17.0682.01000

FISCAL NOTE

Requested by Legislative Council
01/10/2017

Bill/Resolution No.: HB 1284

1 A. **State fiscal effect:** *Identify the state fiscal effect and the fiscal effect on agency appropriations compared to funding levels and appropriations anticipated under current law.*

	2015-2017 Biennium		2017-2019 Biennium		2019-2021 Biennium	
	General Fund	Other Funds	General Fund	Other Funds	General Fund	Other Funds
Revenues						
Expenditures						
Appropriations						

1 B. **County, city, school district and township fiscal effect:** *Identify the fiscal effect on the appropriate political subdivision.*

	2015-2017 Biennium	2017-2019 Biennium	2019-2021 Biennium
Counties			
Cities			
School Districts			
Townships			

2 A. **Bill and fiscal impact summary:** *Provide a brief summary of the measure, including description of the provisions having fiscal impact (limited to 300 characters).*

This bill requires that a series of rumble strips on the edge or center of any street, road, highway, or other public way must be in intervals of twenty feet.

B. **Fiscal impact sections:** *Identify and provide a brief description of the sections of the measure which have fiscal impact. Include any assumptions and comments relevant to the analysis.*

Assuming NDDOT would not have to implement the provisions of this bill until such time as it became necessary to replace a given roadway or re-establish the rumble strips on a given roadway, this bill would not have a material financial impact.

3. **State fiscal effect detail:** *For information shown under state fiscal effect in 1A, please:*

A. **Revenues:** *Explain the revenue amounts. Provide detail, when appropriate, for each revenue type and fund affected and any amounts included in the executive budget.*

B. **Expenditures:** *Explain the expenditure amounts. Provide detail, when appropriate, for each agency, line item, and fund affected and the number of FTE positions affected.*

C. **Appropriations:** *Explain the appropriation amounts. Provide detail, when appropriate, for each agency and fund affected. Explain the relationship between the amounts shown for expenditures and appropriations. Indicate whether the appropriation or a part of the appropriation is included in the executive budget or relates to a continuing appropriation.*

Name: Shannon L. Sauer
Agency: ND Dept of Transportation
Telephone: 328-4375
Date Prepared: 01/13/2017

2017 HOUSE TRANSPORTATION

HB 1284

2017 HOUSE STANDING COMMITTEE MINUTES

Transportation Committee
Fort Totten Room, State Capitol

HB 1284
1/19/2017
#27160

☐ Subcommittee
☐ Conference Committee

Committee Clerk Signature Jeanette Cook

Explanation or reason for introduction of bill/resolution:

A bill relating to the placement of rumble strips on public roads.

Minutes: Attachment #1-2

Chairman Ruby brought HB 1284 before the committee.

Representative Jeff Magrum, District 28, spoke to introduce and support HB 1284 and provided information that was referenced in his testimony. See attachment #1.

Representative Jeff Magrum: I met with county and township people, and they agree that rumble strips are beneficial for safety, but think intermittent rumble strips would be better than continuous ones. Bicycles and motorcycles are having trouble with the strips. When they get into them, they can't get out of them. If they were intermittent, then they could get out of them, or go in between when they are passing someone. Truckers say that they can feel the strips pull the truck one way or the other. In places where there is little shoulder, the rumble strips can pull you over and get you off of the pavement. The farmers are also upset about them because they can't get out of them with their wide implements. The implement tires are continually bouncing on the rumble strips. They also say that the deer and moose lick the salt out of the rumble strips and there is more chance of the deer being on the road, especially at night. This is a safety concern. People also say that the rumble strips break up when trucks hit them, and then they throw the pieces up and cause chips in windshields.

I have a generic number that it costs $10,000 per mile per run to put them in. That would be $30,000 a mile for a road with three strips. I'm not sure if that is an accurate number.

If it was decided to put the strips intermittently, I would like a study done to see what the cost savings would be to the Department of Transportation. I know that the cost won't be cut in half, but maybe one-third?

Representative Sukut: If we would pass this, is it going to relate strictly to going forward, or will we have to go back and change everything that is out there?

Rep. Magrum: No, we would just want it to be in the future.

Vice Chairman Rick C. Becker: Are these the rumble strips that are on the sides of the road and in the middle? What does a series constitute?

Rep. Magrum: Right now they are continuous, but my bill proposes a 20-foot strip of rumble strips and then 20 feet of smooth surface, intermittently.

Representative Paur: In Minnesota there are strips of 1 ½ feet, then a blank, and then a strip. Have you looked at those?

Rep. Magrum: I have seen different ones, but not those specifically.

Representative Grueneich: Did you check to see if it is less expensive to do continuous strips than intermittent? Is it more labor intensive to do 20 feet on and 20 feet off?

Rep. Magrum: I don't know.

Chairman Ruby: I understand your intent, but do you think this will just spread the problem out? Do you think this will be almost the same as if it is constant?

Rep. Magrum: I think it would help. It will still help with safety issues, but if the strips are pulling at you, like a truck or motorcycle rider, the drivers will be able to get out. I was hoping to at least get a study going.

Representative Jones: Do I understand that you are not totally set on the twenty feet on and twenty feet off? You would just like them to be intermittent?

R**ep. Magrum**: That is correct.

There was no further support for HB 1284.
There was no opposition to HB 1284.

14:16
Ron Henke, Deputy Director for Engineering for North Dakota Department of Transportation, spoke in a neutral capacity on HB 1284. He provided written testimony. See attachment #2.
17:30

Vice Chairman Rick C. Becker: You have machinery that mills out the strips. If there are fewer rumble strips, will it save the life of the machinery and save costs?

Ron Henke: I don't have the cost of the life that that machine runs. They go about 15 – 20 mph, and another machine comes along behind and brooms off the millings into the ditch.

