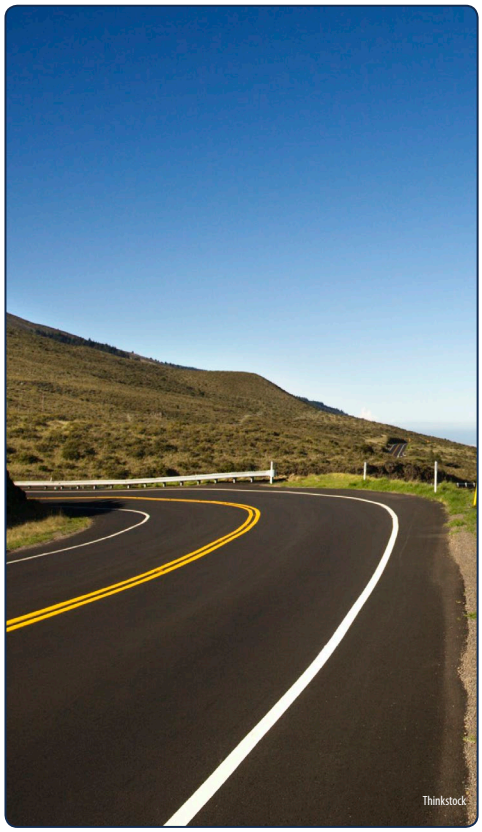
Texas Department of Transportation's Methodology for Selecting Curves to Receive High Friction Surface Treatments and Other Safety Improvements



What was the safety issue, problem, or gap?

The Texas Department of Transportation (TxDOT) explored ways to improve horizontal curve safety by identifying whether geometric improvements or pavement friction restorations would best address safety concerns associated with a particular curve. TxDOT wanted to maximize the investment's benefit and minimize the need for additional improvements.

What were the key challenges that needed to be addressed before the new practice could be implemented?

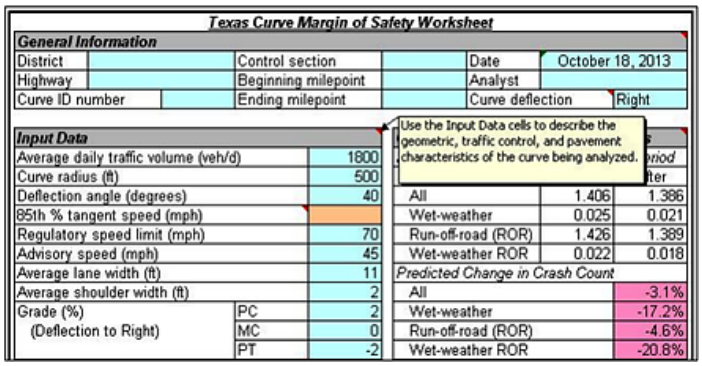
Though it was anecdotally recognized, the interaction and effect among geometric factors (e.g., radius, superelevation rate, and deflection angle), vehicle speed, and available pavement friction were not completely understood. As such, recognizing how these features worked together – or in contrast to one another – would aid practitioners in selecting a safety countermeasure tailored to the site.

Describe the new practice:

TxDOT, in conjunction with the Texas A&M Transportation Institute (TTI), developed a tool to assess the "margin of safety" for a particular horizontal curve. The tool is known as the Texas Curve Margin of Safety, or TCMS.

"Margin of safety" is the "friction demand subtracted from friction supply;" in other words, the available roadway friction subtracted by the amount of friction needed by a vehicle to remain on the roadway at the horizontal curve sections. TxDOT wanted to specifically compute and compare the margins of safety with respect to three safety improvements: high friction surface treatments (HFST), superelevation corrections, or curve realignment.

FRICTION **SUPPLY** – FRICTION **DEMAND** = **MARGIN OF SAFETY**



Texas Curve Margin of Safety Worksheet

General Information					
District		Control section		Date	October 18, 2013
Highway		Beginning milepoint		Analyst	
Curve ID number		Ending milepoint		Curve deflection	Right

Use the Input Data cells to describe the geometric, traffic control, and pavement characteristics of the curve being analyzed.

