2011 HOUSE TRANSPORTATION

HB 1358

2011 HOUSE STANDING COMMITTEE MINUTES

House Transportation Committee
Fort Totten Room, State Capitol

HB 1358
01/27/2011
Job # 13593

☐ Conference Committee

Committee Clerk Signature	Jeanette Cook

Explanation or reason for introduction of bill/resolution:

HB 1358 is a bill relating to rumble strips.

Minutes:

Attachments #1, 2, 3, 4, and 5

Representative Bill Devlin, District 23 of Finley, spoke to support HB 1358 and provided written testimony. See attachment #1. He stated that people in his area are continually straddling the center line while driving because they don't have enough space to drive in their lane without hitting the strips. There have been motorcyclists that report how dangerous the middle strips are when passing. One farmer said that the strips have destroyed his ability to use his deck, enjoy his yard, and sometimes even his ability to sleep. They make an inordinate amount of noise. Rep. Devlin suggested that the highway department could leave gaps in the strips when coming to a farm yard or make the strips narrower.

Vice Chairman Weiler: If this bill gets passed, will it do your constituents any good? Do these rumble strips wear out, or can they be filled in with something?

Representative Bill Devlin: I would doubt that they could go back in and fill them in without a large expense. The farmer that brought this to us said that he was just trying to protect some other farmers from having to go through this. I don't know if they will wear out.

Eric Aasmundstad, farmer from the Devils Lake area: I also think the twelve inch strips do remove a lot of the driving surface; especially on the narrow highways there is no place to drive without hitting them. I think it is a safety issue, because they people are straddling the center line to keep from hitting them. If there is some way that Department of Transportation can be compelled to make these strips narrower, we would appreciate it.

Chairman Ruby: Are the roads that you refer to pretty narrow on their own?

Eric Asmundstad: On State Highway 19, for example, the shoulders are not kept up and are steep, so the strips are being cut into the paved lane in the road. Some of the highways are getting awfully narrow and unsafe. The equipment that we use is also getting wider. They also pose a really annoying inconvenience.

Representative Vigesaa: In our area they have done overlays which do make the roads somewhat narrower and then put in the rumble strips.

Representative Onstad: In our area we haven't heard any complaints about this issue. In fact, the people were somewhat appreciative of them because it did reduce the speed of traffic in our area.

Representative Heller: Who made the decision to put these strips on the highways?

Representative Weisz: Department of Transportation made the policy to add these strips to the roads. They do things to ensure safety.

There was no further support for HB 1358.

Mark Nelson, Safety Division Director for the North Dakota Department of Transportation, spoke in opposition to HB 1358. He provided written testimony. See attachment #2.

Representative Owens: Could you discuss the size of the rumble strip necessary to get the attention of a driver? Does it matter if the strip is six, eight, or twelve inches?

Ron Henke, Department of Transportation: Six inches is still adequate,

Chairman Ruby: Couldn't you always use six inches in the center?

Ron Henke: We could go to six, but twelve is more effective. If you look at the way that we stripe our roadways, in a no passing area those lines from outer edge to outer edge are twelve inches. So, they match up with the rumble strip. I can see where there is the perception that you are narrowing the lane, but they are twelve inches down to eight, and then down to six.

Chairman Ruby: Do you have certain road width that you use to go to different sizes?

Ron Henke: Yes, I will get you a copy.

Chairman Ruby: Do you consider leaving gaps by farms where you omit the strips and leaving places where motorcycles can pass?

Ron Henke: The only gaps that we provide are around urban areas. We stop one half mile before an urban area. At private drives we skip the drive. Our center line rumble strips have a gap, but not the gap that you are thinking about. It is a different pattern to give a different sound, so the drivers know when it is the center line or the outside edge. We have not considered bigger gaps for motorcycle's to make movements.

Chairman Ruby: Could the gaps be considered around rural homes as well?

Ron Henke: It could be considered. One of our challenges would be to determine how far off the roadway a farmstead should be before you cut in the strips or don't cut them in.