Representative Weisz: What does it cost per mile to put in rumble strips?

Ron Henke: About $1500 to $2000 per mile.

Representative Jones: Is there a difference in the size of the mills that might make a difference for the farmers that are losing tires?

Ron Henke: The report gives you ranges to work within. We grind our anywhere from ½ inch to 5/8th inch at the deepest point. It is on a circular path; it is a round mill head. They end up being about 7 inches wide, then a 5-inch gap, and then another 7 inches followed by a 5-inch gap. Depending on the width of the shoulders, we go from 12 inches wide down to 6 inches. If there is no shoulder, we cut down to a 6-inch rumble, and then stripe right over the rumble. Then they don't cut into the lane so much. In the report it gives more variation, but if we don't go as deep, then the more often we have to grind them in. If we do a chip-seal, that would take up some of the space, and we would have to do them more often.

Representative Paur: Is the $1,500 to $2000 per strip?

Ron Henke: I'm not sure. I believe it is for all three, but I will have to get back to the committee about that.

Chairman Ruby: Do you see cracks that are caused by the strips holding water?

Ron Henke: We haven't seen where the rumble strips are causing cracks in the pavement. We have noticed that in older pavement, the strips will sometimes connect together because the pavement starts popping. We are trying to come up with strategies to deal with that.

Chairman Ruby: Do you have data statewide on the difference of head-on collisions and cars leaving the lane since the rumble strips have been put in?

Ron Henke: We are just finishing up a report, and we would be happy to share that with you. We need just a few more days to finish up the details on it.

Representative Jones: I appreciate the rumble strips in North Dakota. I support this bill if we can make it a little better for the farmers and their equipment, then I think we should.

Chairman Ruby: Do you have suggestions on the bill? Would you like it the way it is now, or do you like the bill? Is there some potential for improvements, and the way that rumble strips are placed on the roads?

Ron Henke: There is always room for improvement, and we always look at the newest research that is out there. This bill is specific (20 feet intermittent). If some research came about that said this was a better way; we would do it. If you look at our crash data, our accidents are random in nature. They are on all kinds of roads. That is why we went about the process of putting them on **every** state highway.

Representative Anderson: If you put the strips 20 feet apart, wouldn't a car go between them without hitting them quite easily?

Ron Henke: There are no studies that say a 20-foot rumble and 20-foot gap is bad. All we have is this report that says the studies that they did, allowed a 40 or 60 food cycle with 10-12 foot gaps.

There was no further testimony on HB 1284.
The hearing on HB on 1284 was closed.

Representative Anderson: I am happy with the process that the Department of Transportation has to keep them the way they are. I view this as micromanagement, and something that doesn't need to be done.

Representative Westlind: I think the Department of Transportation is doing their due diligence, and we should just let them determine the spacing.

Vice Chairman Rick C. Becker: I think this is an interesting idea, bit I'm not sure that we really know what is best here. If we did do 12 feet and 12 feet, and it could be a big cost savings, but I am not sure that is what we should do. I am probably not in favor of the bill as it stands right now.

Chairman Ruby: If we do intervals, someone has to measure the intervals. Maybe it wouldn't save any time.

Representative Anderson moved a DO NOT PASS on HB 1284.
Representative Westlind seconded the motion.

A roll call vote was taken. Aye 12 Nay 0 Absent 2
The motion passed.

Representative Westlind will carry HB 1248.

Date: 1-19-17
Roll Call Vote #: 1

2017 HOUSE STANDING COMMITTEE
ROLL CALL VOTES
BILL/RESOLUTION NO. 1284

House Transportation Committee

☐ Subcommittee

Amendment LC# or Description: _____

Recommendation: ☐ Adopt Amendment
☐ Do Pass ☒ Do Not Pass ☐ Without Committee Recommendation
☐ As Amended ☐ Rerefer to Appropriations
☐ Place on Consent Calendar

Other Actions: ☐ Reconsider ☐ _____

Motion Made By Anderson Seconded By Westlind

Representatives	Yes	No	Representatives	Yes	No
Chairman Dan Ruby	X		Rep. Gretchen Dobervich	X	
Vice Chair. Rick C. Becker	X		Rep. Marvin Nelson	A	
Rep. Bert Anderson	X				
Rep. Jim Grueneich	X				
Rep. Terry Jones	X				
Rep. Emily O'Brien	X				
Rep. Mark Owens	A				
Rep. Gary Paur	X				
Rep. Randy Schobinger	X				
Rep. Gary Sukut	X				
Rep. Robin Weisz	X				
Rep. Greg Westlind	X				

Total (Yes) 12 No 0

Absent 2

Floor Assignment Westlind

If the vote is on an amendment, briefly indicate intent:

REPORT OF STANDING COMMITTEE

HB 1284: Transportation Committee (Rep. D. Ruby, Chairman) recommends **DO NOT PASS** (12 YEAS, 0 NAYS, 2 ABSENT AND NOT VOTING). HB 1284 was placed on the Eleventh order on the calendar.

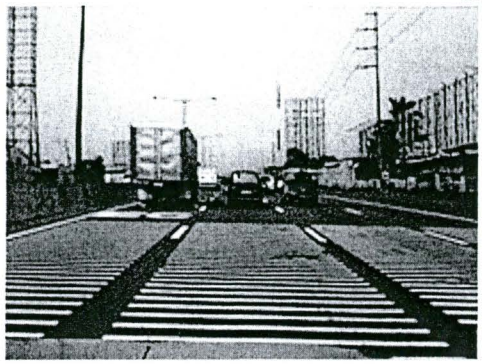
2017 TESTIMONY

HB 1284

HB1284 #1
1-19-17 Page 1

For the English band, see The Rumble Strips.

