ENERGY-SECTOR BRIEF

Maintenance Division, Roadway Asset Management

16-05 PAVEMENT THICKNESS DESIGN CATALOG WITH STABILIZED BASE LAYER

From 10,000 to 24,000 wells were permitted in the state of Texas over each of the last 15 years. Most of these wells have been developed and are producing. The development of each well typically requires from 1,000 to 2,000 heavy truck movements. Most of these trucks are at or near legally loaded limits. Truck traffic is also generated over the production life of the well as vehicles are required to service the well, re-complete the well and haul salt water and crude oil as well and liquid mixtures from the well.

This increased truck traffic has significantly impacted the Texas Department of Transportations (TxDOT) Farm to Market (FM) road network and some of its trunk State Highway (SH) and United States (US) designated highways. Many of these roadways have experienced considerable damage (Figures 1 and 2) and require major rehabilitation.

Repair of these severely damaged roadways requires that the roadway be significantly strengthened. Additional thickness and load carrying capacity is required. TxDOT and the Texas A&M Transportation Institute have developed pavement thickness designs for typical roadways in the energy development area of Texas. These designs have been reduced to design curves and further simplified by the development of design tables or catalogs. The intent of this simplification is to provide a tool for maintenance forces to quickly determine reasonable thicknesses of pavement layers when placing "deep patching", "shoulder widening and repair" and localized pavement strengthening operations. The TxDOT Flexible Pavement Design System (FPS-21) should be used for larger projects that require more extensive repairs. This design catalog is not intended to replace the FPS-21 design method for these larger projects often performed as construction contracts or maintenance funded larger projects.

Additional background information describing the details associated with the development of these "pavement thickness design catalogs" is available in Implementation Report IR-15-01 "Pavement Design Catalog Development for Pavements in Energy Affected Areas of Texas" and Research Report RR-14-03 "Pavement Design Catalog Development for Pavements in Energy Affected Areas of Texas". These documents are available on the TxDOT Maintenance Division (MNT) SharePoint site at https://txdot.sharepoint.com/sites/division-mnt/SitePages/Home.aspx

BACKGROUND

Many of the Farm to Market impacted roadways are narrow (18 to 22 ft.) and have minimum thicknesses of flexible base course material and often are surfaced with multiple surface treatments and seal coats that have built-up over the years. These roadways were not structurally designed to carry the increased traffic generated by the oil and gas development and production. Repair of these roadways typically involves the pulverization of the existing asphalt bound surfacing materials and a portion of the flexible base. These pulverized materials are used to widen the pavement to a minimum total width of 28 to 32 ft. As part of this pulverization and widening process, additional flexible base material may be added and the blended materials modified with portland cement, asphalt emulsion, foamed asphalt or other stabilizers. Two course surface treatments or hot mix asphalt are typically used as surfacing materials (Figure 3).

Figure 1. Fatigue Cracking.

Figure 2. Major Damage Requiring Rehabilitation.

The additional flexible base is used to increase the thickness of load carrying materials as well as adjust the gradation of existing flexible base materials as they may be of poor quality.

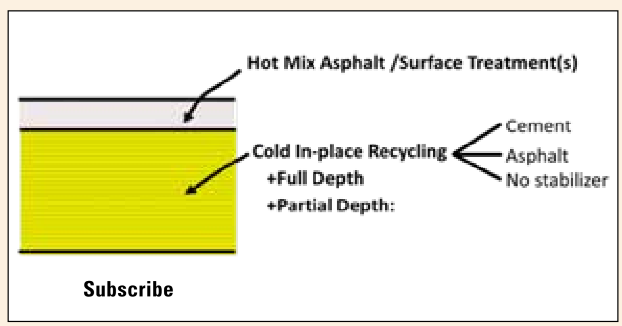

Figure 3. Typical Three Layer Pavement Section.

TxDOT currently uses the Flexible Pavement Design System (PFS-21) to select the type of materials and their thicknesses to satisfy the existing traffic and subgrade conditions on a given roadway segment. The Texas Triaxial design method is then used as a design check to insure that the subgrade and other unstabilized materials will not fail in shear (bearing capacity type of failure) and rut under the action of traffic. Note that the Texas Triaxial design check was not used for the development of the three layer system as the original method development did not consider stabilized pavement layers.

