

TRB Straight to Recording for All

Rumble Strips/Stripes: Practices and Challenges

NCHRP Synthesis Report 490: Practice of Rumble Strips and Rumple Stripes

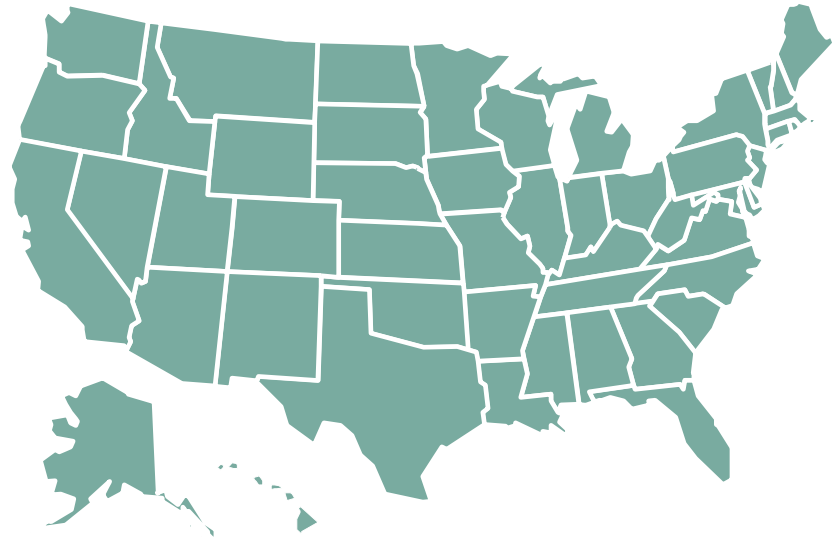
**NCHRP Project 20-05,
Topic 46-13**



NCHRP is a State-Driven Program

- Sponsored by individual state DOTs who

- Suggest research of national interest
- Serve on oversight panels that guide the research.

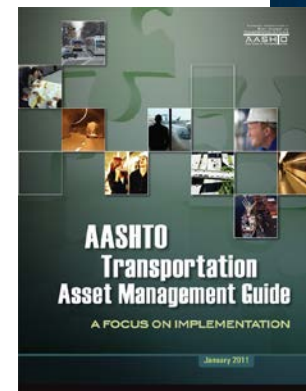
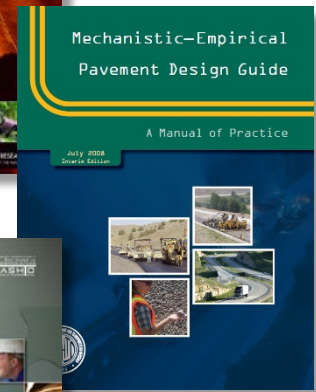
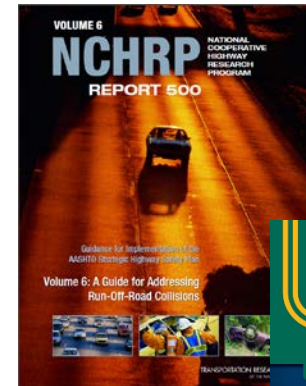


- Administered by TRB in cooperation with the Federal Highway Administration.



Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, syntheses
- Can be applied in planning, design, construction, operations, maintenance, safety, environment



Today's Speaker & Presentation

- *Dr. Omar Smadi*

Director, Center for Transportation Research and Education, Iowa State University

Consultant for this Synthesis Study

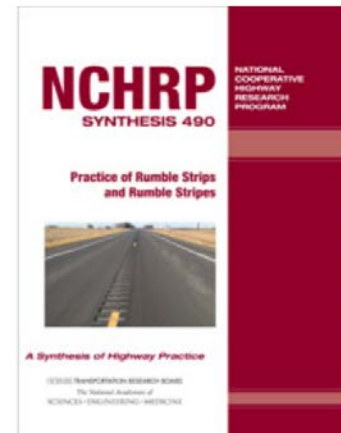
- *“Rumble Strips/Stripes: Practices and Challenges”*



Practice of Rumble Strips and Rumble Stripes (NCHRP Synthesis 46-13) (NCHRP Synthesis Report 490)

Rumble Strips/Stripes: Practices and Challenges

Omar Smadi
CTRE/Iowa State University



Synthesis Objectives

- Rumble designs: patterns, locations, pavement types and widths
- Expected safety benefits: crash modification, white-out/packed snow/fog driving, wet night driving
- Roadside noise
- Impacts on bicycle community
- Public affairs/outreach-education, public involvement, DOT/agency responses, etc.
- Maintenance/durability issues: winter, pavement preservation