Rumble strips, also known as **sleeper lines**, **rumple strips**, **alert strips**, **audible lines**,[1] **"the corduroy"**, **growlers**, "drift lines", "drunk bumps", and "woo woo" boards, are a road safety feature to alert inattentive drivers of potential danger, by causing a tactile vibration and audible rumbling transmitted through the wheels into the vehicle interior. A rumble strip is applied along the direction of travel following an edgeline or centerline, to alert drivers when they drift from their lane. Rumble strips may also be installed in a series *across* the direction of travel, to warn drivers of a stop or slowdown ahead, or of an approaching danger spot.



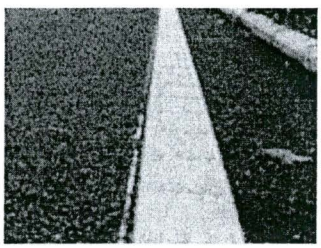
The North Luzon Expressway's raised plastic transverse rumble strips approaching Balintawak Toll Barrier, Philippines

In favorable circumstances, rumble strips are effective (and cost-effective) at reducing accidents due to inattention. The effectiveness of shoulder rumble strips is largely dependent on a wide and stable road shoulder for a recovery, but there are several other less obvious factors to consider during design.

Contents

Placement

Rumble strips are divided into transverse rumble strips, shoulder rumble strips, and centerline rumble strips, depending on how they are used.



Convex road lines, raised thermoplastic pavement lines

Transverse rumble strips are placed in the travel lanes where most if not all vehicles will cross them. They are used to alert the driver of an upcoming intersection, toll booth or similar hazard. They may cross the entire road from shoulder to shoulder, or they may only be in the wheel paths.[2]

Shoulder and centerline rumble strips are used to reduce lane departure crashes. Centerline rumble strips are used on undivided highways to reduce cross-over incidents and resultant head-on collisions. Shoulder rumble strips are used primarily to reduce run-off-road collisions. They alert distracted or drowsy drivers that they are leaving the roadway or crossing the centerline of the road. In this application, they are narrower and outside of the wheelpaths.[3]

Types

There are several different ways to install rumble strips:

- Rolled-in, applied to newly laid asphalt pavement while it is still warm and moldable.
- Milled-in, applied to existing hardened asphalt or concrete roads.[4]
- Formed, a corrugated form is pressed into fresh concrete.
- Raised plastic or ceramic units, fastened to asphalt or concrete pavement and often with a

reflector built into the edge. Botts' dots are a common installation.[5]

- Profiled thermoplastic markings are created by fusing thermoplastic to the pavement and create alternating elevation and recession pattern. This can be done as inverted-profile markings or raised-profile markings. Inverted-profile markings are created by pressing a cog rolling over the markings while they are wet to make them corrugated. Raised-profile markings are created by extruding extra thickness of thermoplastic at a specific interval to create bumps.[6] Raised-profile markings are sometime known as convex traffic lines.[7]
- "Smart car" virtual shoulder rumble strips, referred to as a lane departure warning system, available on luxury vehicles and commercial trucks. The alarm is similar to the sound produced when striking rumble strips.
- "Smart car" virtual transverse rumble strips to prevent cross-path crashes at intersections are being developed.[8]

Surface-mount raised pavement reflectors are easily scraped off by the blade on snowplows, and thus are not practical in many locations in the United States and Canada.[9][10]

Rumble strips combined with pavement markings are sometimes called **rumble stripes**. They may be formed with raised textured plastic pavement markers, or they may use conventional pavement marking materials sprayed onto milled rumble strips. Rumble stripes have markedly increased visibility in wet nighttime conditions, when conventional markings on flat surfaces can be difficult to see.

History

Rumble strips were first implemented on the Garden State Parkway in New Jersey in 1952.[11][12]

Initially, shoulder rumble strip installation focused on freeways using rolled-in rumble strips of different designs using a modified roller on a pavement rolling machines. Later, paving contractors modified pavement rolling machines to mill rumble strips into existing hardened asphalt pavement. Specifically designed commercially available machines followed. The development of ceramic and plastic raised systems enabled installation on concrete paveme

highways, and the smaller footprint was better suited for the dashed centerline. "Virtual" rumble strips followed.

As rumble strips produce audible rumbling in specific audio frequencies based on the spacing of the grooves and the speed of the automobile, they have been used to create novel musical roads. These are also known as "singing shoulders".

Rumble strip installation is widespread, and in some cases controversial. Residents near urban freeways complain of noise at night as vehicles change lanes; or when vehicles strike the transverse rumble strips. The encroachment of shoulder rumble strips onto highways with narrow shoulders may create a hazard for cyclists. US and Canadian guidelines have minimum standards for installation on known cycling routes. In 2009, in Michigan, the Amish claimed that the shoulder rumble strips were dangerous for horse-drawn carriages, and successfully lobbied to have them paved over. In 2010, Kansas has considered removing shoulder rumble strips from an interstate highway to allow buses to travel on the shoulder during periods of traffic congestion.

Accident and driver dynamics

On-road and run-off-road accidents

The single-vehicle crashes are classified into two groups: run-off-road (ROR), and on-road (OR) crashes in which the vehicle remains on the road after the crash. ROR crashes can account for up to 70% of the fatal single-vehicle crashes.

ROR crashes are due to inattention, speeding, traction loss, overreaction, crash avoidance, and mechanical failure.[13] Rumble strips only prevent ROR crashes due to inattention.

