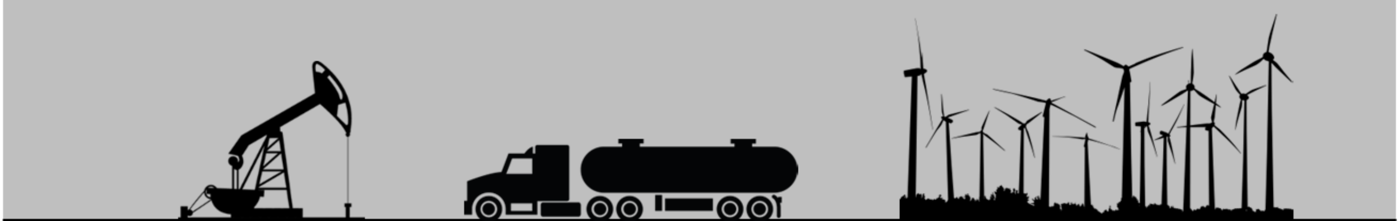
Maintenance and Rehabilitation Strategies For Repair of Road Damage Associated with Energy Development and Production

Implementation Report IR-15-03



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INTRODUCTION

From 10,000 to 24,000 oil and gas wells were permitted each year in Texas during the last decade (1). The rapid development of the state's oil and gas resources has required large volumes of heavily loaded trucks per well developed. This truck traffic has impacted the Texas Department of Transportation (TxDOT) Farm to Market (FM) road network as well as its trunk State Highway (SH) and United States (US) route designated highways. One of the major issues facing TxDOT maintenance forces is the repair of this impacted road network.

The maintenance and repair of the roadway system has required an ever increasing amount of TxDOT's money and workforce. Routine maintenance costs on these FM roadways have increased from typical values of from $500 to $1,500 per centerline mile to $35,000 to $45,000 per centerline mile due to the development of these wells (2). Repair costs for state and local government roadways have been estimated at 2 billion dollars per year (3). If financial resources are not available to repair the roadways the cost to the energy development industry due to rough roads (equipment damage and lower operating speeds) could be in the 1.5 to 3.5 billion dollar range annually (4). It is estimated that TxDOT will expend approximately $500 million annually for maintenance and rehabilitation of roadways impacted by oil and gas development each year for the fiscal years 2015 to 2017. Local governmental agencies are expected to expend over $200 million during this same fiscal year period.

This document is intended to assist the Districts with making investment decisions for the maintenance and repair of roadways impacted by oil/gas development and production (5).

OVERVIEW OF GUIDE

Figure 1 is a flow diagram of key steps used by Districts to select a method for repairing the pavement and shoulders on a roadway impacted by oil/gas development and production. The key steps in this process include:

1. Define geometrics of project-Step 1
2. Assess condition of the existing project-Step 2
3. Estimate traffic volumes and weights expected on the facility over its design life-Step 3
4. Determine the required pavement thickness (main lanes and shoulders)-Step 4
5. Consider project constraints including financial resources and workforce-Step 5
6. Choose maintenance or rehabilitation strategies including:
   a. Routine maintenance- Step 6
   b. Preventive maintenance- Step 7
   c. Rehabilitation-Step 8
7. Economic Analysis-Step 9
8. Selection of Alternative-Step 10

Additional details associated with these steps are provided below. References noted within the steps are provided for the background associated with the development of the guidelines. The flow chart in Figure 1 is intended to provide a checklist of actions to be taken when assessing the maintenance and rehabilitation needs of a particular roadway within the constraints imposed by budgets and labor availability.

PROJECT DEVELOPMENT STEPS

Geometrics-Step 1

The Farm to Market road system was originally developed for relatively low traffic volumes. Many of these roadways are 18 to 22 ft. wide without paved or improved shoulder materials. The widening of these roadways for oil and gas development and production generated traffic is a very high priority for TxDOT. The widths of the right-of-way and drainage structures are important considerations when determining maintenance and rehabilitation alternatives for selected projects. Widening roadways with narrow drainage structures without widening these structures presents a safety problem although the widening of drainage structures is costly.

