ENERGY-SECTOR BRIEF

Maintenance Division, Pavement Asset Management

14-2: Recommended Shoulder Widths

This brief documents the findings of pavement analyses used to determine recommended shoulder widths and corresponding roadway widths for pavements with high traffic volumes and/or heavy truck loads.

The findings show that predicted surface deflections govern the minimum paved shoulder width. The recommended width of the shoulder ranges from 2 ft for stiff subgrades to 4 ft where there are weak subgrades. The recommended roadway surface widths are 28 ft in the case of stiffer subgrades and extend to 32 ft for weaker subgrades. Paved shoulders and surface widths exceeding these requirements could further enhance roadway safety and protection against moisture infiltration.

Background

Many of the pavements impacted by oil/gas energy development and production activities are on narrow two-lane Farm-to-Market roads with paved widths of 18 to 20 ft. Considering that the distance between side-view mirrors ranges from 10 to 10½ ft on heavy trucks used by the energy sector, the outside tires can run at the pavement edge or off the edge when trucks traveling in opposite directions pass each other.

The unpaved shoulder offers little lateral support for this edge-loading condition. The lack of lateral support, coupled with the thin pavement structures typically found on these roads, results in breakage of the pavement edge under repeated heavy load applications. The loss of edge material becomes progressive and can lead to loss of the pavement if left uncorrected. Moreover, road safety is diminished because further narrowing of the paved width increases the risk of collisions between oncoming vehicles. Thus, engineers consider pavement widening when evaluating strategies for maintaining the serviceability of routes impacted by oil/gas energy development and production activities. This summary presents an analysis of paved shoulder width requirements to investigate just how much widening might be needed.

The Challenge

The analysis of paved shoulder width requirements considered the current methodology used by the Texas Department of Transportation (TxDOT) to design flexible pavements. This methodology, as implemented in TxDOT's Flexible Pavement System (FPS) program, is based on modeling the pavement as a linear-elastic layered system, with each layer characterized by a modulus and a Poisson's ratio. This model assumes pavement layers that extend infinitely in the horizontal direction with applied loads acting within the layered system (i.e., no edge loading). In reality, roadways are of finite width. This project examined the variation of the predicted pavement response at different load offsets from the pavement edge to determine paved shoulder width requirements that minimize the effect of the edge boundary and maintain consistency with the interior loading assumption used in FPS.

A shoulder exhibiting signs of degradation due to traffic loads.

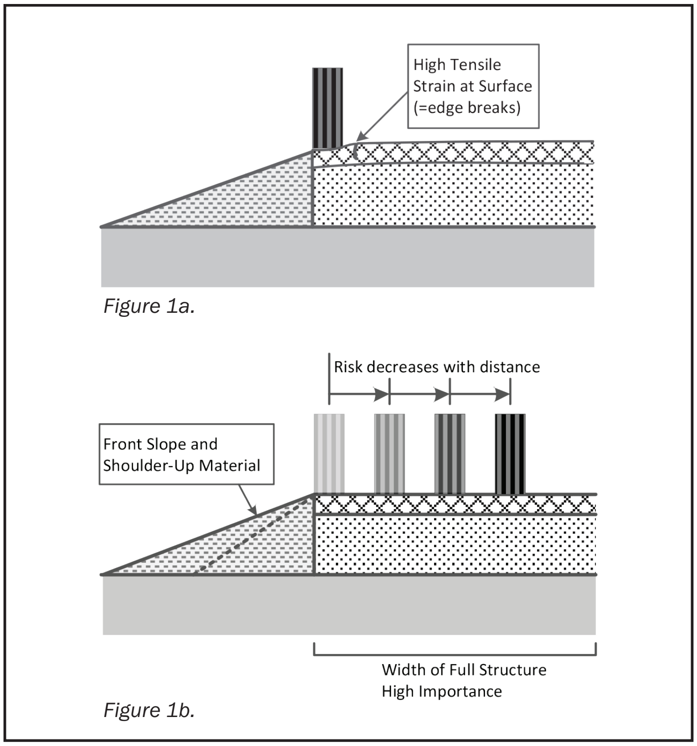
To analyze shoulder width requirements, this study used a two-dimensional finite element program to predict the variation in pavement response as the load is positioned at different offsets from the pavement edge. This analysis covered a representative range of flexible pavements that included different material types and thicknesses.

Findings

1. The study evaluated several performance-related pavement response parameters to investigate the effect of placing traffic loads near the edge of paved surfaces.

2. Performance-related pavement response prediction parameters included surface deflection, subgrade vertical compressive strain, horizontal tensile strain at the bottom of cement modified layers, horizontal tensile strain at the bottom of hot mix asphalt layers, and shear strains in the hot mix asphalt layer.

3. Pavement surface deflection was the most sensitive pavement prediction parameter. For stiff subgrade conditions, the deflection of the pavement at the edge of a pavement as compared to 3 to 4 ft from the pavement edge is within 5 percent. For soft subgrade conditions, the deflections at the edge of a pavement as compared to 5 to 6 ft from the pavement edge is within 5 percent.



When loads are at the edge of the pavement, there is a significant risk for cracking at the top of the structure. In this case, it acts like a cantilever and bends downward placing a high tensile stress in the surface materials as shown in Figure 1a. As the load moves away from the edge as shown in Figure 1b. the critical horizontal stress moves to the bottom of the underlying bound layers (HMA or cement modified). The location of the critical stress defines how a pavement will develop cracking or distress.

4. Pavement performance is more dependent on the stiffness of the subgrade soil (soft versus weak) than the thickness of the base course.

5. Pavement performance is more sensitive to base course thickness than stiffness of the base course.

6. Stiff base course materials are more effective in improving performance on weak subgrade as compared to strong subgrades.

7. The use of hot mix asphalt as compared to surface treatments, the use of stiff base course materials (stabilized or higher quality flexible base), and/or increasing the thickness of hot mix asphalt or stiff base material allow the use of narrower shoulders.

The photo above shows a dangerous failure at the edge of the pavement.

8. Pavement strain calculations indicate that thin hot mix surface (2 inches plus or minus) will not perform well when used on narrow shoulders.

9. The use of thicker sections of hot mix asphalt (4 inches plus) and the use of thicker layers of portland cement modified base course material (6 inches plus) allow the use of narrower shoulders.

10. In lieu of changing the surface materials from a one course surface treatment to 2 inches of hot mix asphalt, consider increasing the flexible base thickness or using a stabilized base of sufficient thickness.

11. Side slopes ranging from flat to 1:3 and 1:6 did not significantly affect the magnitude of the deflection and other pavement response parameters.

12. From a practical point of view (cost, width of drainage structures, width of right-of-way, etc.) shoulders in the range of 2 to 4 ft are recommended depending on subgrade strength and traffic volumes.

13. Wider paved shoulders are needed on roadways subject to high traffic volumes and/or heavy truck loads.

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