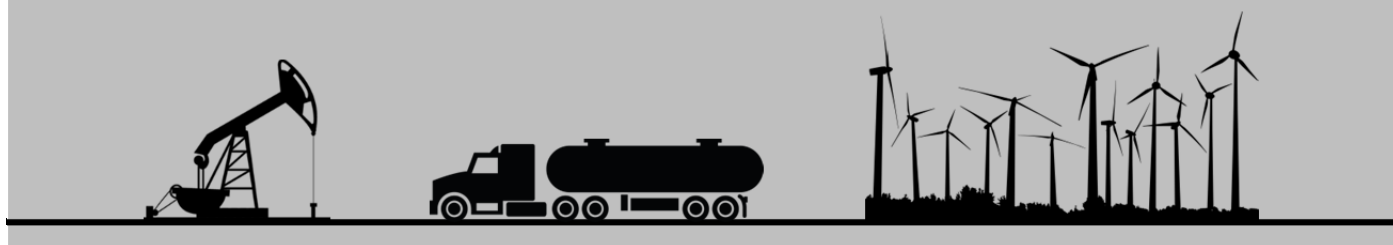


Project Level Pavement Evaluation Guidelines

Implementation Report IR-15-02



Prepared for Texas Department of Transportation
Maintenance Division

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INTRODUCTION

A significant number of roadways in Texas have been damaged by traffic associated with energy development. The repair of these roadways requires both routine maintenance and pavement rehabilitation. Routine maintenance operations used by the Texas Department of Transportation (TxDOT) to repair damaged roads in the energy sector are defined in other reports in this project. When more extensive pavement rehabilitation operations are used, it is often necessary to perform a more detailed pavement evaluation of the damaged roadway. This implementation report summarizes methods that have been used by the Texas A&M Transportation Institute (TTI) to evaluate the condition of existing pavements, provide recommendations for the selection of rehabilitation alternatives including mixture design for the various pavement layers, and conduct forensic analysis.

This basic approach has been used for corridor analyses for roadway sections in many districts and eight roadways evaluated for the Maintenance Division and Districts associated with energy sector repair projects. **Error! Reference source not found.** shows these roadways and their associated Technical Memorandum.

Table 1. Roadways Studied and Associated Tech Memos.

Roadway	County/District	Project Limits	Technical Memorandum No.
FM 99	Live Oak/Corpus Christi	US 281A to McMullen Co. Line	TM-14-01
FM 443	Gonzales/Yoakum	Curve at CR 368 (north of FM 533)	TM-14-02
FM 468	La Salle/Laredo	Cotulla	TM-14-03
SH 97	Gonzales/Yoakum	US 80 to US 183	TM-14-04
SH 349	Martin/Odessa	SH 176 to Dawson Co. Line	TM-14-05
SH 72	Karnes/Corpus Christi	SH 239 to FM 792	TM-14-06
US 87	Gonzales/Yoakum	Wilson to Dewitt Co. Line	TM-14-07
FM 624	LaSalle/Laredo	SH 16 to McMullen/LaSalle Co. Line	TM-15-01

EVALUATION GUIDELINES

Outlined in this implementation report is a relatively simplified approach for determining repair alternatives for roadways damaged by energy sector traffic. A five-step process is:

- Step 1 Project History.
- Step 2 Condition of Existing Pavement Structure and Roadside Features.
- Step 3 Verify Pavement Structure Thickness and Obtain Materials Samples.
- Step 4 Mixture Design.
- Step 5 Pavement Thickness Design.

Each of the steps is briefly discussed in this document.

STEP 1: PROJECT HISTORY

The history and geometric characteristics of the project being evaluated should be defined. The date(s) of construction, rehabilitation, seal coat (chip seal, slurry seal, fog seal, etc.) placement, and major maintenance operations should be defined. Lane width, shoulder widths, and pavement cross sections should be defined together with the types of materials used for the various pavement layers.

If possible, laboratory records should be obtained to define the subgrade soil characteristics. Items of interest include gradation, Atterberg Limits, and Triaxial Class. Other laboratory information may be available to define the characteristics of the subbase, base materials, and the asphalt bound materials.