Representative Gruchalla: Are you cutting rumble strips into the left of the fog line in the driving lane?

Ron Henke: We are cutting them in the center line and to the left of the fog line when there is enough shoulder to do so. When we have a four foot shoulder, the strip will be on the outside of the fog line. We will do that up to the point where the rumble strip, twelve inches wide, will come into the edge line. Then we start reducing the rumble strip width. When we have no shoulders, the rumble strip is six inches wide, so, if we place the strip in the right spot two inches will be intruded into that lane.

Mark Nelson: I am aware of a study that was done by Kansas University in conjunction with Kansas Department of Transportation that deals with the noise levels, and I will provide you with a copy of that. It does talk about the distance of farmsteads from the road. See attachment # 3.

There was no further support for HB 1358.

Jody Skogen, North Dakota Highway Patrol, spoke in opposition to HB 1358 and provided written testimony. See attachment # 4.

Representative Onstad: Do you receive complaints about rumble strips?

Jody Skogen: We have not. If we have, I am not aware of them.

Mark Dorhdey, the Associated Contractors of North Dakota, spoke in opposition to HB 1358. He stated that his association puts the strips in the roads. He feels that Department of Transportation does what they think is best for safety, and they support them in that. He thinks that doing this through legislation is not the way to do it. If there are complaints, then the Department of Transportation needs to work with that.

Representative Carlson, spoke in *support* of HB 1358: From a safety standpoint and as a motorcycle rider I don't like the center rumble strips. This will be a policy that the state is going to implement on all two lane highways. I know that we do have high risk areas in the state, and I am not against rumble stripes. But, to make this a statewide policy for every highway and spend that money on roads that have minimal traffic; I think is a mistake. I think that it is against good economic policy. I have also had a few calls from people that don't like the noise. I do agree that there are some areas where they should be used because it is a public safety issue. (Rep. Carlson was delayed because of meeting with the Governor.)

Representative Vigesaa: What is the plan for additional rumble stripes?

Ron Henke: Our current plan is to have rumble strips in all two lane roads by 2013.

Representative Heller: How much do these stripes cost?

Ron Henke: Center line rumble strips cost about $750 per mile. Edge line rumble strips are about $500 per mile per edge. These are unit prices that we are seeing from contractors on the average.

Representative Gruchalla: When you do a chip seal where there are rumble strips, do you have to go back and redo them?

Ron Henke: No, we do not. We have designed them to be effective after the first chip seal, probably even after the second chip seal.

Representative Gruchalla: After a chip seal would they be less obtrusive?

Ron Henke: They would get shallower; I wouldn't say that they would be less effective after one chip seal.

Representative Heller: How many miles are there left to do in the state?

Ron Henke: I can't answer that question because when we do overlay projects, we are cutting rumble strips in. This last year we did our first district wide rumble strip project. We took care of the Williston district. We cut every two lane roadway. We have bid projects to date for the Fargo and the Dickinson districts.

Chairman Ruby: I think that if we are hearing complaints now, it will be a lot worse when it is all done. We may have to consider the overall policy.

Charles W. Murphy, Chairman of the Standing Rock Sioux Tribe, provided testimony for the committee in opposition to HB 1358. See attachment # 5.

There was no further testimony in opposition to HB 1358.
The hearing for HB 1358 was closed.

2011 HOUSE STANDING COMMITTEE MINUTES

House Transportation Committee
Fort Totten Room, State Capitol

HB 1358
02/04/2011
Job # 14046

☐ Conference Committee

Committee Clerk Signature	Jeanette Cook

Explanation or reason for introduction of bill/resolution:

Minutes:

Chairman Ruby brought HB 1358 before the committee.

Representative Vigesaa: This is the rumble stripe bill, and it is a constituent bill from our district. Rep. Devlin and I are on the bill. The Department of Transportation has a very strategic plan for using rumble strips. Not everyone likes them; some people love them. I could bring forth amendments to try to make it better. Whatever the committee would like me to do.