These design tools were used to determine design tables or catalogs for four and three layer pavement sections. The pavement cross section of the three layer pavement section consists of the subgrade soil, a stabilized layer containing pulverized materials generated from the in-place materials and added flexible base materials and a surface treatment or hot mix asphalt surface (Figure 3). This Energy Sector Brief summarizes the pavement structural section requirements associated with the three layer system.

PAVEMENT THICKNESS DESIGN INPUTS

The key parameters selected by TxDOT and TTI for input into FPS-21 to develop the thickness designs are available in the references previously identified. Typical materials properties were selected as well as other design inputs to FPS-21. These material resilient modulus values are conservative. Hot mix asphalt thicknesses were selected as 2, 4 and 6 inches.

Performance models are used to predict fatigue cracking in the asphalt bound mixture and rutting in the subgrade in the FPS-21 software. Numerous thickness design curves were developed from the FPS-21 software. These curves were converted into design tables or catalogs (Table 1). The design tables are used to select the thickness of the stabilized base course layer.

Table 1. Energy Sector Pavement Design Catalog for 3-Layers (Surface, FDR, Subgrade) Pavement. Numbers in table are FDR Base thickness in inches.

Traffic, ESAL	<0.5 Million				0.5-1.5 Million				1.5-3.0 Million				3.0-4.0 Million				4.0-5.0 Million				>5.0 Million
EF #Wells	<10				10-90				90-200				200-270				270-340				
PB #Wells	<20				20-110				110-250				250-340				340-440				
BS #Wells	<40				40-210				210-470				470-640				640-810				
EAGLE FORD (Subgrade Modulus < 7 ksi)																					Use Formalized Design
Surface	2CST	2" AC	4" AC	6" AC	2CST	2" AC	4" AC	6" AC	2CST	2" AC	4" AC	6" AC	2CST	2" AC	4" AC	6" AC	2CST	2" AC	4" AC	6" AC	
Stiff Base	8	6	6	6	9	7	6	6	10	8	6	6	-	8	7	6	-	8	7	6	
Med. Base	9	7	6	6	11	9	6	6	11	9	7	6	-	10	8	6	-	11	9	6	
Soft Base	11	9	7	6	14	11	9	7	15	12	10	8	-	14	12	9	-	15	12	0	
MEDIUM SUBGRADE (Subgrade Modulus < 7 – 15 ksi)																					
Stiff Base	7	6	6	6	8	7	6	6	9	7	6	6	-	8	6	6	-	8	6	6	
Med. Base	8	6	6	6	10	8	6	6	10	8	6	6	-	9	7	6	-	10	7	6	
Soft Base	10	8	6	6	13	10	8	6	13	11	9	6	-	12	10	7	-	13	10	7	
PERMIAN																					
Stiff Base	6	6	6	6	7	6	6	6	7	6	6	6	12	7	6	6	-	7	6	6	
Med. Base	7	6	6	6	8	7	6	6	8	7	6	6	12	8	6	6	-	8	6	6	
Soft Base	8	6	6	6	10	8	6	6	10	8	6	6	12	9	7	6	-	10	7	6	

Not Recommended – Premature Failure Expected

EF #Wells = Number of wells serviced by road in the Eagle Ford Shale

PB #Wells = Number of wells serviced by road in the Permian Basin

BS #Wells = Number of wells serviced by road in the Barnett Shale

Stiff Base: E_{FDR} = *300,000 psi*

Medium Base: E_{FDR} = *200,000 psi*

Soft Base: E_{FDR} = *100,000 psi*

E = *Resilient Modulus*

FDR = *Full Depth Recycling*

2CST = *two course surface treatment*

AC = *asphalt concrete or hot mix asphalt (HMA) or warm mix asphalt (WMA)*

EXAMPLE

An existing roadway, 1 inch of multi-seal coats with 6 inches of existing flexible base needs rehabilitation.

Project Located in South Texas	Subgrade Modulus of 7,000 psi
50-90 wells to be served by roadway	0.5 to 1.5 million ESAL's
Two course surface treatment used as surfacing material	

The required thickness of a medium stiffness, stabilized base course thickness is 11 inches.

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