As part of obtaining the project history files, it may be convenient to obtain current traffic and traffic projections for the roadway under study. This traffic information should not only contain average daily traffic but also estimates of Equivalent Single Axle Loads.

Off pavement features should be obtained as well. These include location and number of driveways, adjacent businesses, intersections, roadside drainage, side slopes, right-of-way widths, location of vegetation, sight distances, and other geometric features.

This first step is an important part of the process. Layer thickness and other geometric features will be confirmed with additional evaluation and testing as described below. Traffic volumes will be adjusted depending on the existing and anticipated energy related traffic using the pavement section.

STEP 2: CONDITION OF EXISTING PAVEMENT STRUCTURE AND ROADSIDE FEATURES

The condition of the existing pavement and roadside features needs to be evaluated with a number of different techniques. These are outlined below.

Step 2.1: Soil Classifications from USDA Maps

Soil classification maps can be obtained from the U.S. Department of Agriculture, Natural Resources Conservation Services Web Soil Survey at the following site: <http://websoilsurvey.nrcs.usda.gov/app/>. The general soil type is described (clay, silt, loam, sand, gravel, etc.) on this website. In many cases, the gradation (size distribution) and Atterberg limits of the native soils are available. Figure 1 shows a typical Conservation Services web map.

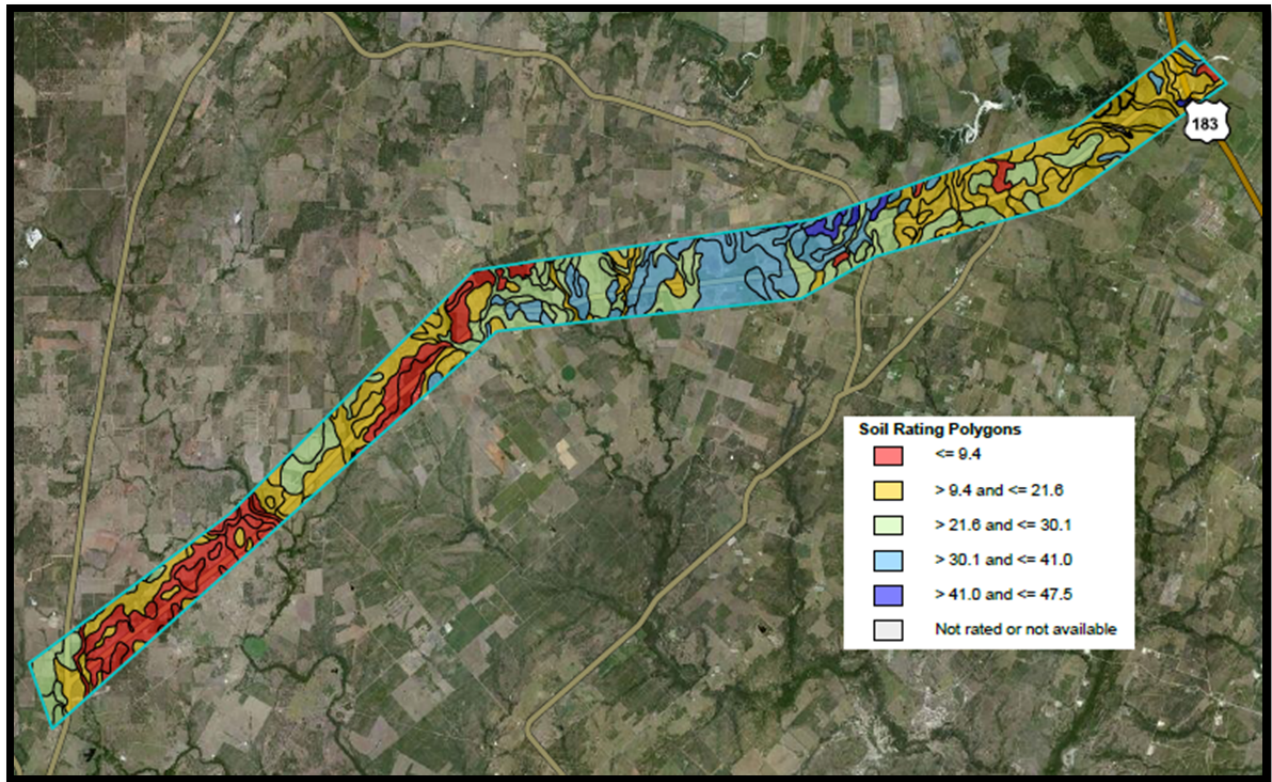


Figure 1. Example Plasticity Index Soil Map from Website.