Vice Chairman Weiler: Since the Department of Transportation has a desire to put rumble strips on all two lane roads, do you think that they got the message that maybe they need to change some of their policy in certain areas, like the size of the strips? If that is the case then I am not sure that this bill is needed. I understand the concern of the people who live close to these strips and have to listen to the noise. But, these rumble strips are saving lives and are a good thing.

Representative Vigesaa: I think that the Department of Transportation did get the message that there are concerned citizens out there. What I would do if there are going to be amendments, is make the stripes narrower, and have them try to break sooner before a residence that is close to the highway. It may be difficult for them to administer as well. I think that the Department of Transportation was surprised that this came forward, and that there are a lot of concerned people around the state.

Representative R. Kelsch: The strips are often useful, and I think that there are a lot of people who do like them.

Chairman Ruby: The times that they have especially proven themselves are during low visibility or when there is snow on the roads.

Representative Delmore: When we first had this bill, I sent a text to someone who told me that rumble strips have saved his life. We live in a state that has terrible weather conditions. They may be annoying, but I think it is important that we have them.

Vice Chairman Weiler: Are the narrower stripes less effective?

Representative Vigesaa: I think that Department of Transportation said that as they get narrower, they will be less effective. At high rates of speed you may go over a six inch rumble strip and not hear a lot. The Department of Transportation is the expert. It is not our job to micromanage them. They study these issues, and it is their business to engineer the strips to be proper.

Vice Chairman Weiler: If you would get considerably less noise out of an eight inch or nine inch strip, and it would still have the same basic safety, then maybe something like that would work. The concern that we heard from motorcycle drivers is that the twelve inch strips in the center are really dangerous. I am not proposing that we make the Department of Transportation change this. If there is a way it could work out for both sides, it would be nice.

Representative Weisz: Department of Transportation pointed out in testimony that on eleven foot roads they have already gone to a six inch strip in the center of the road. If you cross a six inch strip as opposed to a twelve inch strip, you cut the time in half that you hear the noise. In some states they have small gaps that allow motorcycles to pass.

Representative Weisz moved a DO NOT PASS on HB 1358.

Vice Chairman Weiler seconded the motion.

A roll call vote was taken. Aye 13 Nay 1 Absent 0
The motion carried.

Representative Sukut will carry HB 1358.

Vice Chairman Weiler: If we went to eight inches and the noise is less, maybe that would work.

Representative Weisz: I have had several discussions with Department of Transportation on this issue. On roads that are

Date: 2-4-11

Roll Call Vote #: 1

2011 HOUSE STANDING COMMITTEE ROLL CALL VOTES

BILL/RESOLUTION NO. 1358

House TRANSPORTATION Committee

☐ Check here for Conference Committee

Legislative Council Amendment Number ______

Action Taken ☐ Do Pass ☒ Do Not Pass ☐ Amended ☐ Adopt Amendment

☐ Rerefer to Appropriations ☐ Reconsider

Motion Made By Weisz Seconded By Weiler

Representatives	Yes	No	Representatives	Yes	No
Chairman Ruby	X		Representative Delmore	X	
Vice Chairman Weiler	X		Representative Gruchalla	X	
Representative Frantsvog	X		Representative Hogan	X	
Representative Heller	X		Representative Onstad	X	
Representative R. Kelsch	X				
Representative Louser	X				
Representative Owens	X				
Representative Sukut	X				
Representative Vigesaa		X			
Representative Weisz	X				

Total (Yes) 13 No 1

Absent 0

Floor Assignment Sukut

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

REPORT OF STANDING COMMITTEE

HB 1358: Transportation Committee (Rep. Ruby, Chairman) recommends **DO NOT PASS** (13 YEAS, 1 NAYS, 0 ABSENT AND NOT VOTING). HB 1358 was placed on the Eleventh order on the calendar.

2011 TESTIMONY

HB 1358

#1

Good Afternoon chairman Ruby and esteemed members of the House Transportation Committee:

For the record I am Rep. Bill Devlin of Finley and I along with Rep. Vigesaa represent District 23 in the Legislature. District 23 is a rural district in the eastern part of the state that includes all or parts of five counties.

