, knifes, steel-toed boots etc., within 1 meter (3 feet) of the scan unit may have an effect on the measurements.

F. REPORT

The test report should include the following information

A. Project name & location
B. Date and time of testing
C. PCC design thickness
D. Dowel diameter
E. Station and GPS coordinates of reflector discs as placed and as
F. Excel sheet outputted from MIT-SCAN-T2 unit.

G. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

H. REFERENCE:

MIT GbR A. Ulbricht+R. Weiß, "MIT-SCAN-T2 Device for Nondestructive Testing of Pavement Thickness Operating Manual," March 2006

End of Text (California Test XYZ contains 5 pages)

Table 1. Disc selection guide

Design Pavement Thickness	Disc Diameter
0 to 180 mm (0 to 7.1 in)	70 mm (2.7 in)
181 to 450 mm (7.1 to 17.7 in)	300 mm (11.8 in)

Table 2. Clearance distances for operation of MIT-SCAN-T2 sensor unit

Interference type	Minimum clearance from sensor unit
Parked cars	2 m (6.6 ft)
Moving traffic	1 m (3.3 ft)
Other reflector discs	0.5 m (1.7 ft)
Construction equipment	4 m (13 ft)
Guardrails and other safety features	1 m (3.3 ft)

Figure 1. MIT-SCAN-T2 system disassembled for storage.

Figure 2. Assembled MIT-SCAN-T2 system.

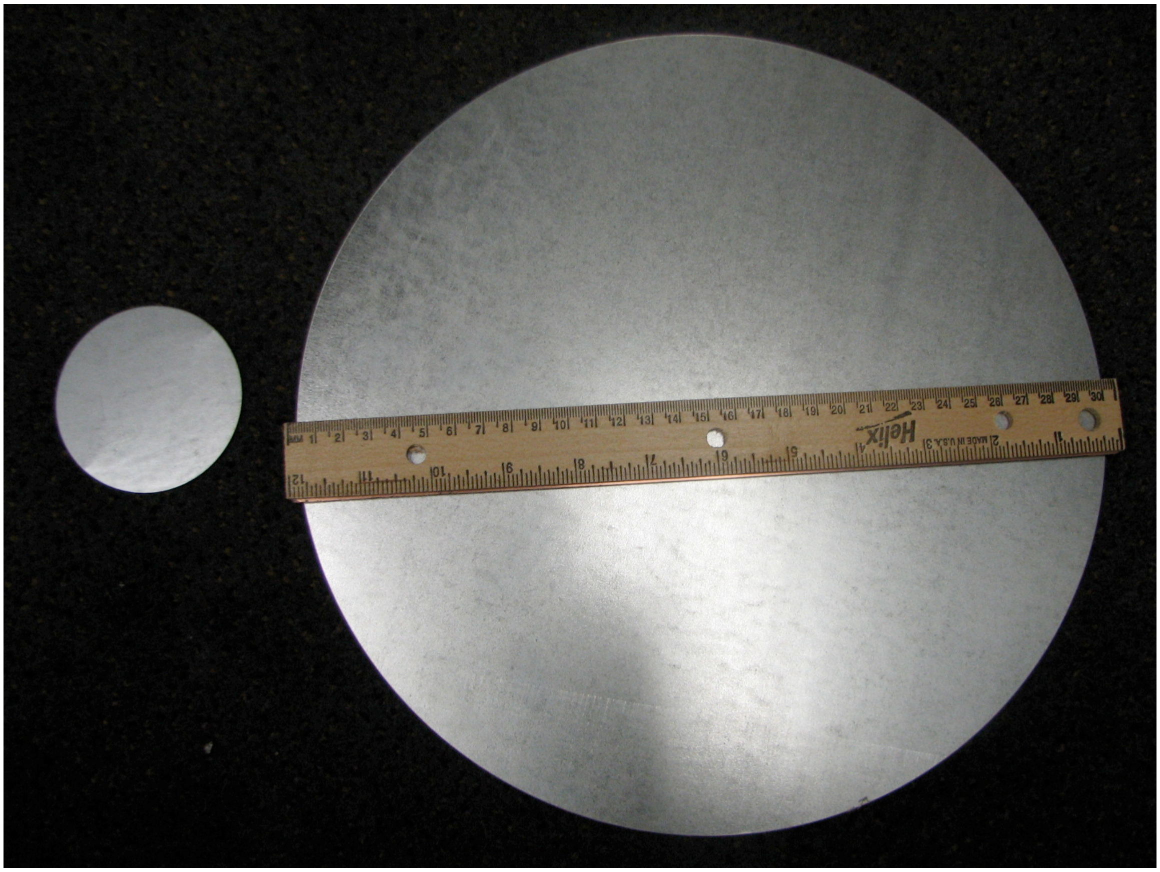


Figure 3. Steel reflector discs of 70 mm and 300 mm diameter.