Research indicates that 47% of ROR's exited the highway to the left; while 53% exited the highway to the right (in the USA where driving is on the right-hand-side of the road).[9]

Inattentive driving

A US Federal Highway Administration (FHWA) sponsored study stated that driver inattention

comes in many forms, including distraction, daydreaming/competing thoughts, fatigue/drowsiness, and alcohol/drug impairment.[14] Early evening low alcohol intake also worsens sleepiness-related driving impairment.[15]

In a 2008 survey in the US, 33% of fatally injured drivers tested were found to be legally impaired (BAC > 80 mg %), and an additional 5% were found to have a legal amount of alcohol in their bodies.[16] Canada has similar statistics.[17]

Migration of accidents

Studies support the hypothesis that some crashes are not prevented, but merely "migrated" or displaced vehicle-to-vehicle, season-to-season, location-to-location, further downstream of rumble strips on the highway system, or prevented-to-unprevented crash severity.

An FHWA sponsored study wrestled with the moral dilemma of rumble strips keeping "unsafe drivers" (which includes impaired drivers) on the highway. "This group of unsafe drivers temporarily saved by the rumble strips may have caused some multiple-vehicle crashes involving harm to innocent victims to occur downstream from the treated site where no rumble strips existed. Unfortunately, as noted above, an examination of downstream crashes could not be conducted."[14]

A 2008 Swedish study using a driving simulator and 35 sleep-deprived drivers concluded: "The main results showed an increase in sleepiness indicators from start to before hitting the rumble strip, an alerting effect in most parameters after hitting the strip. The alertness enhancing effect was, however, short and the sleepiness signs returned 5 min after the rumble strip hit. Essentially no effects were seen due to type of strip."[18]

A 2003 Montana study suggested that on Interstates, shoulder rumble reduced the roll-over accident rates but the severity of unprevented roll-over accidents increased. This was thought to be due to the rumble strip "scaring" sleeping drivers to the extent that they overreacted. This problem was more pronounced on primary highways (that have narrower shoulders) with rumble strips.[19]

"Classic" one-car crashes

The 'classic' one-car crash results when a vehicle slowly drift to the right, hits dirt or rumble strips on the right shoulder of the road, and the driver becomes alert and overreacts, jerking the wheel left to bring the vehicle back onto the road. This motion causes the left front tire to strike the raised edge of the pavement at a sharp angle, often causing a rollover or a swerve into oncoming traffic. This form of one-car crash is "classic" because it occurs very often.[20] Raised edges of pavement (or "edge-drops") were once common, but are now recognized as a hazard; it is now standard practice to level the gravel shoulder with the pavement, although edge-drops may reform due to soil erosion. This "slowly drift to the right" scenario applies to jurisdictions with right-hand traffic, so in jurisdictions with left-hand traffic it would be a "slowly drift to the left" scenario.

This phenomenon implies that a sleeping driver often does not react and begin to recover, until all four wheels have struck a rumble strip; if the paved shoulder is narrower than the width of the vehicle wheel track, a rumble strip may not prevent a sleeping driver from going off the road.

On a single-lane highway, an overreacting driver has less room to regain control, which may exacerbate their initial overreaction after striking the strips, resulting in a roll-over or head-on collision. A crash investigating officer stated: "It's consistent with someone who falls asleep or overreacts to the rumble strips", which implied that this was not the first time the officer has witnessed this situation.[21] Note that in the KATU.com article photograph (in the upper left-hand corner) of the crash scene, the passenger-side tire print in the soft shoulder that suggests that all four wheels passed over the rumble strip before the driver attempted the unsuccessful recovery.[22]

Fluidity of accident profiles

Accident profiles can change over time, and this can be considered a form of migration. Studies from Canada shows that over one decade the rate of off-road ATV accidents requiring hospitalization increased by 66%, while the rate for snowmobile accidents decreased 20%.[23] Many of these recreational vehicle owners own both or choose one over the other. Data from the US shows that motorcycles are becoming more popular and that motorcycle fatalities are increasing, while car fatalities are decreasing.[16] Many motorcyclists own or have access to a

car.

Behavior adaptation

Rumble strips may gradually encourage inattentive driving – thereby partially negating any safety benefits in the long term. This is referred to as "behavior adaptation".[24][25]

A 2006 US study suggested that airbags and antilock brakes can lead to unsafe driving.[26] A 2007 Canadian study suggested that unsafe drivers are habitual, and that unsafe driving is increasing.[27] A 2009 Canadian study indicated that, after a steady decline, drinking and driving has been on the increase since 2004.[28] These support the migration and behavioral adaptation rumble strip concerns.

A safe driver population has more potential for negative behavior adaptation than an extreme unsafe driver population; whereas, an extreme unsafe driver population has more potential for positive behavior adaptation than a safe driver population.

Accident rates and profile

Different jurisdictions have different accident and fatality rates, as a function of various factors such as climate, road layout, demographics, educational programs, level of policing, driver attitudes toward night driving, promptness of emergency response, and level of medical intervention.[13] For example, the 2006 Canadian motor vehicle fatality rate per province varied between 8.8 and 26.8 per 100,000 licensed drivers per year, with a national average of 13.[29] The 2008 US rate is 20.05.[16] Installing rumble strips on a highway with a relatively low accident rate and low proportion of accidents due to inattention will be relatively ineffective, even if the highway has 12 foot paved shoulders.

The FHWA states: "Long sections of relatively straight roadways that make few demands on motorists are the most likely candidates for the installation of shoulder rumble strips." The degree of engagement of a highway affects the accident rate. Implied in this statement is that highways that are twisty and hilly with a variable foreground have low rates of accidents due to inattention, and are therefore not likely candidates for the installation of rumble strips.[30] Installing rumble strips along a highway that is highly engaging, with a narrow shoulder, a low

accident rate, and relatively low proportion of accidents due to fatigue or inattentive driving would have questionable value.

Diminishing marginal returns

In addition, safety improvements are not linear; there are diminishing marginal returns with a safer driver population, in which it is more difficult to further reduce the accident rate. Within the industrialized countries the rate varies between about 8 and 27 (per 100,000 licensed drivers per year).