I am here in support of HB1358. In the overall scheme of things we deal with in the Legislature in the legislature this isn't one of those bills that grabs a lot of attention but for some of our constituents it is a very important bill and that is why they asked us to do something about it by introducing a bill.

This bill quite simply removes what we call rumble strips from the driving surface of the road inside the two white lines.

If you spend most of your time on the interstate highways and four lane roads you don't have to deal with this issue. If you go out on the interstate and you get to far our past the white line you will hit the rumble strips to remind you to pay attention not run in the ditch. I have no problem with that as they are mostly located a foot or more from the white line and most people don't know they are there. I also have no problem when they are used to alert drivers to upcoming intersections.

But on the narrow two lane roads in our area and I understand eventually every two lane road in the state they are a continuous strip cut into the pavement on each side of the road and down the center. They aren't put in place with any type of gaps but instead run continuously for hundreds of miles except in towns and partially along some farms.

On the roads in my area they are 12 inches wide down the center of the road and down the edges. Unfortunately the state highway department, in an effort to save money, decided paved shoulders weren't needed. Therefore the strips go on the white lines and towards the center. You lose a foot or more of driving surface whenever they do that. Logic would make you think it you had not paved shoulder and had a gravel shoulder anyone driving a vehicle would know when they hit the rough gravel they would figure out they were getting close to the ditch.

I have driven a car in all 50 states and have never run into anything like this. Most states use the small reflector type deals in the middle. Others use some type of alerts every so often on a road but not a continuous mini speed bump. We may not be able to use the reflectors because of snow plow issues but certainly we can find a way to protect the public and still allow the people of our state to be impacted in a less intrusive way.

I expect those testifying behind me will say this is a safety issue. I agree with part of that.

I believe it creates unsafe conditions for motorcycle drivers and believe Rep. Carlson will talk a little about that. I had a biker from my area say you take your life in your hands every time you have to pass someone when you hit the strips going out to pass and coming back into your lane.

I think you force more people to straddle the centerline creating unsafe conditions. That happens all the time in our area in the winter when there are pillow drifts in on the edge of your driving lane. Before you would crowd the centerline until you saw someone coming and move back over. Now you can't drive where the pillow drifts are and you can't drive on the strips so you move over and straddle the strips and centerline. You have no choice.

I have had people with wide loads in this case someone hauling wind-towers that said they almost shook their teeth out of their heads as they were constantly driving on them to allow on-coming cars more space..

I have had farmers tell me that taking a load of grain to town in our area is like driving a truck down a railroad track. To them the strips aren't much different than driving on mile after mile of railroad ties.

One of our constituents in Griggs County said the strips have taken away the peaceful tranquility of his farmstead. As vehicles go by and hit the strips he hears them in his house. He said that they could no longer sit in the yard or on a deck and enjoy his yard because of the noise created by people hitting the strips. I had another farmer in Steele County tell me the same thing.

The Griggs County Farmer isn't one who recently moved to the farm for the quiet tranquility of the country. His family homesteaded there in 1883 and his house was built in 1906. In fact the highway didn't even go past his farm until the 1950s.

Part of his problem could be averted if this committee would force the highway department to not put rumble strips on the road by the farm. The same scenario is used when you come to towns could be used. They stop before they get to the town and don't start again until well past the town.

I think what you have created is nightmare for the people that have to use these roads or live by them.

I can't combat the statistics that department will use to bolster their case. But I think this committee should look long and hard at that information. I couldn't find on their website the number of head-on crashes and one car roll-overs. I would be surprised if they show a sharp increase that weren't alcohol or animal related. If we have to address this for safety reasons I hope this committee will find a way to make them a little more palatable for the people of rural North Dakota that have to deal with them every day.