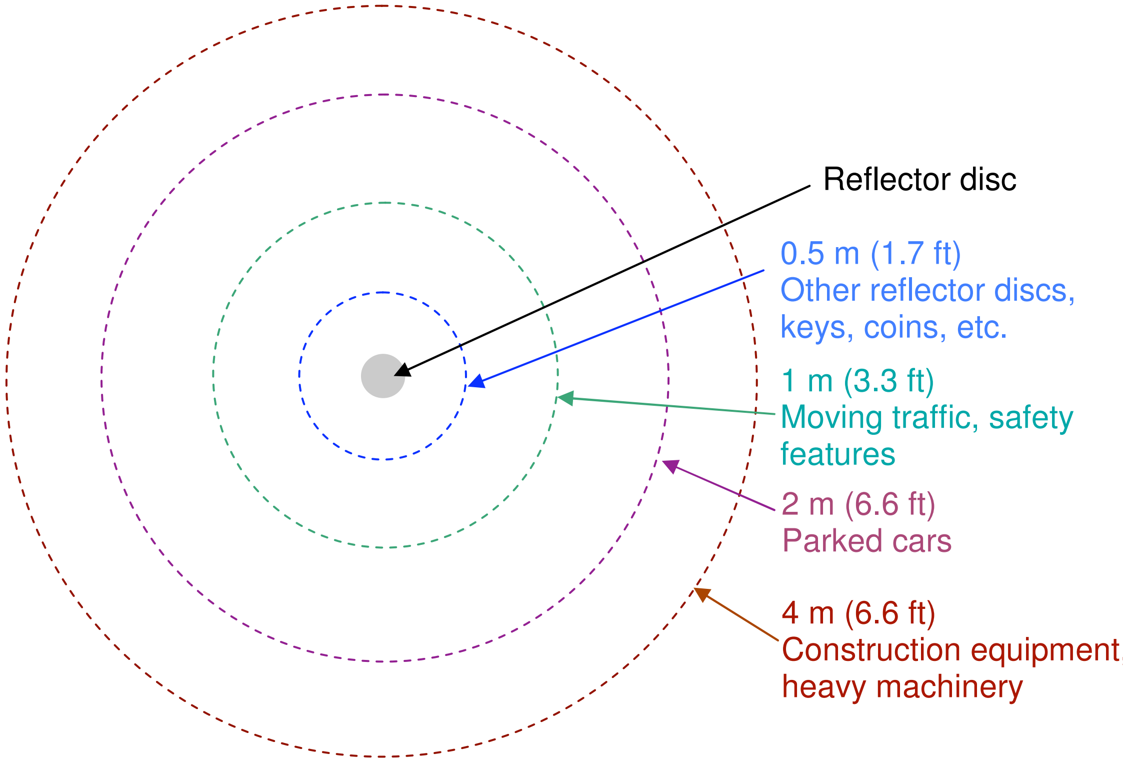


Figure 4. Clearance zones required during measurement.

SECTION 3—POWER POINT PRESENTATION FOR CALTRANS ON USING THE MIT-SCAN T2 SYSTEM

Power Point Slide 1:

MIT-SCAN-T2

Non-Destructive Thickness Measurement Device

Power Point Slide 2:

INSTRUMENT CAPABILITIES

- ❑ Can measure to a depth of 460 mm (18 inches)
- ❑ Accuracy: ±[(0.5% of measured value in mm) + 1 mm]
  - ➢ ±3.3 mm for 460 mm (18 inches) thick pavement
- ❑ Battery life: 8 Hrs. or 1,000 measurements
- ❑ Charging time: Zero to Full in 1.5 Hrs.
- ❑ Instrument weight with battery: 3 Kg (6.7 lb)

Power Point Slide 3:

OPERATING PRINCIPLE

Magnetic Imaging Tomography

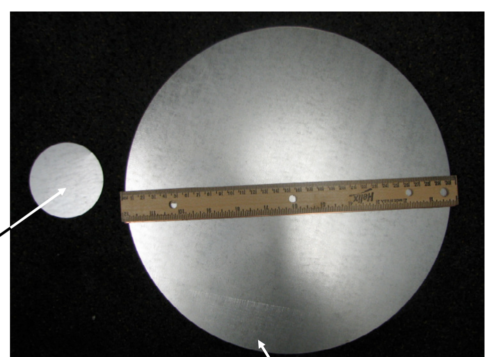
- ❑ Device generates magnetic field
- ❑ 4 sensors detect alterations caused by nearby metal objects
- ❑ Magnetic reflectors are placed on base layer prior to placement of PCCP

Power Point Slide 4:

SELECTION OF REFLECTOR DISCS

- ❑ Zinc clad steel discs used as magnetic reflectors
- ❑ Selection based on designed layer thickness

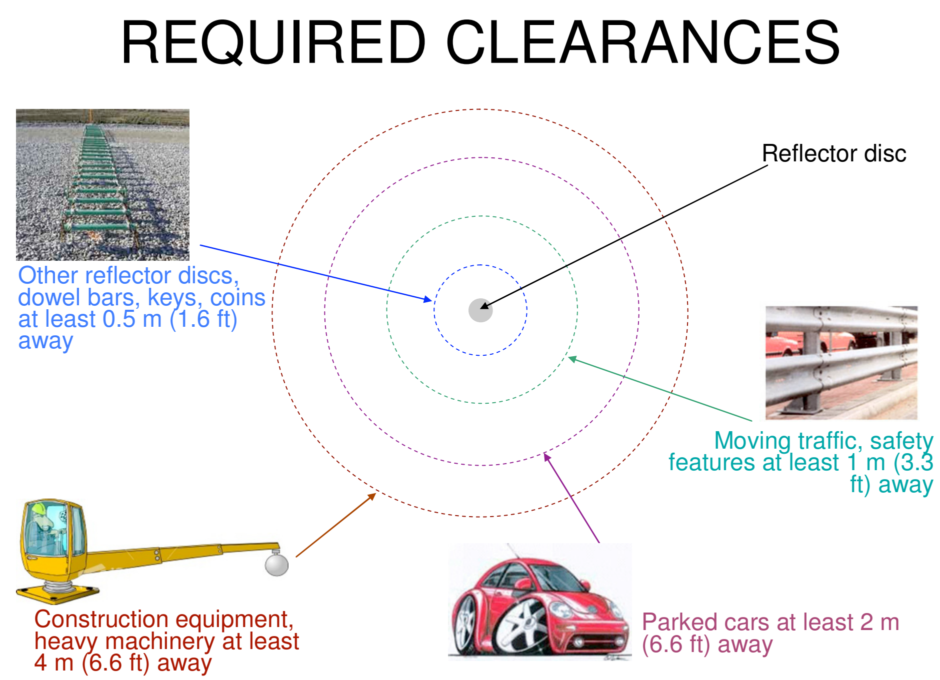
Disc A:
Diameter: 70 mm
Thickness: 0.6 mm



Disc B:
Diameter: 300 mm
Thickness: 0.6 mm

Design Pavement Thickness	Disc Diameter	Identifier	Calibration File
0 - 180 mm (0 to 7 in)	70 mm (2.7 in)	Disc A	MIT-R07
181 - 460 mm (7 - 18 in)	300 mm (11.8 in)	Disc B	MIT-R30

Power Point Slide 5:



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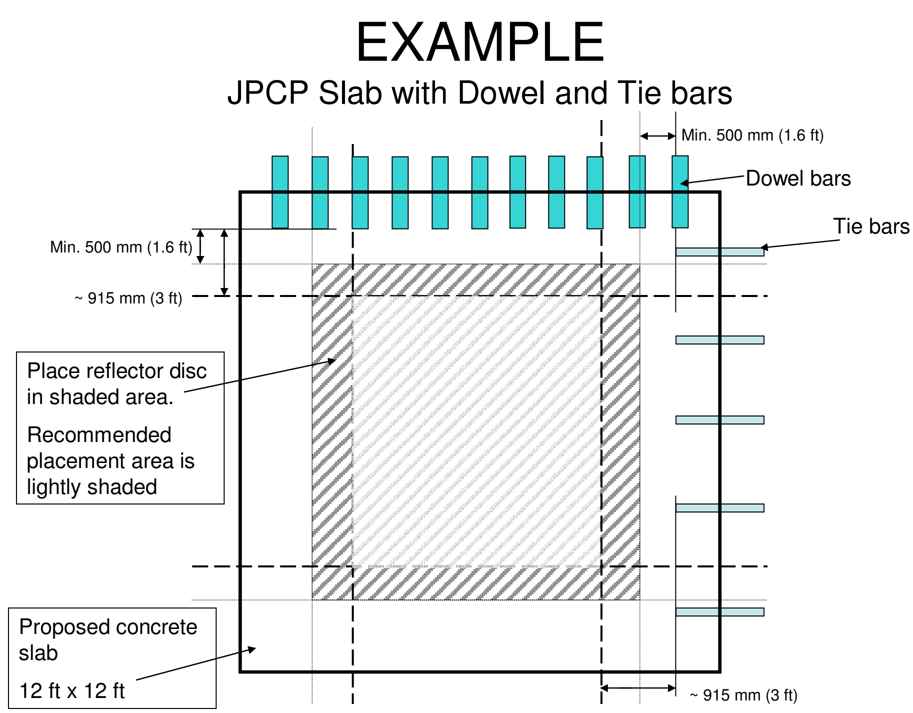
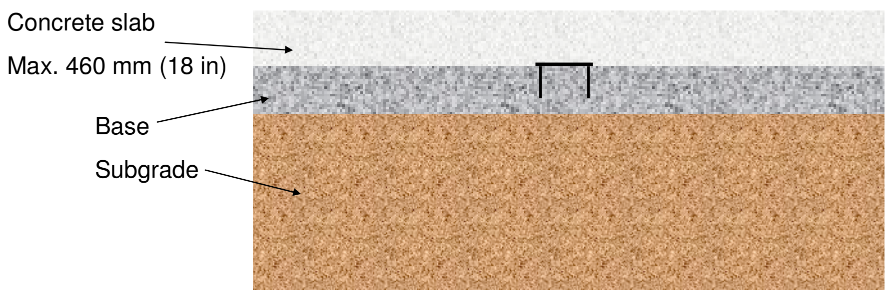