Existing lane widths and shoulder widths and pavement thicknesses are inputs to structural design and widening considerations. The amount of materials for full depth reclamation (FDR) operations is directly dependent on the width and thickness of the existing travel lanes and shoulders.

The operational capacity and structural adequacy of existing intersections and driveways are part of the decision making process. Driveways are needed to provide access for oil and gas development. Intersections and driveways should be designed to allow for the wide turning radii of large haul units. Turning lanes and widening on both sides of the road may be necessary. Driveways and curb and gutter features provide safe and efficient access to roadways adjacent to businesses.

Pavement Condition-Step 2

The condition of the existing pavement and shoulder needs to be defined. The effort expended to determine pavement condition depends on the available budget and labor needs of the project. If sufficient funds are available for rehabilitation, then a higher level of effort should be used to define the pavement conditions. Reference 6 provides details relative to determining pavement condition.

Three levels that can be used to determine pavement condition are defined below. Note that each successive level includes the level or levels above it. Reference 6 provides more details for the activities described below.

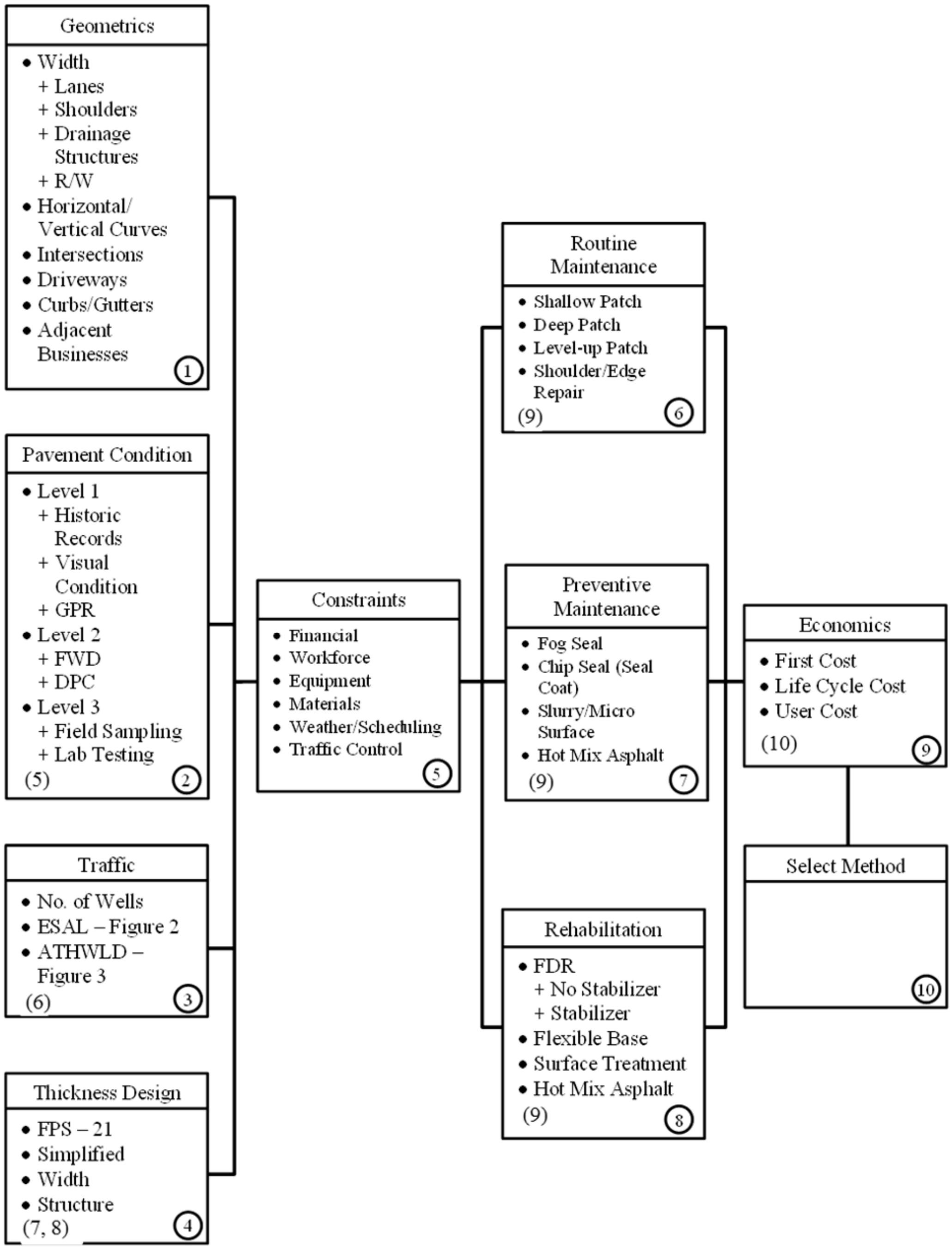

Figure 1. Key Steps for Selecting Maintenance and Rehabilitation Strategies.

Level One

This approach is appropriate when time constraints and pavement conditions indicate that structural problems are likely not present. If records indicate a rapid increase in truck traffic or the visual survey shows indications of deep rutting or structural cracking or the GPR survey indicates excessive moisture in the structure, a Level Two evaluation may be in order.

As-built plans and maintenance management records should be reviewed to determine the uniformity of the project. These records will define the geometry of the travel lanes and shoulders and the cross-section. This will help narrow the types of treatments that have been placed on the roadway section and identify the location of pavement problems.

The pavement condition will help determine the cause of pavement distress. TxDOT's Pavement Management Information System (PMIS) data and a visual condition survey should be conducted. The type, extent and degree of the distresses should be identified.

Ground penetrating radar (GPR) may be used to determine the thickness and moisture conditions of the pavement layers along a section of highway. The GPR can operate at highway speeds, data reduction is fast, and the output is relatively easy to interpret. It can be used to verify historical records indicating the types and depths of the various layers of the pavement along a project.

Level Two
Level Two activities, in addition to the activities for Level 1, involve the use of a Falling Weight Deflectometer (FWD) and/or Dynamic Cone Penetrometer (DCP). This information is used to determine the load capacity of the pavement as well as the strength of individual layers. Both devices require traffic control for data collection. The FWD provides information on the overall load carrying ability of the pavement structural section as well as an indication of the load carrying ability of each pavement layer. The DCP will help determine the relative stiffness of the base, subbase and subgrade materials.