If this committee doesn't want to go the whole way and eliminate them at least help us out by saying they can't be inside the white lines, they can't run continuously down the roads for mile after mile but instead must be place in intervals that allows bikers and others to pass without hitting them. Don't allow them to be placed near the occupied farmsteads and don't allow them to be any wider than four inches in any spot.

Chairman Ruby and members of the committee that concludes my testimony and I would be happy to try answer and questions you might have for me.

#2

HOUSE TRANSPORTATION COMMITTEE
January 27th – 2:30 p.m. – Fort Totten Room

North Dakota Department of Transportation
Mark Nelson, Director, Safety Division

HB 1358

Mr. Chairman, and members of the Committee, good afternoon, my name is Mark Nelson, and I serve as the Safety Division Director for the North Dakota Department of Transportation (NDDOT).

I am here today on behalf of the Department to speak in opposition to HB 1358, a bill that would eliminate the use of center-line rumble strips/stripes (CLRS) on North Dakota roadways.

The mission of our agency is clear: 'To Provide a Transportation System that Safely Moves People and Goods'. In the ongoing effort to remain focused on this mission, we are constantly looking for ways to reduce and eliminate traffic deaths on our roadways.

One type of crash that continues to be the number one contributing factor in fatalities in North Dakota is the lane departure crash. Lane departure crashes are defined as follows:

- vehicles leaving the roadway to the left,
- vehicles leaving the roadway to the right,
- sideswipe in opposite direction and
- vehicles meeting head-on.

Nearly 62% of all fatal crashes during the past three years (2008-2010) involved lane departure.

Why do lane departure crashes occur and what causes drivers to leave their designated lanes? In a report published by the Federal Highway Administration (FHWA), "Many factors, and combination of factors, contribute, including driver fatigue and drowsiness; distracted driving; and slippery road surfaces and poor visibility in adverse weather conditions."

How do CLRS work? When drivers are about to cross the centerline, the CLRS will create noise and vibration, alerting the driver that they are about to cross into the oncoming lane and that immediate corrective action is necessary to remain in their lane of travel.

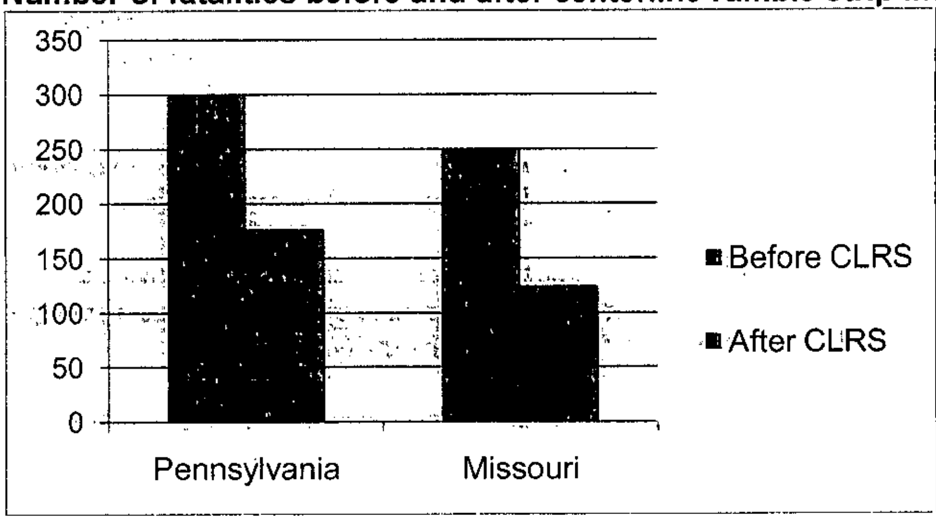
Nationwide, CLRS are a recognized and proven strategy to reduce lane departure crashes. Eleven states and one national study published by the FHWA concluded that cross-over crashes were reduced 18 to 64 percent, with most states showing a 40 to 60 percent reduction.