Step 2.2: Visual Condition of the Pavement and Adjacent Area

A visual condition survey of the pavement should be made to define the type, extent, and severity of distress. TxDOT's pavement management visual evaluation method can be used. Types of distress of interest are rutting, raveling, bleeding, transverse cracks, longitudinal cracks, fatigue cracks, patching, and potholes.

Type (soil, flexible base, seal coat, hot mix, etc.) and condition of shoulders should be noted. Roadside drainage and transverse drainage feature condition should be recorded together with the general slope of the side slopes. Drive way conditions, intersection section sight distances, other geometric features, and roadside vegetation should be noted together with the width of right-of-way. Images of the roadway should be taken as part of this investigation.

As part of the visual condition and site survey, an opinion should be provided as to the cause of the distress that may exist on the roadway. In addition, an opinion of possible repair options should be formulated. These opinions will help define the type and extent of additional investigative efforts. Figure 2 shows an energy sector roadway with alligator cracking.



Figure 2. Alligator Cracking.

Step 2.3: Non-Destructive Testing

Non-destructive testing (NDT) of the pavement is a critical part of determining the condition of the existing pavement. The types of equipment available to the districts for NDT include:

- Ground Penetrating Radar (GPR) – depth of pavement layers and indication of moisture content.
- Falling Weight Deflectometer (FWD) – structural load carrying capacity of layers.
- Dynamic Cone Penetrometer (DCP) – structural load carrying capacity of layers.

Table 2 provides a general guide relating the type of pavement repair anticipated to the amount of testing that should be considered to evaluate the load carry capacity and condition of pavements. In general, GPR should be performed on all projects and FWD and DCP on those projects with structural load carrying problems. Field sampling and laboratory testing should be used on the more expensive rehabilitation projects. Figure 3 shows GPR and FWD equipment. Figure 4 shows an example of GPR output data.

Table 2 . Guides for NDT of Pavements.

Anticipated Maintenance/Rehabilitation	Pavement Condition Investigation	
	Investigation Level	Activities
Routine Maintenance	1	Historic records/visual condition/GPR (perhaps)
Preventive Maintenance	2	Historic records/visual condition/GPR/FWD/DCP (perhaps)
Rehabilitation	3	Historic records/visual condition/GPR/FWD/DCP and field sampling and testing



Figure 3. GPR and FWD Testing.

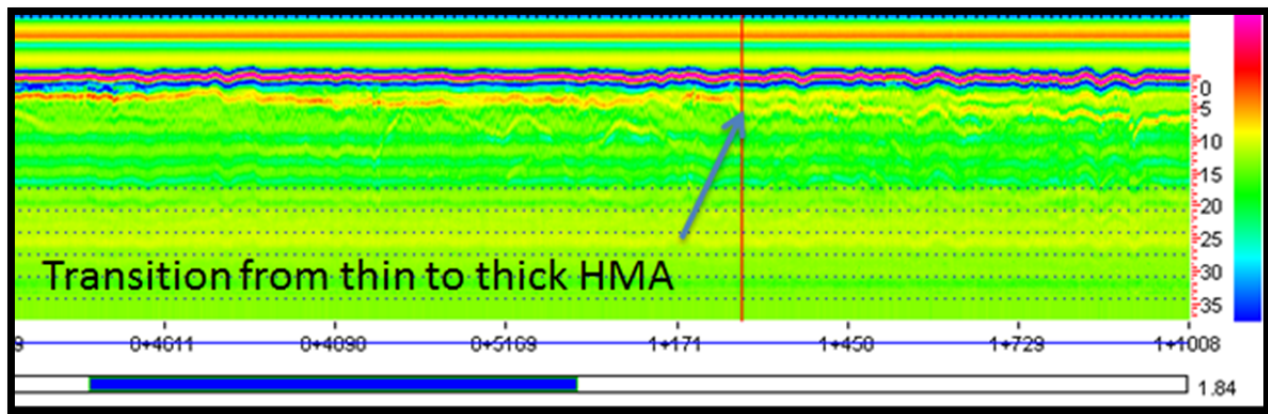


Figure 4. Example View of GPR Data.