Level Three
Level Three activities include those from Levels One and Two and field sampling and laboratory testing of the existing pavement materials. Samples of the subgrade, subbase, base and surfacing materials are obtained and laboratory tests are performed to determine their load carrying ability. Pavement rehabilitation alternatives can be determined from this information as described in Reference 5.

Recommended Levels of Investigation
Recommended levels of investigation associated with anticipated maintenance/rehabilitation activities are provided in Table 1.

Table 1. Guide to Level of Investigation According to Anticipated Corrective Action.

Anticipated Maintenance/Rehabilitation	Pavement Condition Investigation	
	Level	**Activities**
Routine Maintenance	1	Historic records/visual condition & perhaps GPR
Preventive Maintenance	1 & 2	GPR/FWD & perhaps DCP
Rehabilitation	1, 2 &3	Field sampling and laboratory testing

Traffic-Step 3
Traffic growth in oil and gas areas has been very fast and nearly impossible to capture with conventional methods. Quick estimates of traffic flow may be obtained from TxDOT Traffic Planning and Programming (TP&P) using traffic maps for statewide planning or PMIS. However, these do not account for the rapidly changing nature of oil and gas development. Some

Districts have performed their own studies which allow for more accurate estimates of existing traffic volumes. These estimates are used to forecast future traffic. Other methods have been developed that allow for traffic estimates depending upon the number of wells being developed in a given area.

Special studies have been conducted to estimate the number and weights for the development and production of oil and gas from single wells. A systematic approach (7, 8) was taken to determine the traffic loads for pavement design (ESALs) in connection with the development and operation of typical horizontal, hydraulically-fracked oil and gas wells in the Eagle Ford Shale, Permian Basin, and Barnett Shale regions of the state. The general process to determine ESALs for individual wells involved determining the typical number of trucks involved in various phases of a well's 20 year operation, estimating the axle weight distribution through a study of weigh-in-motion data and video logs, applying the axle weight distribution data to the trucks involved in well development, and arriving at the total number of ESALs for a typical well. Due to differences in well development and the type of drilling, different ESALs/well were developed for the Eagle Ford Shale, Permian Basin, and Barnett Shale formations.
Recent studies (7, 8) have greatly improved the understanding of the traffic loads required to complete and operate wells in different parts of the state. While the traffic dissipates with the distance from the well, the amount of concurrent traffic on routes dictates that pavement design be based assuming no dissipation. In other words, the amount of wells in a given area should generate a steady flow over the affected pavements so that dissipation is minimized.