I recently had the opportunity to participate in a domestic scan sponsored by the American Association of State Highway Transportation Officials (AASHTO) that was entitled 'Best

Practices in Solutions for Lane Departure Avoidance'. The scan team focused on low cost initiatives taken by transportation agencies to mitigate the causes and effects of lane departures, and one of the key findings included strong support for CLRS implementation.

The following are two examples of results from states that have implemented a CLRS program. In Pennsylvania, head-on fatalities in those areas with CLRS installed have decreased from 300 head-on fatalities per year to 177 in 2009, a 41% decrease. And in Missouri, CLRS have reduced head-on and oncoming sideswipe crashes by 51%.

Number of fatalities before and after centerline rumble strip installation



Just next door in Minnesota, since installing CLRS on many of their rural roadways, the Minnesota Department of Transportation has experienced:

- A 73 percent lower rate of fatal and very severe crashes
- A 42 percent lower crash rate overall
- A 37 percent lower crash severity rate and
- A 9 percent reduction in crash density (the number of crashes per mile).

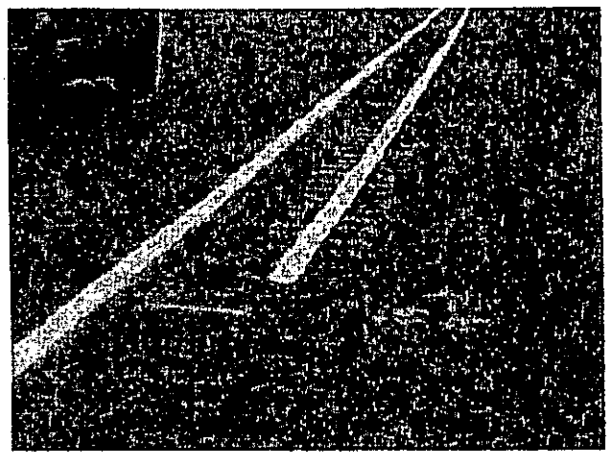
During my past career with the North Dakota Highway Patrol, it was frustrating for me to see that consistently over 100 people were killed per year on our highways. Enforcement efforts were conducted on a regular basis to target alcohol and seatbelt violations; radar and lidar patrols were emphasized to target speed; but it seemed that no matter how much enforcement effort was placed on these high emphasis areas, the number of fatalities always seemed to remain relatively consistent.

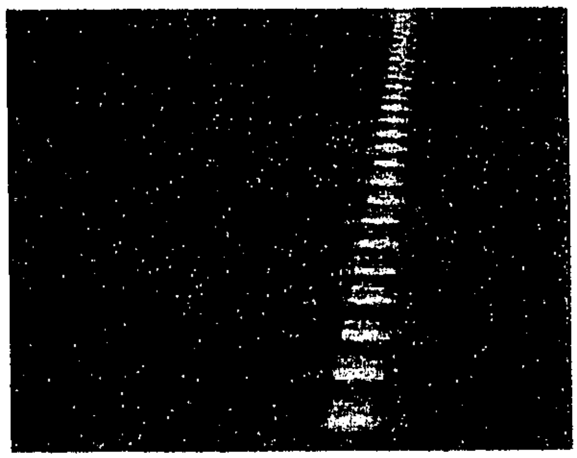
What is exciting to see in the research on CLRS is the effectiveness in which they are working; they are making a difference nationwide, and we are confident that they will make a significant difference in North Dakota. Before we installed CLRS on ND 1806 and ND 24 there were two fatal crashes from January 1, 2005 to October 31, 2008. After the CLRS were installed in October 2008 as our first test project there were zero fatal crashes on the exact same 62 miles of highway from November 1, 2008 to current.

From 2008 through 2010, we have seen 25 fatal crashes resulting in 37deaths that were attributed to head-on and sideswipe lane departure crashes, on state highways in North Dakota. Of these 25 crashes, 24 occurred in rural areas where CLRS have not been installed, and the 1 fatality crash that did occur where CLRS were installed involved a driver who intentionally crossed the CLRS in an attempt to pass in foggy weather conditions and struck an oncoming vehicle head-on.