"Safety improvements are usually subject to the law of diminishing marginal returns. This means that for every improvement of a fixed amount, the safety benefit gained decreases a little each time. For example, increasing the width of the median from 50m to 60m will decrease the number of collisions less than increasing it from 10m to 20m. Eventually, a width will be reached at which widening the median further cannot be justified because the improvement in safety is too small."[31]

When the accident rate is close to the baseline of 8, there may already be several factors pushing it down so adding another safety factor (initiative) will only yield a very small improvement. Installing rumble strips on a highway with a high accident rate close to 27 should yield a relatively high accident reduction. This assumes that the road shoulder is adequate for a recovery, once a straying driver has been alerted by the rumble strips.

Types of rumble strips

Continuous shoulder rumble strips (CSRS)

Montana undertook an extensive 10-year multi-site study of the effectiveness of CSRS on Interstate and primary highways (both types are divided pavements). This study also investigated the *severity* of crashes, which sets it apart from previous studies. The results indicated a 14% reduction in crashes on Interstate highways; however the effectiveness on primary highways indicated both improvements and worsening, and the results were considered inconclusive. It was found that "roll-overs" decreased in number, but increased in

severity. The study only considered crashes in dry and wet conditions, not snow and ice.[19]

The FHWA undertook a multi-state study involving test sites from Illinois and California. The Illinois component indicated crash reduction from 7.3% to 21.7%. The California component indicated crash reductions of 7.3%. This study also indicated an overall reduction of about 14%.[14]

The 1997 New York State Thruway study indicated a 65% to 70% reduction.[10] However, in a 1999 *New York Times* article regarding the New York State Thruway study, an official stated that the experiment was not done completely "pure", due to Troop T concurrently conducting a campaign to reduce drunk driving and increase seat-belt use, and Troop T's campaign would also reduce the number of fatal vehicle crashes.[32] 10 to 24 percent of crashes are estimated to involve fatigue or inattention of some kind, but these numbers are based on guesswork.[32] Despite this, the New York State Thruway study indicating a 65% to 70% reduction continues to be cited in literature.[10][19]

New Zealand used rumble strips in small applications since the late 1980s, and started a larger program in 2004. Research in the country indicated that lane delineation with rumble strips reduced crashes by an average of 27% over all crash types and studies, with types of crashes such as "run off road" being reduced by up to 80% in some studies. Centre-line rumble strips showed similar effects. However, it appears that there were other crash reduction initiatives that may have contributed to the relatively sizable results.[33]

The effects remained even after road users had become accustomed to the feature, while other road safety measures (when studied at specific installations) often showed declining effectiveness over time.[33] Cost-benefit analysis showed that even on relatively low-volume roads, the costs of applying the markings were quickly exceeded several-fold by the economic benefits of improved road safety (as counted by the reduction of crash rates weighted against the average social costs of a crash).[33]

Further research in New Zealand led to recommendations that strip edge lines and centre lines be marked over extended lengths of road, rather than just at focal points and crash black spots. Apart from the safety benefits of providing a consistent road environment, continuous markings provide valuable alerts to drivers long before the more common crash spots.[34]

A one-third reduction rate is commonly cited and is based on an average of early studies. It includes the New York State Thruway and Pennsylvania Turnpike results which produced a skewed result non-representative of typical situations.[5][10]

The *one-third* reduction rate and the *Pennsylvania Turnpike Study* (with a 60% reduction) are the *rule-of-thumb* and the *classic study*, but these can be misleading as CSRS do not have a "fixed" effectiveness that may be applied to any highway.[35]

A 1999 FHWA study concluded that "a best guess" might be 20% to 30% reduction in single-vehicle run-off-road crashes on rural freeways, with less effective on urban freeways.[14]

It should be noted that almost all before-and-after studies are based on Interstate (freeway, turnpikes, thruways) test sites have minimum 12-foot paved shoulders and very high crash rates due to inattention.

The collision reduction attributed to the installation of CSRS is mainly a function of stable shoulder width, crash rate and profile, climate and diminishing marginal returns.

Centerline rumble strips (CRS)

Centerline Rumble Strips are applied to single-lane undivided highways to help prevent head-on collisions. When present, these are often milled into the pavement.

A 2005 National Cooperative Highway Research Program (NCHRP) study concluded that overall motor vehicle crashes at sites treated with Centerline Rumble Strips were reduced overall by 14%." [9] In these situations the opposite lane and any paved shoulder would function as a generous recovery zone. However, this study did not investigate changes in crash severity, as did the 2005 Montana study.

It is interesting that the CRS reduction value is the same as the 2005 Montana CSRS study that indicated a 14% reduction in accidents on Interstate highways. This supports the hypothesis that the overall effectiveness of CSRS with a generous recovery zone is about 14%.

and slush filled rumble strips can be a concern,particularly so for milled centerline rumble

strips. For this reason, some jurisdictions are reluctant to install them.[36]

A 2015 Federal Highway Administration study evaluated the application of shoulder rumble strips and centerline rumble strips in combination by analyzing geometric, traffic, and crash data obtained at treated two-lane rural road locations in Kentucky, Missouri and Pennsylvania. The results suggested that the effect of combining centerline and shoulder rumble strips further reduces run-off-road crashes compared to shoulder rumble strips alone and both total and fatal+injury crashes compared to centerline rumble strips alone. However, it appeared that shoulder rumble strips do not further reduce head-on+sideswipe-opposite-direction crashes than applying centerline rumble strips in isolation.[37]

Continuous lane rumble strips (CLRS)

CLRS are applied to multiple lane highways to help prevent vehicles from drifting into the adjacent lane and possibility colliding with an overtaking vehicle. These are typically a raised reflective system.