Thickness Design-Step 4

Pavement rehabilitation practices associated with the repair of oil and gas roadways typically involve some type of pavement strengthening operations performed by maintenance forces or maintenance or construction contracts. These include deep patches, widening of the roadway or rehabilitation of the entire roadway section. Determining the structural thickness is a part of selecting a maintenance or rehabilitation alternative for a particular roadway. A simplified catalog approach to pavement design has been developed.

The types of rehabilitation operations currently used by TxDOT Districts are summarized in reference 9. Rehabilitation on oil and gas affected roads often takes the form of full-depth reclamation with strengthening, and the reclaimed material may be either stabilized or non-stabilized. Once the FDR operations have been completed either a new flexible base can be applied with either a two-course surface treatment (2CST) or an asphalt concrete (AC) overlay for the wearing course (9). This is referred to as a 4-layer pavement (surface, flex base, FDR, and subgrade). In some instances, a 3-layer pavement (surface, FDR, and subgrade) may be used with a stabilized FDR (cement, asphalt emulsion, or foamed asphalt) used as a base course with no flexible base and with a 2CST or an AC overlay surface.

A simplified method of structural design has been developed to provide quick estimates for pavement layer thickness. Two design catalog tables (4-layer and 3-layer pavement) were prepared using TxDOT's FPS21 program and mechanistic models. Since the 4-layer pavements have flex base, these designs were also subjected to a Triaxial Classification check to preclude subgrade shear failure. Typical Texas material properties were used to develop the design catalogs.

Constraints-Step 5

Selection of maintenance and rehabilitation alternatives are based on a number of engineering related factors as well as a wide variety of other considerations such as financial resources, workforce availability, equipment availability, materials availability, weather conditions, scheduling and traffic control.

Financial constraints include the amount of money available for maintenance and rehabilitation operations as well as the source of the money. Financial constraints are typically the most significant limitations in selecting maintenance and rehabilitation alternatives. For example, certain types of allocated funding can only be used for rehabilitation and not routine maintenance.

Many districts have experienced a reduction in the available workforce for maintenance operations which limits the routine maintenance operations that can be performed on roadways. Districts heavily impacted by oil and gas development and production have made arrangements to use maintenance crews from other districts. The arrangements for sharing of personnel across district lines have been made at the District Level as well as a statewide program.

Some districts do not have key equipment necessary to efficiently repair damaged roadways. Cold milling machines and pulverizers/stabilizers are examples that are no longer available in certain Districts. Equipment sharing across District lines has been practiced often across the state.

Weather conditions can influence the type of maintenance or rehabilitation selected for a roadway. Pulverization, stabilization, placing new base course and placing a surface course should not be scheduled during cold/inclement weather unless emergency conditions exists. Seasonal use constraints of different materials should be considered in the decision making process.

Traffic control during construction is difficult on narrow FM roadways and constrained right-of-ways. The maintenance and rehabilitation alternatives selected for repair of the roadway should consider traffic control issues. Typically traffic must be allowed on the project as a minimum in one direction at a particular time. Complete closure of roadways for short durations should be considered if access to landowners is available. Roadway closing will allow for the maintenance/rehabilitation alternative to be completed in a relatively short period of time and result in a safer work zone. Notification of adjacent land owners and business is an important part of this approach.

Maintenance

Data collected to this point in the decision tree will dictate the level of maintenance required; conversely, the level of maintenance selected may allow a lower level of data needed to make effective decisions depending upon the condition of the roadway.

