CENTER FOR TRANSPORTATION RESEARCH

TxDOT Project: 0-6995

Multifunctional Centerline Rumble Strips for Highway Condition Improvement during Winter Weather Operations

Presenters: Md Al Amin, Vivek Turkar, Michael Rung and Dr. Raissa Ferron (rferron@mail.utexas.edu)

Department of Civil, Architectural, and Environmental Engineering

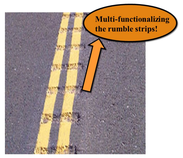
THE UNIVERSITY OF TEXAS AT AUSTIN

Introduction

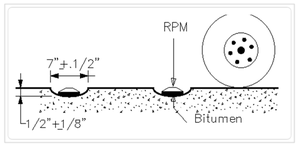
- Raised Pavement Markers (RPMs) are delineation devices that are used to guide drivers, especially at night and in poor weather conditions.
- Snowplowing results in the loss of RPMs in northern Texas. This impairs visibility, especially at nighttime; furthermore, replacement of RPMs results in additional time, labor and resource costs.
- The goal of this project is to investigate alternative approaches to produce an economical, snow-plowable resistant RPM system in existing rumble strips. This poster summarizes the results of an approach based on novel installation methods of commercially available RPMs.

Methodology

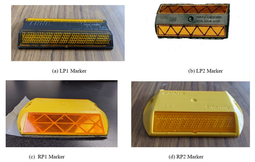
- Most of the two way two lane highways in Texas use centerline milled rumble strips.
- This study evaluated an innovative approach in which RPMs are installed in the groove of milled rumble strips to achieve a cost effective and snowplow resistant configuration with the goal of reducing the loss of RPMs during winter weather operations.



Multi functional rumble strips



RPM embedded in rumble strips



Selected RPMs from TxDOT approved list

The study consisted of *3 phases* to evaluate the physical condition and visibility performance of the RPMs:

- **Phase 1: Laboratory retroreflectivity analysis**

  Laboratory photometric studies were performed to gain insight into the critical depth that the RPMs should be installed in the groove of the rumble strips.

- **Phase 2: Pilot test section performance evaluation**

  The rumble insert markers were installed in an asphalt pavement test section. Rumble strips were grooved into the pavement using TxDOT specifications prior to installing the RPMs . The physical condition of the markers was evaluated after each dry snowplow run.

- **Phase 3: Field study performance evaluation on in-service highway segments**

  The RPMs that performed the best in phase 2 were installed in existing rumble strips on 2 in-service highway sections. The performance of the installed rumble insert markers after multiple cycles of real-event snow plowing operations was evaluated.

Results and Discussions

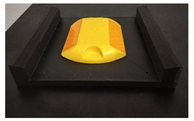
Phase-1 Laboratory Retroreflectivity Analysis

- ***Purpose:*** Determine the feasible height of the RPMs in rumble strips
- The test setup consisted of a 50 ft (15 m) photometric range with a CCD (Charged-Coupled Device) camera.

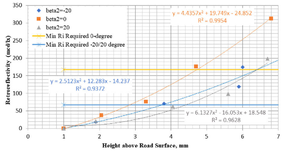
Results and Discussions

Phase-1 Laboratory Retroreflectivity Analysis

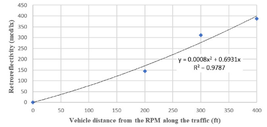
- A goniometer was controlled by software applying the input angle sets (ASTM E 808-01).
- The test RPMs were placed in a 3D printed groove mimicking the rumble strip.



RPM in lab setup



Variation in retroreflectivity with height for RPM in 3D printed groove, with minimum retroreflectivity value for different angle sets shown by horizontal lines



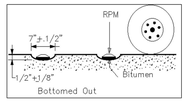
Variation in retroreflectivity of markers at critical height with the distance of vehicle from the marker

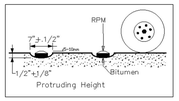
- ***Outcome:*** protruding height of 7 mm

Phase 2: Pilot Test Section Performance Evaluation

- ***Purpose:*** Investigate the role of installation method and RPM insert geometry on snowplow resistance
- 76 RPMs were installed on a 800 foot long test road at UT Austin's research campus following two installation methods.