Transverse rumble strips

Transverse rumble strips (TRS) may be used to warn drivers: of the need to stop (e.g. intersections, toll plazas); the need to slow down; the need to change lanes; of a change in roadway alignment; that they are leaving the traveled way; upcoming construction zones; wildlife crossings; and other potentially unexpected conditions.[5][38]

As a speed reduction measure, TRS have been marginally successful. A 2003 Texas study concluded: "However, the actual reductions in speeds have been in the range of 2 to 8 mph (3.2 to 12.9 km/h), which may be barely perceptible to the traveling public. There have been no studies that evaluate the reduction of excessive speeds."[5]

As a construction zone safety measure, the effectiveness appears unclear. A 2007 Minnesota study concluded that while transverse rumble strips offer a low cost and easy-to-install option, they "did not seem to be successful at reducing approach speeds at the project sites".[39] A 2005 Maryland study stated: "In conclusion, although in the present study rumble strips did not produce the desired speed reduction effect, its use for work zone applications is still hig

encouraged; though, not as a speed control measure but as a driver's attention-catching device."[40]

[redacted] an approach stop-control crash reduction measure they have proven successful. The 2003 Texas indicated: "The majority of studies found reported large reductions (40% to 100%) of accidents after installing transverse rumble strips."[5]

In Ghana, rumble strips running across the entire carriageway were installed at Suhum Junction on the main Accra-Kumasi highway and reduced crashes by about 35% and fatalities by about 55%. By reducing speeds the environment for and safety of pedestrians was improved with a decline in the "hit pedestrian" crash rate of 51%. "While the enforcement of speed limits by traffic police may not be affordable for most developing countries, rumble strips and speed humps were found to be effective on Ghanaian roads."[41]

A 2009 FHWA intelligent systems study suggested that a combined infrastructure-based and in-vehicle warning could be highly effective in reducing crossing path crashes and fatalities at signalized intersections.[8]

[redacted]ffectiveness

Effectiveness of CSRS on different classes of highway [redacted]

Recent before-and-after studies suggest that the effectiveness of CSRS on Interstate highway (or freeways or thruways) with 12 foot paved shoulders is about 7% to 21% with an overall effectiveness of about 14%.

The effectiveness of CSRS on the lower-standard primary highways (that are also divided) has not been given the same consideration as those on Interstate highways. The 2003 Montana study suggested that CSRS on primary highways can result in either worsening or improvement of crash rates. This may be due to variation in recovery zone width and condition, and other factors. The study also stated that unprevented crash severity may worsen, and the overall results were inconclusive. The study suggested that the differences in [redacted]mble strip-related crashes between Interstate highways and primary highways were due to [redacted] primaries having smaller shoulders than Interstates.[19]

Secondary highways are single-lane undivided highways, and CSRS would be expected to be less effective than on primary highways. The most serious problem would be an increase in crash severity. Also, there is the concern of drivers sometimes overreacting and crossing the centerline, resulting in a head-on collision.[22] The recovery zone width and condition of single-lane highways can vary greatly. It appears that there may be no published before-and-after CSRS studies for single-lane highways.

Actual vs. isolated CSRS and centerline rumble strips effectiveness

Given behavior adaptation and migration, the current rigorous Interstate effectiveness of 14%, and CLRS on single-lane highways effectiveness of 14% could be over-estimations of the actual "big-picture" reduction. In certain situations, such as an engaging single-lane highways that typically have narrow shoulders, high precipitation, in a northern climate with frequent freeze-thaw cycles, rumble strip effectiveness may be negative.[19]

As before-and-after studies become broader and more sophisticated, it appears the reduction estimates for both CSRS and CRS are less impressive. This may be due to the initial installations were on highways that had been identified as having very high accident rates du to inattention. Also, there may have been other accident reduction campaigns in concert with rumble strip programs."[32]

Also, as lane departure warning systems built into vehicles become more widespread, the physical CSRS, CRS, and CLRS in pavements may become increasingly redundant.

Shoulder width

Further information: Shoulder (road)

Research has found that on rural freeways, rumble strips are much more effective when placed at or near the edgeline than when placed closer to the shoulder edge. Edgeline rumble strips can be expected to reduce crashes by 28.8%, and non-edgeline rumble strips only reduce crashes by 8.9%.

On two-lane roads, there is little difference in effectiveness between edgeline and non-

edgeline rumble strips, with crash reduction factors of 39.2% and 41.9%, respectively.[42] FHWA now recommends rumble strips on two lane roads if the edge of shoulder is more than [redacted]3 feet from the centerline, especially if the road has high volumes, poor geometry, or a history of run-off-road crashes.[43]

The 2003 Montana study stated that in certain cases, the rumble strips may act only as a warning of an impeding crash, and that sort of a situation is much more likely where less shoulder is available for recovery.[19]

Recovery zone condition

A concern about highways with narrow paved shoulders is the condition of the adjacent gravel shoulder. Sometimes, the paved and gravel shoulders are combined as the "recovery zone" beyond the rumble strip. However, if the gravel is loose, soft, non-level, eroded, or there is an "edge-drop" from the pavement to the gravel, then the gravel shoulder portion will be ineffective for recovery, especially at highway speeds. When a vehicle's tires sink into a soft shoulder, thus compromising vehicle handling, it is known as "vehicle tripping".[35]

[redacted]rtual rumble strips require an adequate recovery zone as well.