Routine Maintenance-Step 6

TxDOT's "Maintenance Planning Activities & Associated Function Codes" can be used as a general guide for selection of routine maintenance activities. Detailed descriptions of these activities can be located in the Maintenance Division's Code Chart 12 Guidelines. Reference 9 provides a summary of current maintenance practices used by the Districts impacted by oil and gas development and production according to the following methods:

1. Shallow patch
2. Deep patch
3. Level-up patch
4. Shoulder/edge repair

Routine maintenance operations are mostly used to repair localized pavement problems to improve safety, provide a smoother riding surface and to delay more extensive maintenance or rehabilitation. The use of patches and shoulder/edge repair techniques have been effective in delaying major maintenance or rehabilitation on roadways that are in reasonably good condition.

Routine maintenance techniques have been largely ineffective on roadways that are in poor condition and that carry high traffic volumes. Routine maintenance operations under these conditions should be viewed only as temporary repairs and more extensive maintenance or rehabilitation scheduled as funding and weather permit.

Preventive Maintenance-Step 7

This work is done to prevent the major deterioration of a pavement. Preventive maintenance techniques are seal coats (fog, chip and slurry or microsurfacing) and thin hot mix asphalt overlays.

For oil and gas impacted roadways, the condition of the pavement is often in such poor condition that preventive maintenance techniques are not beneficial. Many of the impacted roadways are structurally deficient and preventive maintenance techniques do not significantly improve the structural load carrying ability.

The use of slurry seals or microsurfacing on roadways that are structurally deficient should be approached with caution. Seal coats are able to tolerate higher deflections and strains to failure than most slurry seals and microsurfacing materials.

The use of thin overlays (less than 2 inches) on roadways subjected to energy sector traffic should be approached with caution. High deflections on roadways will cause premature cracking of the hot mix asphalt under moderate to heavy traffic. In areas of relatively soft subgrades (south Texas) overlays may need to be 4 inches and greater. In areas of the state where subgrade strength is higher (west Texas), overlays in the range of 3 to 4 inches may be suitable. Thin overlays should not be placed on structurally deficient pavements.

Rehabilitation-Step 8

The types of rehabilitation operations are summarized in Reference 9. Typical sections involve the use of full depth recycling (FDR) to pulverize and widen the existing roadway, followed by the placement of a flexible base and asphalt bound surface. Full depth recycling (FDR) operations are sometimes performed without the addition of a stabilizer. The use of portland cement at a level of 2 to 3 percent (cement modified) with the full depth recycling operation is common. Some Districts have used asphalt emulsions or foamed asphalt as binders in full depth recycling (FDR) operations.

The materials produced from the pulverization and in some case the addition of stabilizers can be used as subbase materials. The depth of the recycling to produce the subbase will depend on the amount of granular and asphalt bound materials existing on the roadway, the depth of pulverization and the extent of widening. Some districts add new flexible base prior to stabilization to form this layer. Flexible base is typically placed on top of the FDR layer in order to provide the desired thickness. The use of portland cement stabilization of the base course is discouraged if a surface treatment or thin hot mix asphalt layers are to be applied. Disintegration of the portland cement stabilized material may occur under high truck traffic volumes and loads.

Surface treatments or hot mix asphalt surfaces are typically used. A double surface treatment often is used on top of the new flexible base material. It is recommended that a minimum of 4 inches of hot mix asphalt be used in the south Texas Districts. Thickness designs for rehabilitation activities should be determined by TxDOT’s FPS-21 thickness design method. A simplified method is available in this document (Step 4) if sufficient time or personnel are not available to perform the FPS design.

Economic Analysis-Step 9

First cost and life cycle cost should be calculated for several maintenance and rehabilitation options. Budget, work force availability, equipment availability, materials availability, traffic control and weather or scheduling may eliminate some of the maintenance and rehabilitation alternatives under consideration.

Ideally three to four maintenance/rehabilitation alternatives should be considered in this step of the process. This reference also includes a methodology for determining and incorporating “road user costs” into the economic analysis.

Selection of Alternative-Step 10

This step of the process selects the maintenance or rehabilitation alternative to be used on a specific project. If life cycle costs for various maintenance or rehabilitation alternatives are within 10 percent of each other, the selection of the final alternative should be based on project considerations and District experience.

Prior to selecting the maintenance/rehabilitation option, it is useful to review the process shown in Figure 1 and the notes and calculations developed to support the decision

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