Input Data				
Average daily traffic volume (veh/d)		1800		
Curve radius (ft)		500		
Deflection angle (degrees)		40	All	1.406
85th % tangent speed (mph)			Wet-weather	0.025
Regulatory speed limit (mph)		70	Run-off-road (ROR)	1.426
Advisory speed (mph)		45	Wet-weather ROR	0.022
Average lane width (ft)		11	*Predicted Change in Crash Count*	
Average shoulder width (ft)		2	All	-3.1%
Grade (%)	PC	2	Wet-weather	-17.2%
(Deflection to Right)	MC	0	Run-off-road (ROR)	-4.6%
	PT	-2	Wet-weather ROR	-20.8%

TCMS Screenshot

TCMS, shown in screenshot, is a spreadsheet tool that considers roadway and curve geometry, regulatory and predicted vehicle speed, traffic volumes, and other factors to estimate side friction demand at key points along a curve. By combining the side friction demand estimates with the knowledge of existing pavement friction values, the margin of safety is assessed for the point of curvature (PC), midpoint, and point of tangent (PT) by inputting the actual and proposed curve conditions. The proposed conditions may indicate a:

1. Variation in the pavement friction, indicating the application of HFST as a potential solution.
2. Variation in superelevation, indicating superelevation corrections as a potential solution.
3. Variation in curve radii, indicating curve realignment as a potential solution.

The resulting margin of safety allows users to understand which safety improvement is most likely to yield better results for the site.

Additionally, TCMS allows the analyst to examine crash trends on a curve of interest to determine if the observed crash count is in line with what would be predicted for a similar curve. Occurrence of a higher-than-expected crash frequency can suggest that the curve needs to be treated.

Key accomplishments, including roadway safety improvements:

This method can be used to prioritize proposed treatments at a set of curve sites, identify points along the curve where roadway departure crashes due to pavement friction deficiencies are most likely to occur, and evaluate several treatment alternatives besides HFST. In particular, the provision of enhanced pavement friction, increasing superelevation, and increasing curve radius through realignment are designed to increase the curve's margin of safety, either by increasing side friction supply or by reducing side friction demand. [1]

The TCMS tool has allowed TxDOT to confidently assess horizontal curve safety within the State and increase HFST application with 125 installations planned. HFST is now included in TxDOT's Highway Safety Improvement Program (HSIP). The TCMS tool also allows TxDOT to identify the critical points of a curve that need treatment by identifying the margin of safety at the PC, midpoint and PT.

What technical and/or institutional changes resulted from the new practice?

TCMS can be used to estimate the initial effectiveness of a proposed surface treatment plus its decrease in effectiveness over time if the analyst provides data about the life-cycle friction performance of the treatment. With the help of the tool, TxDOT was able to develop the following guidance to ensure that roadway user benefits and life-cycle costs are considered:

- A proposed surface treatment must be determined for its sufficiency to meet the margin of safety requirements for a given curve before it is installed.
- It must be determined whether, or how often, the surface treatment will need to be replaced so the needed margin of safety will continue to be available.

This study also resulted in a guidance material, the TCMS spreadsheet, to help practitioners assess the need and the potential safety benefit of curve pavement improvements, including HFST.

What benefits were realized as a result of the practice?

The evaluation tool enabled agencies to foresee the benefits of HFST and other horizontal curve safety improvements before their application. Given the installation and maintenance costs of HFST, and the treatment not being recommended for pavements with limited structural integrity, it is crucial to optimize site selection and application of HFST.

TxDOT is increasing its efforts to install friction treatments on curves, particularly through their HSIP. By using the TCMS tool, TxDOT will be able to target curves that stand to benefit the most from the application of a treatment, thereby making most efficient use of the limited safety improvement funds. TxDOT will also be able to identify the critical points of a curve that need treatment by identifying the margin of safety at the PC, midpoint and PT.

[1] Michael Pratt et al. *Evaluating the Need for Surface Treatments to Reduce Crash Frequency on Horizontal Curves.* Report No. FHWA/TX-14/0-6714-1. May 2014.

FOR MORE INFORMATION

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