Note that the GPR can be used to help determine thickness changes in the hot mix asphalt (HMA) layers and the presence of moisture area or layers in the pavement. FWD can estimate the load carrying ability (stiffness modulus) of different pavement layers.

STEP 3: VERIFY PAVEMENT THICKNESS AND OBTAIN MATERIALS SAMPLES

This step consists of identifying sample locations, obtaining samples of the pavement materials including the subgrade, and performing DCP measurements. Stratified random sampling should be used. GPR and FWD measurements can help locate areas of interest (stratify or identify particular area that are different in the pavement and then randomly sample these areas). If NDT data are not available, it is recommended that borings be made every 0.5 miles or less. Soil Conservation Service Maps can be used to help stratify or partition the roadway length. General guidelines for sampling and testing are:

- *Verification* locations should be selected at locations of non-typical GPR signature to verify the pavement structure and aid in interpreting the GPR signal. Verification locations are not used to generate materials for laboratory testing. Perform only one boring at verification locations and include the subgrade in the boring.

- *Sampling* locations should be selected from places with the typical pavement structure as based on GPR. Sampling locations serve to both verify the pavement structure and generate materials for laboratory testing. Multiple borings take place at sampling locations to generate sufficient quantities of materials for use in laboratory testing. At least one boring at sampling locations should go into the subgrade to fully validate the interpretation of the GPR signal at that location and enable collection of subgrade samples for laboratory testing.

At each verification location, perform the following:

- Collect a DCP profile from within the pavement. Figure 5 illustrates the DCP test and an example profile.
- If lack of edge support is suspected, move approximately 2 ft off the pavement edge and collect a DCP profile to a depth of interest as determined by the Engineer, which will typically be between 2 and 5 ft.
- If sufficient HMA is present, or if stabilized layers are present, collect a pavement core to verify their condition. Figure 6 illustrates how coring helped determine a stabilized layer was failing under the traffic loads.
- Collect material samples to verify the pavement structure. Use of augur as shown in Figure 7 generally generates material gradation similar to that obtained from a pavement recycler. Alternatively, the materials can be excavated as also shown in Figure 7.
- Collect subgrade soil samples for plasticity index, sulfates, and organic tests.

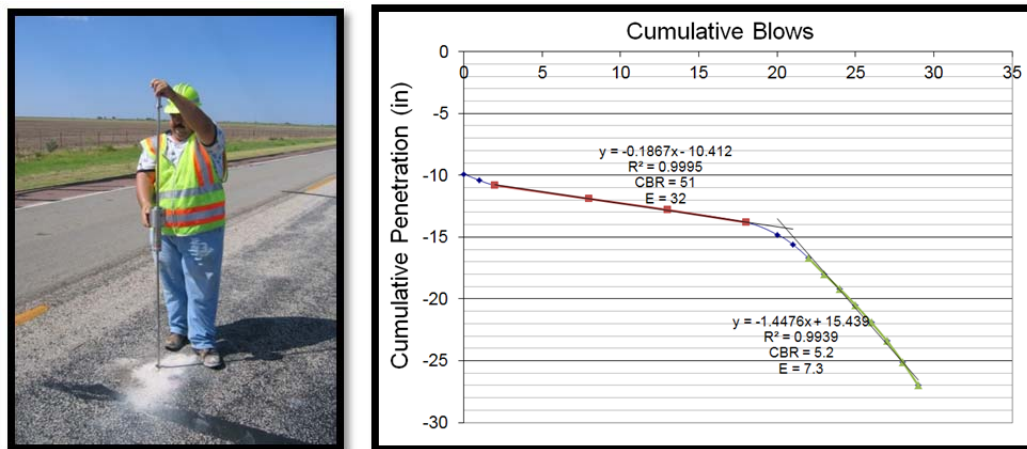


Figure 5. DCP Test and Example DCP Profile.