Synthesis Panel

- DUANE F. BRAUTIGAM
- JAMES W. BRYANT, JR., *TRB*
- ERIC T. DONNELL, *The Penn State*
- PATRICK GALARZA, *New York State DOT*
- KENNETH E. JOHNSON, *Minnesota DOT*
- TRACIE J. LEIX, *Michigan DOT*
- ROBERT G. “BOB” PAPPE, *Oregon DOT*
- CATHERINE M. SATTERFIELD, *FHWA*
- ABDUL ZINEDDIN, *FHWA*

Key definitions:

Shoulder Rumble Strip is a longitudinal safety feature installed on a paved roadway shoulder near the outside edge of the travel lane. It is made of a series of milled or raised elements intended to alert inattentive drivers (through vibration and sound) that their vehicles have left the travel lane. (FHWA definition).

Shoulder Rumble Stripe is a special type of shoulder rumble strip placed directly at the edge of the travel lane with the edge line pavement marking placed through the line of rumble strips.

Center Line Rumble Strip is a longitudinal safety feature installed at or near the center line of a paved roadway. It is made of a series of milled or raised elements intended to alert inattentive drivers (through vibration and sound) that their vehicles have left the travel lane. (FHWA definition).

Centerline Rumble Stripe is a longitudinal safety features at or near the centerline and created when the center line pavement marking is placed over the center line rumble strip.

Key definitions:

Bicycle Gap Pattern (gap plus cycle) consists of a gap clear of rumbles (typical between 10 to 12 feet) and then a cycle of rumbles (typical 40 to 60 feet).

Intermittent Gap is a gap created between continuous application of the rumble line, for pre-determined situations such as intersections, major driveways, bridge decks, etc...

Tactile is the vibration induced in the motor vehicle by the rumble strips which can be referred to as the “tactile warning”.

Audible is the noise generated as the motor vehicle tires pass over the rumble strip thus providing an audible warning to the motorist.

Key definitions:

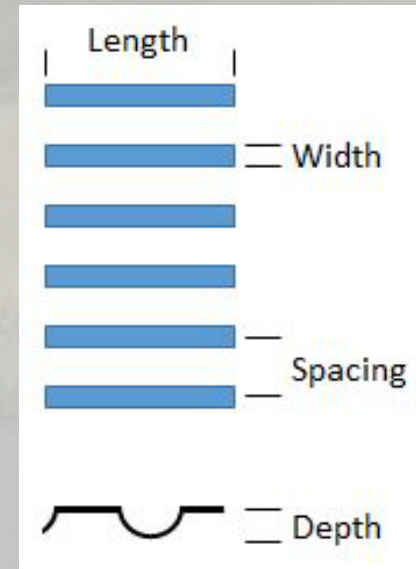
Rumble Strip and Stripe Dimensions

Length: Dimension of the rumble strip measured lateral to the travel way. This dimension is sometimes referred to as the transverse width.

Width: Dimension of the rumble strip measured parallel to the travel lane.

Spacing: Distance measured between rumble strips patterns. Typical terms used to describe this dimension are on-center spacing, spacing on-center, center-to-center spacing, or simply “spacing.”

Depth: Dimension is the vertical distance measured from the top of the pavement surface to the bottom of a rumble strip pattern. This distance refers to the maximum depth of the cut or groove.



Synthesis Survey

- **Six Categories Investigated:**

- State DOT general rumble practices
- Roadway selection criteria
- Design and installation
- Maintenance practices
- Benefits
- Issues

Results from the Survey (41 states responded)

Use of Rumble Strips

Does your agency use rumble strips?	Number of Agencies	Percent
Yes	41	100%
No	0	0%

41 responding agencies

Does your agency have a written policy/guidelines concerning the application of rumble strips?	Number of Agencies	Percent
Yes	37	90%
No	4	10%

41 responding agencies

Rumble Strip Installation Practices

Type of Roadway	None	Left Shoulder (median)	Center Line	Right Shoulder (outside)
Urban multilane divided highways	59%	37%	5%	41%
Urban multilane undivided highways	73%	7%	12%	27%
Urban two-lane roads	76%	5%	15%	22%
Rural multilane divided highways	5%	88%	5%	95%
Rural multilane undivided highways	5%	39%	59%	85%
Rural two-lane roads	5%	39%	71%	85%

41 responding agencies

Factors Influencing Shoulder Rumble Strip Installation

Influencing Factor	Number of Agencies	Percent	Minimum Required Values/Explanation
Shoulder Width:	37	93%	Between 2 and 8 feet
Speed Limit:	25	63%	Between 40 and 55 mph with the most common answer at 45 mph
Other (please specify):	19	48%	Factors include: Lane width, bicycle presence, home locations, roadway type
Pavement Condition:	18	45%	Good condition
Crash frequency/rate:	11	28%	
Pavement Type:	10	25%	Mostly asphalt and no treated surfaces (microsurface, seal coat, and chip seal)
ADT:	3	8%	
Alignment:	1	3%	

