ENERGY-SECTOR BRIEF

Maintenance Division, Roadway Asset Management

16-04 PAVEMENT THICKNESS DESIGN CATALOG WITH FLEXIBLE 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 and other 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 or other stabilizers. Additional flexible based is typically added to the top of the pulverized and chemically modified layer. Two course surface treatments or hot mix asphalt are typically used as surfacing materials (Figure 3) 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 1. Fatigue Cracking.

Figure 2. Major Damage Requiring Rehabilitation.

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. These design tools were used to determine design tables or catalogs for four and three layer pavement sections. The pavement cross section of the four layer pavement section (Figure 3) consists of the subgrade soil, a pulverized and chemical modified layer generated from the in-place materials (this layer is not always modified with a chemical), added flexible base material and a surface treatment or hot mix asphalt surface. The pavement cross section for the three layer system consists of the subgrade soil, a stabilized layer containing pulverized material generated from the in-place materials and added flexible base materials and a surface treatment or hot mix asphalt surface. This Energy Sector Brief summarizes the pavement structural section requirements associated with the four layer system.

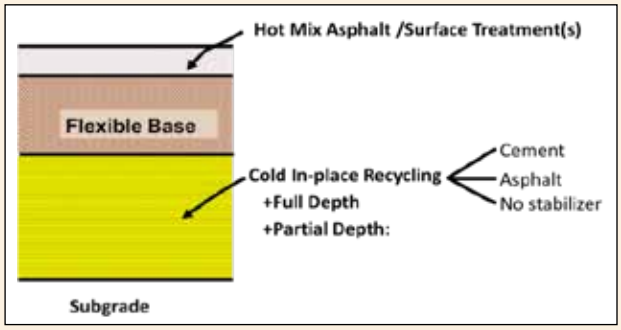

Figure 3. Typical Four Layer Pavement Section.

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 very conservative. Six and eight inch thicknesses were the only values selected for the subbase thickness (pulverized existing surface and existing base). These thicknesses were based on current practices. Hot mix asphalt thicknesses were selected as 4, 6 and 8 inches as layer thicknesses in the 2 to 3 inches range exhibit poor performance on these heavy, truck traffic roadways when placed on unstabilized base courses.

Performance models are used to predict fatigue cracking in the asphalt bound mixture and rutting in the subgrade in the FPS-21 software. The Triaxial design checks were performed to prevent rutting types of failures. Numerous thickness design curves were developed from the FPS-21 software and the Triaxial design checks. These curves were converted into design tables or catalogs (Table 1).

Table 1. Energy Sector Pavement Design Catalog for 4-Layers (Surface, Flex Base, FDR, Subgrade) Pavement. Numbers in table are Flexible 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)																
Surface	2CST	4" AC	6" AC	2CST	4" AC	6" AC	2CST	4" AC	6" AC	2CST	4" AC	6" AC	2CST	4" AC	6" AC	
CM 6"	11	7	6	12	8	6	12	9	7	-	-	7	-	-	7	
CM 8"	9	6	6	10	6	6	10	7	6	-	-	6	-	-	6	
AE/NS 6"	12	8	6	12	9	7	12	10	7	-	-	8	-	-	8	
AE/NS 8"	12	6	6	12	7	6	12	10	7	-	-	8	-	-	8	
MEDIUM SUBGRADE (Subgrade Modulus < 7 – 15 ksi)																
CM 6"	7	6	6	10	6	6	12	6	6	-	-	6	-	-	6	
CM 8"	6	6	6	7	6	6	10	6	6	-	-	6	-	-	6	
AE/NS 6"	12	6	6	12	6	6	12	6	6	-	-	6	-	-	6	
AE/NS 8"	12	6	6	12	6	6	12	6	6	-	-	6	-	-	6	
PERMIAN (Subgrade Modulus > 15 ksi)																
CM 6"	6	6	6	6	6	6	10	6	6	12	-	6	-	-	6	
CM 8"	6	6	6	6	6	6	10	6	6	12	-	6	-	-	6	
AE/NS 6"	6	6	6	9	6	6	12	6	6	12	-	6	-	-	6	
AE/NS 8"	6	6	6	8	6	6	12	6	6	12	-	6	-	-	6	

Use Formalized Design

- *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*

CM 6"= *Cement Modified FDR, 6 inches thick*

CM 8"= *Cement Modified FDR, 8 inches thick*

AE/NS 6"= *Asphalt Emulsion FDR or Non-Stabilized FDR, 6 inches thick*

AE/NS 8" = *Asphalt Emulsion FDR or Non-Stabilized FDR, 8 inches thick*

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 50-90 wells to be served by roadway	Subgrade Modulus of 7,000 psi
	0.5 to 1.5 million ESAL's
Existing materials pulverized and portland cement modified	6 inches thick
Two course surface treatment	used as surfacing material

The required new flexible base course thickness is 12 inches.

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