Figure 6. Coring to Help Determine Layer Condition.

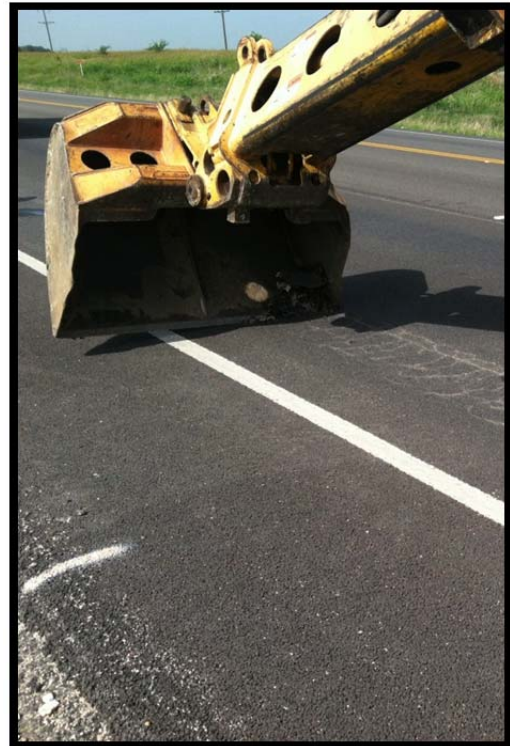


Figure 7. Material Sampling.

At the sampling location(s), perform the following:

- Collect a DCP profile.
- If lack of edge support is suspected, move approximately 2 ft off the pavement edge and collect a DCP profile to a depth of interest as determined by the Engineer, which will typically be between 2 and 5 ft.
- If sufficient HMA is present, collect a pavement core to verify the condition of the HMA.
- Collect material samples to verify the pavement structure down to the subgrade.
- Collect subgrade soil samples for plasticity index, sulfates, and organic tests.
- Use an auger to excavate existing materials that will be used in laboratory mixture design and maintain separate samples of RAP, flexible base, and subgrade.
- For cement stabilization design tests, the amount of material collected among all the sampling locations combined should be at least 15 five-gallon buckets of material.
- An additional 10 five-gallon buckets of material is required to perform a laboratory emulsion stabilization series of tests with two different emulsion levels.
- If lime or lime-fly ash treatment is being considered, an additional 5 five-gallon buckets of material is required for each level of lime or lime-fly ash treatment under consideration.

STEP 4: MIXTURE DESIGN

Materials that exist in the pavement structure can be recycled in-place using full depth recycling (FDR) methods. For narrow roadways, the existing pavement materials are typically pulverized and spread to provide a base material for both the 12 ft lanes and shoulders (typically 2 to 6 ft). Soil stabilizers are often used to stabilize these recycled materials. Portland cement, asphalt emulsions, foamed asphalt, lime, and fly ash are common stabilizers used on projects. TxDOT's *Guidelines for Modification and Stabilization of Soils and Base for Use in Pavement Structures* should be used to determine the appropriate or type of stabilizers for the FDR process. Availability and cost of additive should be considered.

A mixture design should be performed to determine the optimal method of using the in-situ materials:

1. For laboratory testing, reconstitute RAP and base materials in proportions representative of field conditions. However, limit RAP to no more than approximately 50 percent of the mixture for design purposes. If substantial particle breakdown is suspected beyond that produced in the field sampling program, consider increasing the amount of fine sands (passing the #40 and retained on the #200) in the reconstituted laboratory mixture 10 percent and decreasing the amount of coarse aggregate in the reconstituted laboratory mixture by 10 percent.
2. Perform Tex-117-E strength tests if considering options with no stabilization.
3. For stabilization options, use appropriate TxDOT Test Procedures to select the optimum stabilizer contents:
 - Portland cement treatment is a commonly investigated option. Cement content is based on the demonstrated strength and durability characteristics and includes satisfying the following criteria in 2. Note that most Districts will limit the Portland

cement content to about 2 percent to reduce the amount of transverse cracking caused by drying of the cement stabilized layer.