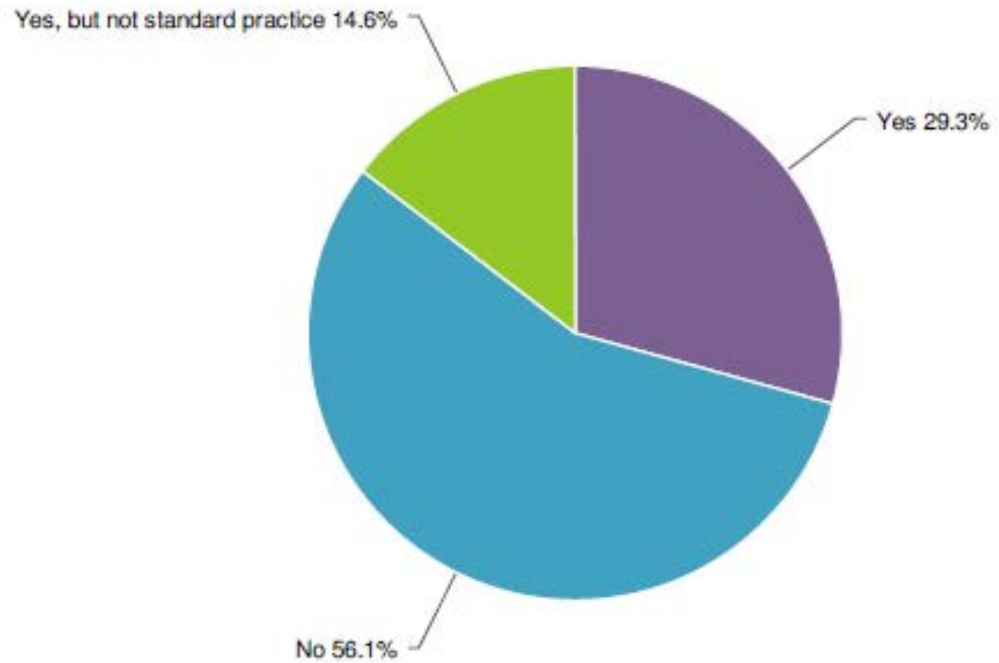
40 responding agencies




Factors Influencing Center Line Rumble Strip Installation

Influencing Factor	Number of Agencies	Percent	Minimum Required Values/Explanation
Lane Width:	22	58%	Between 10 and 12 feet
Other (please specify):	20	53%	Factors include: Homes, noise, functional class, and rural
Speed Limit:	18	47%	Between 35 and 55 mph with the majority at 45 mph
Pavement Condition:	17	45%	Good condition
Crash frequency/rate:	13	34%	Locations with a crash history or above average head-on crashes
Pavement Type:	9	24%	Mostly asphalt
ADT:	4	11%	
Alignment:	1	3%	

38 responding agencies

Seal or Not Seal?



Yes	29.3%		12
No	56.1%		23
Yes, but not standard practice	14.6%		6
Total			41

Rumble Strip Location

Inches from Edge Line	Number of Agencies	Percent
0	7	17%
4	7	17%
6	12	29%
12	3	7%
16	2	5%
18	1	2%
Varies	9	22%

41 responding agencies

Why Create Gaps in Rumble Strips?

Gaps Created For:	Number of Agencies	Percent
Bridge Decks	30	79%
Other	29	76%
Noise	22	58%
Bicycles	17	45%
Special Users	6	16%

38 responding agencies

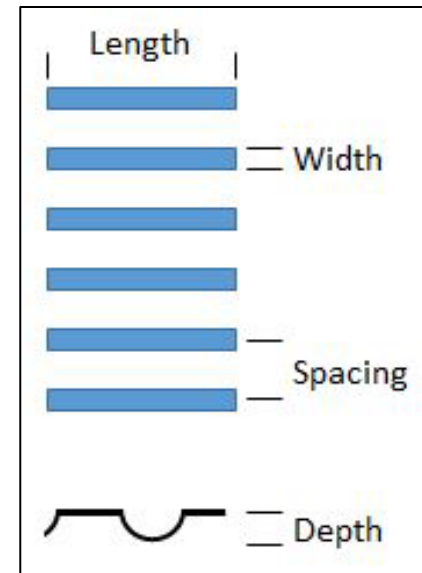
Center Line Rumble Strip Installed Dimensions