Power Point Slide 7:

PLACEMENT OF REFLECTOR DISCS

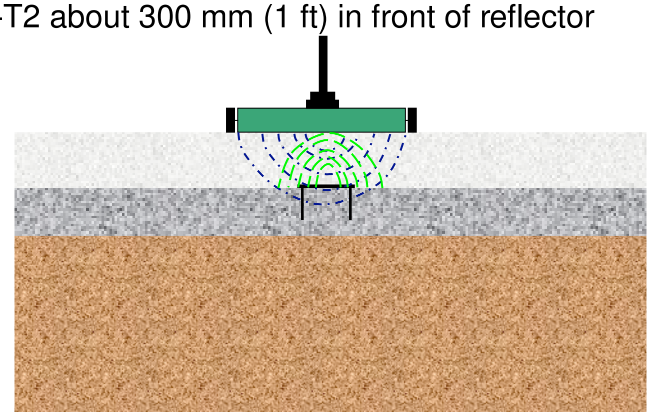
- ❑ Identify reflector disc type and placement location
- ❑ Place and secure reflector disc to base using PK nails or other fastening method



Power Point Slide 8:

MEASUREMENT OF SLAB THICKNESS

- ❑ Ensure proper clearance from metal objects
- ❑ Power up MIT-SCAN-T2; select appropriate configuration file.
- ❑ Place MIT-SCAN-T2 about 300 mm (1 ft) in front of reflector disc
- ❑ Roll over reflector disc at slow and steady pace until beep sounds



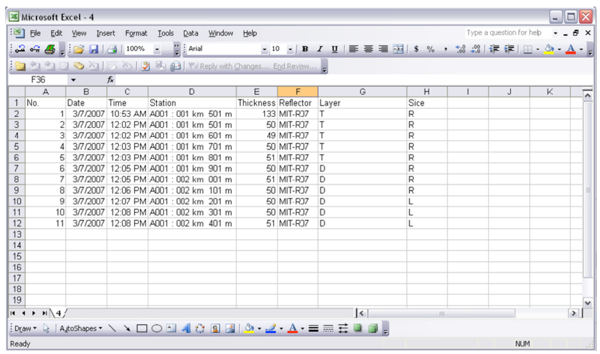
Power Point Slide 9:

RESULT

- ❑ Layer thickness is immediately displayed on screen in SI units

- ❑ ScanT software can be used to retrieve stored data from MIT-SCAN-T2 onto a computer in text format.

- ❑ The text file generated by ScanT can be imported into MS Excel



No.	Date	Time	Station	Thickness	Reflector	Layer	Sice
1	3/7/2007	10:53 AM	A001 : 001 km 501 m	133	MIT-RJ7	T	R
2	3/7/2007	12:02 PM	A001 : 001 km 501 m	50	MIT-RJ7	T	R
3	3/7/2007	12:02 PM	A001 : 001 km 601 m	49	MIT-RJ7	T	R
4	3/7/2007	12:03 PM	A001 : 001 km 701 m	50	MIT-RJ7	T	R
5	3/7/2007	12:03 PM	A001 : 001 km 801 m	51	MIT-RJ7	T	R
6	3/7/2007	12:05 PM	A001 : 001 km 901 m	50	MIT-RJ7	D	R
7	3/7/2007	12:05 PM	A001 : 002 km 001 m	51	MIT-RJ7	D	R
8	3/7/2007	12:06 PM	A001 : 002 km 101 m	50	MIT-RJ7	D	R
9	3/7/2007	12:07 PM	A001 : 002 km 201 m	50	MIT-RJ7	D	L
10	3/7/2007	12:08 PM	A001 : 002 km 301 m	50	MIT-RJ7	D	L
11	3/7/2007	12:08 PM	A001 : 002 km 401 m	51	MIT-RJ7	D	L