- Asphalt treatment with either emulsified asphalt or foamed asphalt, with or without a small percentage of cement, has become a popular option to provide increased strength while retaining some flexibility. Table 4 presents the recommended criteria for asphalt treatment. These criteria are similar to Wirtgen recommended design criteria. TTI is developing test methods and acceptance criteria for asphalt bound FDR processes.
- Fly ash and lime-fly ash are used in some districts for stabilization. Table 5 shows the lab requirements for these mixtures.
- Lime-treated mixtures can be appropriate for materials of elevated plasticity index and are tested in accordance with Tex-121-E. Table 6 shows the strength requirements for lime treatment.

Table 3. Laboratory Requirements for Cement Treatment.

Test	Spec Limits
Unconfined Compressive Strength (psi) (Tex-120-E)	175 min*
Retained Strength after Moisture Conditioning (Tex-120-E, 10 day capillary soak)	80% of 7-day Unconfined Compressive Strength

*Some Districts reduce this requirement to 150 psi.

Table 4. Recommended Laboratory Requirements for Asphalt Treatment.

Property	Test Procedure	Criteria
Min Indirect Tensile strength ¹	Tex 226-F	45 psi
Strain at Break in IDT	Tex 226-F	Report
Min (wet) IDT ²	Tex 226-F	30 psi
Tensile Strength Ratio		70% ⁴
Min Unconfined Compressive Strength ³	Tex 117-E, Part II	Report

- 1) Average of three specimens air dried overnight then oven dried at 104°F for 3 days.
- 2) Average of three specimens 24 hours under water.
- 3) Average of three specimens subjected to 10 days capillary moisture absorption before conducting UCS.
- 4) Average rainfall < 20 in./yr: > 50%.
Average rainfall 20–40 in./yr: > 60%.
Average rainfall > 40 in./yr: > 70%.

Table 5. Laboratory Requirements for Fly Ash and Lime-Fly Ash Treatment.

Test	Spec Limits
Unconfined Compressive Strength (psi)* (Tex-127-E)	150 min as subbase; Similar to cement treatment for base course
Unconfined Compressive Strength (psi)**	200 psi

*After conditioning per Tex-127-E over 17 days.

**After 6 days benchtop curing per project 0-5223 recommendations; not currently in TxDOT practice.

Table 6. Laboratory Requirements for Lime Treatment.

Test	Spec Limits
Unconfined Compressive Strength (psi) (Tex-121-E Part I)*	50 psi min as subbase; 150 psi for final course of base construction

*After conditioning per Tex-121-E over 17 days.

STEP 5: PAVEMENT THICKNESS DESIGN

Pavement thickness designs should be performed according to TxDOT's FPS design method. Thickness design tables developed during the conduct of this research project are available in an Energy Sector Brief and an implementation report. These thickness design tables are useful for determining the thickness requirements for deep patching methods and for shoulder widening operations when time is not available for detailed pavement design. These design tables may be useful for developing preliminary designs for the District-performed FWD projects.

Good estimates of expected traffic are necessary for structure pavement design. Traffic estimates can be obtained from TxDOT's Transportation Planning and Programming Division. These estimates may not always indicate traffic on energy sector roadways as the time gap between traffic measurements and reporting may be long as compared to the almost instant development of oil/gas drilling operations. This research project has developed a simplified method to estimate traffic on roadways based on number of wells likely to be served by the roadway. An Energy Sector Brief, implementation report, and research report are available that describe this relatively simple methodology.

Measured material properties or District Guidelines can be used as input into design methods. If the FPS 21 method is used, the Texas Triaxial design check in FPS should be used to reduce the risk the subgrade may fail prematurely.

Include in the design recommendations any additional considerations, such as:

- If possible, narrow pavements should be widened to a minimum of 28 ft.
- If using cement-treated base, consider incorporating microcracking to reduce shrinkage cracking the treated base.
- For sections with project-specific issues such as high plasticity index subgrades, steep front slopes, or trees close to the pavement edge, consider using geogrid reinforcement with a flexible base overlay to reduce the risk of future edge cracking.
- Specialized materials such as low-fines bases or surface mixes designed with the Overlay Test can also be included to reduce the risk of recurring reflection cracking problems.