Length in Inches	Inches											Number of Agencies
	7	8	9	10	11	12	13	14	15	16	17	
4												1
7												2
8												2
10												1
12												18
14												1
16												11

36 responding agencies

Width in Inches	Inches					Number of Agencies	
		4	5	6	7		8
4							1
5							6
6							2
7							22
7.5							2

33 responding agencies



Pavement Marking Materials Used for Rumble Stripes

Pavement Marking Material Used	Number of Agencies	Percent
Standard Acrylic Waterborne Paint	17	46%
Epoxy	16	43%
Other (required)	15	41%
High Build Acrylic Waterborne Paint	11	30%
Sprayed Thermoplastic	11	30%
Polyurea	6	16%
Urethane	1	3%

37 responding agencies











Rumble Strip Benefits

- Reducing crashes: crash modification factors
- Cost effective countermeasure: range is 7:1 to 75:1. Seven agencies reported and several are working on developing.
- Extending pavement marking longevity (rumble stripes): anecdotal
- Added visibility
- Winter operations

Issues With Rumble Strips

Ranking 5=Most Important Issue Faced

Issue	5	4	3	2	1	Average
Bicycle complaints	12	9	10	9	1	 3.5
Noise complaints	9	15	4	10	3	 3.4
Pavement deterioration (center line joint)	10	7	6	8	10	 3.0
Rumbles on challenging surfaces	4	10	8	10	9	 2.8
Pavement deterioration (edge line)	4	7	9	10	11	 2.6
Pavement Marking Performance	4	2	12	8	15	 2.3
Motorcycle complaints	0	5	12	13	11	 2.3
Winter maintenance issues	0	1	6	15	19	 1.7


41 responding agencies

Public Complaints Against Rumble Strips

Complaints Regarding:	Level Of Public Complaints		
	Low	Medium	High
Noise	18	16	7
Bicycle related	17	11	13
Motorcycle related	33	6	1
Pavement deterioration (center line joint)	36	3	2
Pavement deterioration (edge line)	35	5	1
Winter maintenance issues	38	3	0
Pavement Marking Performance	35	6	0
Rumbles on challenging surfaces	34	5	2

41 responding agencies

Public Campaigns




SAVING LIVES BY KEEPING DRIVERS FOCUSED

Noise from Centerline Rumble Strips

On just one stretch of 2-lane highway in rural Minnesota from 1986-2011

Overall head-on crash statistics found in the reports
of the Minnesota Department of Transportation
statistics/Pages/crash-facts.aspx

25 PEOPLE WERE KILLED IN HEAD-ON CRASHES



this averages out to **one person killed per** *YEAR*

What is a rumble strip?

Rumble Strips are indentations in the road surface – usually on the shoulders or along the centerline – that cause noise and vibration when a vehicle drives over them.

Drivers who are:


- *distracted*
- *tired*
- *speeding*
- *inexperienced*

can unintentionally drift over the centerline and cause crashes.

How do rumble strips help?

The “rumble” alerts motorists that are straying from the travel lane, prompting them to correct their steering and stay in their lane or on the road. Centerline rumble strips reduce crashes significantly:

9%	12%	39%	44%
Total Crashes	Fatal & Injury Crashes	Total Head-On Crashes	Fatal & Injury Head-On Crashes



Based on multi-state data from NCHRP Report 641, 2009.

Future Research Suggestions

- Dealing with noise (new design standards): state DOTs could further investigate alternative rumble designs to reduce noise. As the literature showed, the sinusoidal pattern is promising, but further research is needed. The reduction of the rumble length from 16 inches to 8 inches, in the MnDOT study, resulted in reduce audible and tactile warning when the whole tires was not in contact with the rumble.
- Specifications (audible and tactile): rumble strips and stripes provide feedback to the drivers by producing audible and tactile warnings. From the survey, only two agencies have developed specifications for these two items. Additional research could assess how much audible and tactile warning are needed and how do we measure it.

Future Research Suggestions

- Rumble stripes: when the pavement marking and the rumble strip are combined, a rumble stripe is born. The survey showed the lack of information on the impact of the rumble on the performance of the pavement marking. Another aspect of rumble stripe is the wet night visibility advantage. Very few states measured wet retroreflectivity of rumble stripes to determine that.
- Pavement deterioration: additional research could assess the impact of the rumble on the pavement deterioration. A number of states said they have an electronic database with all locations of their rumbles that is tied to a location referencing system.

Future Research Suggestions

- Rumble Strip Design (Impact on Safety Benefits): the results from the survey showed how the DOT practices vary from size, to design, to installation and also the resulting crash modification factors from one state to another vary. This suggested research topic would address the potential differences in safety benefits due to different rumble strip and stripe designs.

Thank You!

Omar Smadi

smadi@iastate.edu