Test roadway section





Installation Scheme

Snowplow

- 5 dry plow runs were conducted in order to evaluate the snowplow resistance of RPMs in rumble strips.
- ***Outcome:***
  - LP1, LP2 and RP1 markers were selected for field studies on in-service highways.
  - The bottomed out installation method was selected for use in the field.

Phase 3: Field Study Performance Evaluation on In-Service Highway Segments

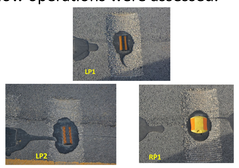
- **Objective:** Investigate the performance of the RPMs in rumble strip under real-life conditions.
- The selected RPMs were installed in existing rumble strips on 2 in-service highway segments in northern Texas
- Physical condition and nighttime visibility after multiple cycles of snowplow operations were assessed.

Wichita Falls (US-380)
- Pavement- existing
- AADT – 1078
- % Truck – 16.9

Marker	Number Installed	Adhesive
Regular Profile-1	200	Bitumen
Low Profile 1	100	Bitumen
Low Profile 2	100	Bitumen

Amarillo (SL-335)
- Pavement: Resurfaced
- AADT – 8000
- % Truck - 6

Marker	Number Installed	Adhesive
Regular Profile-1	97	Epoxy
Low Profile 1	100	Bitumen
Low Profile 2	70	Bitumen

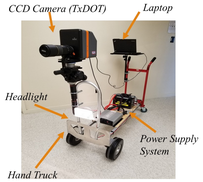


Results and Discussions

Physical condition assessment after multiple cycle of snowplowing

- The physical condition of the installed RPMs in rumble strips was evaluated after snowplowing.
- Rumble strips at the Wichita Falls test site were deeper than the TxDOT specification and rumble strips at the Amarillo test site were shallower than TxDOT specification.

Physical Assessment of RPMs



Field Retroreflectivity Equipment

Percentage of Good RPMs

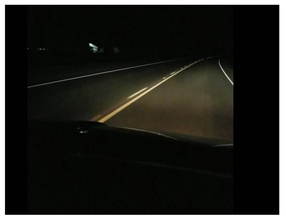
Wichita Falls (US 380)	
	% Good Markers
LP1	100%
LP2	100%
RP1	95%
Amarillo (SL 335)	
	% Good Markers
LP1	83%
LP2	72%
RP1	42%

Nighttime visibility assessment of RPMs in rumble strips

- Nighttime visibility of RPMs in rumble strips was evaluated both quantitatively and qualitatively.
- Retroreflectivity measurement equipment was developed for field site use per ASTM E-1710. This was used to measure luminance of RPMs with an observation angle of 1.05^0 and entrance angle of 88.76^0 from 100 ft.

Quantitative visibility of RPMs

Wichita Falls (US 380)	
	Avg. Retroreflectivity (mcd/lx) at 100 ft
LP1	6.1
LP2	9.1
RP1	53.1
Amarillo (SL 335)	
	Avg. Retroreflectivity (mcd/lx) at 100ft
LP1	5.2
LP2	3.7
RP1	8.1



Qualitative Visibility at Amarillo (SL 335)

Qualitative Visibility at Wichita Falls (US 380)

Qualitative visibility assessment revealed that from 500 ft 4 to 6 RPMs were visible

Conclusions

- The approach of embedding commercial RPMs into rumble strips is an effective method to reduce losses and damage to RPMs during snowplow operations.
- Both epoxy and bitumen are suitable adhesives for embedding commercially available RPMs into rumble strips.
- The depth of the rumble groove plays a significant effect on visibility and snowplow resistance of the RPMs.
- RPMs in rumble strips are able to delineate the centerline promisingly.

Aknowledgements

- The research team would like to thank the Texas Department of Transportation (TxDOT) for sponsoring the study.
- Special thanks to TxDOT district offices and personnel who extended their help and assistance.

collaborate. innovate. educate.