Using the crash reduction numbers as reported by other states and applying them to our fatal crash history from 2008-2010, a reduction of 40% in fatal crashes would equate to 10 less fatal crashes, and a reduction of 60% during that same time period would have resulted in 15 less fatal crashes, how many of these 37 victims over the past three years could have been saved?

Research has also found that they are easier to see in inclement weather because there is greater reflectivity.





Rumble stripes daytime (left) and at night in the rain (right). Note the brightness of the rumble stripes as compared to the normal pavement marking to the left of the rumble line.

During the past month, the state has seen storm after storm hit and deposit considerable amounts of snow on our roadways, travel has been difficult to say the least, and the fatality numbers have been high. What I have found in my conversations on CLRS by citizens, is how they were able to navigate on the snow-covered roadways through the use of the CLRS and shoulder rumble-strips. When the center line could not be seen, and visibility was poor, drivers have been able to recognize that they were about to enter the oncoming lane by hitting the CLRS, and take immediate corrective measures to remain in their lane.

Personally, I can recall numerous times when I was on patrol during winter storms where an oncoming vehicle created white out conditions as they went by my squad car. As I continued to drive in complete zero visibility, and having no idea where my vehicle was in relation to the roadway, I hoped that I could continue traveling straight in my lane until visibility improved. What an uncomfortable feeling of sheer panic that a crash wouldn't occur. The benefits of CLRS installed in these instances are a potential lifesaver!

Recently, a 28 year old man from Devils Lake was killed in a head-on collision on U.S. Highway 281 near New Rockford. The highway patrol reported that a semi driver became disoriented when a truck he was following hit snow, throwing up snow fog and reducing visibility. The semi driver crossed into the oncoming lane of traffic and struck the oncoming vehicle head-on, the 28 year old man was killed. Would CLRS at that location helped the semi-driver to realize his position on the roadway?

And in southwest North Dakota, a state snow plow was clearing the road and kicking up snow fog, when a vehicle passed by him in the opposite direction, the driver of that vehicle became disoriented in the snow fog and crossed over into the oncoming lane of travel, a head-on occurred and one of the drivers was killed, could CLRS have prevented this crash?

We have an opportunity in our state to save lives on our roadways. Through this engineering countermeasure, we have the ability to correct driver behavior immediately, it doesn't require any enforcement action, no citations are issued, but yet the corrective action is taken!

The National Highway Traffic Safety Administration (NHTSA) made the following policy statement regarding distracted driving:

> "States can take some steps immediately to reduce the risks of distracted driving. One example is installing rumble strips along the road to get drivers attention before they leave the roadway and/or deviate from their lane.'

Saving Lives in North Dakota remains our mission within the NDDOT, a responsibility that is shared with all of our safety partners. The goal of highway safety in North Dakota is clear; to continue to move Towards Zero Deaths on our highways. I have every confidence that as the CLRS program continues, we will see a difference in lane departure crashes, and lives will be saved in North Dakota!

Mr. Chairman, this concludes my testimony and I will be happy to answer any questions.

#3
H 6/1353

CHAPTER 2 - A STUDY OF EXTERIOR NOISE

The objective of this study was to quantify the level of exterior noise created by CLRS and to discover if the mean level of noise created by CLRS is statistically different than the noise generated by vehicles driving over smooth pavement.

2.1 Literature review

Several studies have been conducted in order to verify if rumble strips increase noise levels and disturb residents, but no one provided definitive conclusions. Some of the studies are listed below.

- Higgins and Barbel (1984), tested several configurations of transverse rumble strips (TRS) in Illinois. Results: at 50 feet distance the increase in the noise levels was 7 dB compared to the base noise levels. Different configurations (formed and cut type) of TRS had no effect on exterior noise. The noise created by a commercial vehicle traveling over smooth pavement was slightly higher and had longer duration than the noise associated to cars traveling over TRS.
- Gupta (1993) measured the noise generated by cars and trucks at 10 feet when driven over smooth pavement and over rumble strips in Ohio. Results: rumble strips increased the maximum level of noise in 5 dB, compared to the base lane. This difference was 7 dB for trucks.
- Chen (1994) compared the exterior noise levels between a van driven over milled rumble strips and a truck driven over an asphalt surface without rumble strips in Virginia. Conclusion: at 200 feet the effect of the rumble strips noise on surrounding environments can be ignored.