Deterioration

Climate

Climate is another factor that affects the success of a rumble strips installation. If they are installed in a northern climate, they may be filled or partially filled with a deicing salt and traction sand mixture. They may also be filled with ice. This is a particular concern in regions with freeze-thaw cycles requiring frequent deicing. Furthermore, strips filled with water, snow, slush, and ice may cause or aggravate occasional accidents. Generally, air turbulence and vibration from passing large trucks keep rumble strips clear of [redacted]bris and ice, but this process may take several days.[10] Moist

traction sand tends to cake together or freezes, and is not easily dislodged by truck traffic. This is problematic on low-volume highways with frequent deicing, and can significantly reduce the effectiveness of rumble strips in winter months.

Traction sand filled shoulder rumble strip. The sand is "cemented" in-place and is not easily removed by truck traffic.

When rumble strips are installed on a very narrow paved shoulder, sometimes sand and gravel can fill the rumble strip which is usually a problem in the winter and early spring.

If the snow-cover is substantial, then the shoulder (including the rumble strip) is usually partially snow-covered as the snowplow's wing-blade doesn't clear the entire shoulder. Vehicles going off the road usually collide with the shoulder snow bank or go into a snow-filled ditch which reduces the possibility of serious damage and injury. In these situations, the rumble strip effectiveness can be negated but the crash implications are mitigated by the snow bank.

Pavement deterioration

Generally, deterioration of the shoulder asphalt pavement due to rumble strip installation is not a problem. However, if the sub-grade under the CSRS is poorly compacted or has poor drainage characteristics; or the gravel shoulder has eroded, crack(s) may form in the CSRS. Sand tends to fall into these cracks resulting in "jacking" of the cracks. Water percolates vertically down through the soil, but it also creeps horizontally under the paved shoulder. This may be a particular problem with narrow paved shoulders in regions with frequent freeze-thaw cycles that may result in frequent frost-heaving of the paved shoulder.[44]

An example of extensive cracking in rumble strips due to frost jacking on Interstate Highway 81 north of Syracuse. These parallel cracks were sealed. There were other sections with grass and weeds growing up through the rumble strip cracks

US and Canadian guidelines recommend not installing rumble strips in asphalt pavement displaying cracks, to avoid excessive break-up of pavement. It is also recommended that rumble strips be inspected in summer months for cracking, potholing, water ponding, and snowplow damage. If necessary, structural problems should be repaired.[10] If the cracks become wide enough, grass

and weeds will grow in the cracks accentuating the deterioration.

The centerline of highway has a pavement joint and if milled CLRS are installed over this joint they will make pavement more vulnerable to deterioration. Truckers have reported deterioration of the joint and the CLRS.[9]

Also, road salt prematurely degrades asphalt, so having it retained and concentrated in rumble strips is not desirable.[45]

Opposition and removal

In February 2010, Johnson County, Kansas, considered legislation to allow buses to travel on the paved shoulder (which was rumble stripped) when traffic slows to less than 35 mph (56 km/h). The estimated cost was between $17.6 million and $20 million, including $2.4 million to remove the already-existing rumble strips along the shoulder of I-35.[46] The Kansas House Transportation Committee had said it would be modeled after a similar project in Minneapolis, Minnesota.[47][48][49]

Some residents living close to either newly installed lane or transverse rumble strips have complained about noise levels and were successful in having them removed at considerable expense. In 2004, the town of Chapel Hill, North Carolina, had transverse rumble strips removed as the measured noise from nighttime traffic on the rumble strips exceeded the Town's Noise Ordinance. The noise levels at the sidewalk ranged from 60 to 77 decibels, higher than the 60 decibel noise level limit in the Town's Noise Ordinance during nighttime hours.[50] In 2005, the London borough of Bromley removed transverse rumble strips after residents complained of the excessive "machine gun fire" noise.[51] In 2010, Reno County planned to remove rumble strips from a roundabout after residents complained about excessive noise levels.[52]

The Transportation Association of Canada and US FHWA guidelines basically specify that a width of 1.5 m (4.9 ft) of clear paved shoulder between the outside of the rumble strip and the edge of pavement is adequate to provide cyclists with a clear travel path.[10][30]

However, in situations of parked vehicle on the shoulder, debris on the shoulder, or downhill

sections even with the 1.5 m (4.9 ft) clear path requirement, rumble strips present a significant hazard particularly if the pavement is wet. The argument that rumble strips help protect cyclists is moot, as inattentive drivers' vehicles generally pass entirely over the rumble strip before recovery (if any).

Other related FHWA guidelines are: "Rumble strips should not normally be used in urban or suburban areas or along roadways where prevailing speeds are less than 50 mph (80 km/h)." and "All responsible agencies should work in cooperation with bicycle groups, enforcement agencies, emergency groups and other roadway users, to develop policies, design standards and implementation techniques that address the safety and operational needs of all roadway users." and "To provide a clear area beyond the rumble strip for bicycle travel, highway maintenance agencies should periodically sweep shoulders along identified bicycle routes of high bicycle usage."[30]

In the United States, the 1999 American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities recommends minimum standards for road shoulders receiving rumble strips to accommodate all users of the roadway and make best use of funds.[53]

In New Jersey, a centerline rumble strip was placed in the vicinity of the D&R Canal[54] without a permit from the Delaware & Raritan Canal Commission in violation of state law.[55] The excessive noise through a residential area and the fact that the work was not appropriately permitted was complained about to the New Jersey Department of Transportation by a local homeowner, with no corrective action taken the New Jersey Department of Transportation.[54]

Excessive noise is noted in a Canadian study as a reason not to install rumble strips, and it is advised not to install rumble strips within 200 meters of a residential area. The report states that "a balance is required between installing effective rumble strips and minimizing noise impacts. Studies show that rumble strips terminated approximately 200 m away from residential or urban areas produce tolerable noise impacts on residences. At an offset of 500 m, the noise from rumble strips is negligible."[56] In an Open Public Records Act Request,[57] this study was the only document provided by the New Jersey Department of Transportation when requested to provide policy documents and safety studies relating to its implementation of centerline rumble strips.

Cycling complaints

Numerous US and Canadian cycling associations have complained about encroachment of rumble strips.[58][59][60][61][62] One club even launched a lawsuit to have them paved over,[63] although the suit was dismissed for lack of standing.[64]

A 2005 Quebec study concluded: "Based on the results of the analyses, it was not possible to recommend a type of rumble strip that would provide sufficient warning to drivers who encroach on the shoulder while remaining safe for cyclists who ride over it."[65] A 2003 Montana study stated that bicyclists cannot operate on shoulders with rumble strips and that shoulders would have to be swept as needed.[19]

Once a section of highway with narrow paved shoulders is rumble-stripped, informed cyclists tend to avoid it, but unsuspecting cyclists occasionally have serious accidents.[66] Much bicyclist opposition to rumble strips stems from situations in which no quantitative data was used to justify their installation, or installation was not in accordance with guidelines. Rumble strips on narrow shoulders force cyclists into the travel lanes, where it is less safe to ride.[59][60][61][62] Furthermore, this scenario forces drivers to make an otherwise unnecessary lane change to go around cyclists and there is a correlation with frequency of lane changes and accidents. "According to the National Highway Traffic Safety Administration, 9 percent (533,000) of all accidents occurred when vehicles were changing lanes or merging."[67] In certain incidents, a vehicle attempting to avoid cyclists (without striking the cyclists) may go off the road or even sideswipe a passing or an oncoming vehicle. Center-line rumble strips are a concern for cyclists as well, as motorists are less inclined to cross the centerline to provide sufficient space when passing bicyclists.[9]

Rumble strips are very inexpensive to install, so there is concern that some installations are frivolous. The 2009 economic stimulus infrastructure spending in the US and Canada has raised concerns that many new shoulder rumble strips will be frivolous as well.[59][60][61][62]

Amish lobby

In 2009 in St. Joseph County, Michigan (US), after a lobbying campaign by the local Amish community, a new $20,000 rumble strip installation was removed at a cost of $275,000 to the

taxpayers. "M-DOT says they are not removing the strips just to appease the Amish. They say it is far more dangerous to have horses jumping out into the road that [sic] it is to not have the rumble strips on the road."[68]

Tire damage

Motor vehicle tires can become permanently damaged if a flat occurs in the traffic lane and the driver pulls over onto the shoulder with the flat tire passing over the rumble strip. This may cause the flat tire's sidewalls to be crushed or abraded between the metal wheel rim and rumble strip high-points.

Wildlife attraction

See also: Roadkill

Wildlife-vehicle collisions can be a significant problem when large animals are involved such as moose, elk, and deer, which can cause serious vehicle damage, injury, and fatalities.[69][70] Separate studies in New Hampshire (US) and Quebec (Canada), of radio-collared moose found that home ranges were associated with salt licks formed by road salt runoff. These roadside salt licks were thought to increase moose-vehicle collisions.[71][72][73] Normally, salt would make its way off the pavement onto the gravel shoulder and into the soil, however, rumble strips will retain and create a salt lick on the road surface. Loose rock salt in the rumble strip subjected to evaporating moisture will cake and accumulate and is not easily dislodged by truck traffic.

Deicing salt-filled and stained rumble strip. The rock salt has been "cemented" in place

See also

- Raised pavement marker
- Road hazard

- Road surface marking
- Road traffic control

Speed bump

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External links

- US FHWA on Rumble Strips

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HB1284
1-19-17
#2

HOUSE TRANSPORTAITON COMMITTEE
January 19, 2017 - 2:00 p.m. – Fort Totten

North Dakota Department of Transportation
Ron Henke, Deputy Director for Engineering

HB 1284

Mr. Chairman and members of the committee, I'm Ron Henke, Deputy Director for Engineering for the North Dakota Department of Transportation (DOT). I'm here today to provide some information as it relates to HB 1284.

The North Dakota Department of Transportation (NDDOT) implemented design criteria for the installation of rumble strips in 2009. Design guidance for rumble strips was developed by combining best practices from other states, user groups such as bicyclists, and information obtained from the NCHRP Report 641. NCHRP Report 641 identified significant reductions in crashes after shoulder and centerline rumble strips were installed.

NCHRP Report 641 identifies a range of values for length, width, depth, and spacing of the grooves. Variations of these values will result in different vibrations and noise levels. Deeper rumble strips also provide more tolerance and longevity for future chip seal and other preventative maintenance projects. The Department has considered all these factors when the design criteria was established.

Research and National studies show conclusive evidence that centerline rumble strips add no measurable risks to motorcyclists. There is also no conclusive evidence to recommend that centerline rumble strips should be discontinued within passing zones. For those reasons, we use continuous rumble strips for the centerline.

Other research and current practice identifies intermittent gaps in the shoulder rumble strip pattern better accommodates the needs of bicyclists. This research and current practice shows it is common to provide periodic gaps in the shoulder rumble strips of ten (10) or twelve (12) feet to enable bicyclists to maneuver from one side of the rumble strip to the other without having to encounter the indentations/grooves. For these reasons, the design criteria for shoulder rumble strips on undivided highways uses a repeating forty-foot rumble strip pattern followed by a ten-foot gap.

The NDDOT has established and implemented design criteria that was developed based on extensive research best practices from other states, and input from user groups. We continue to review any new research that is done so that we can implement new design criteria if needed.

We were also asked to prepare a fiscal note for this bill and we submitted a fiscal note that indicates there is no fiscal impact provided the Department would only be required to follow this guidance when new rumble strips are being installed or reinstalled as part of a project.

Thank you. That concludes my testimony. I'd be happy to answer any questions you may have.