- Sutton and Wray (1996) studied the increase of external noise associated with TRS in Texas. Results: at the edge of the pavement, the maximum difference in comparison to the base level noise was 12 dB. At 25 and 50 feet, the difference was 8 and 7dB, respectively. Conclusion: in order for the difference to be zero, the distance would be approximately 200 feet.
- Meyer and Walton (2002) compared "rumbler" (removable) and asphalt rumble strips at two different work zone locations in Kansas. Results: rumbler presented higher levels of noise, and it could be an efficient alternative for work zones due to its versatility.
- Finley and Miles (2007) measured the exterior noise produced by two types of vehicles (sedan and truck) traveling over five types of rumble strips applications at two different speeds (50 and 70 mph) in Texas. Results: 87 percent of the maximum baseline noise levels for trucks were greater than the peak rumble strips levels. Differences greater than 4 dB, in comparison to baseline conditions, occurred in more than half of rumble strips configurations. Differences were greater at 70 mph and lower for the truck. Pavement type (chip seal vs. hot mix asphalt) had significant effect on the noise levels. In addition, noise levels increased as milled rumble strips' width increased and as the spacing decreased.
- Kragh et al., (2007) compared the noise generated by five different types of milled CLRS in comparison to baseline conditions in Denmark. Three types of vehicles were driven at a speed of 80 km/h (49.7 mph), and the external noise was measured at 25 feet from the center line. Results: the

two tested patterns of sinusoidal strips (shown in Figure 2.1) presented the lowest difference, leading to an increase of only 0.5 – 1 dB in the external noise level. The rectangular strips presented the highest difference (3 – 7 dB).

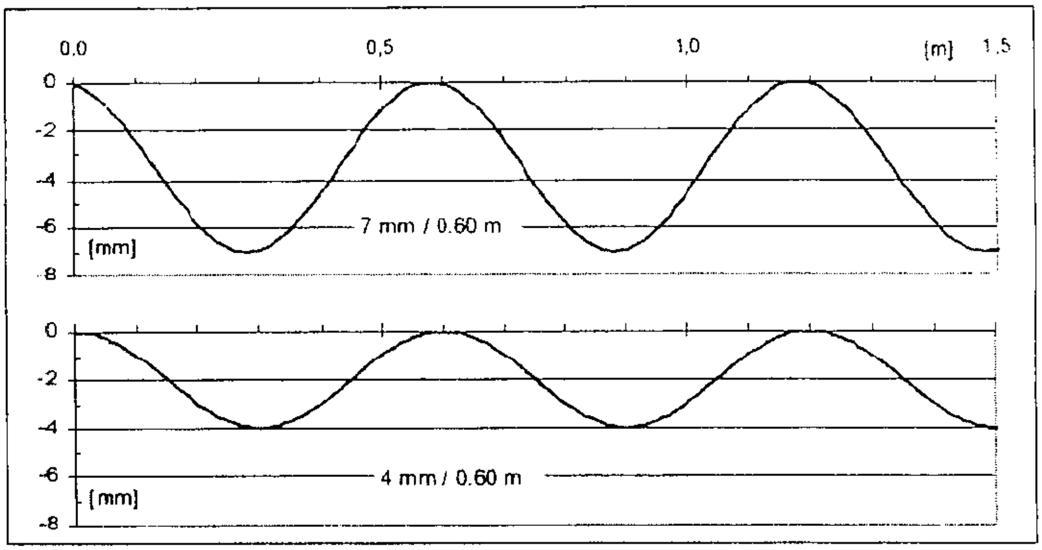


Figure 2.1: Sinusoidal strips. Source: Kragh et al. (2007)

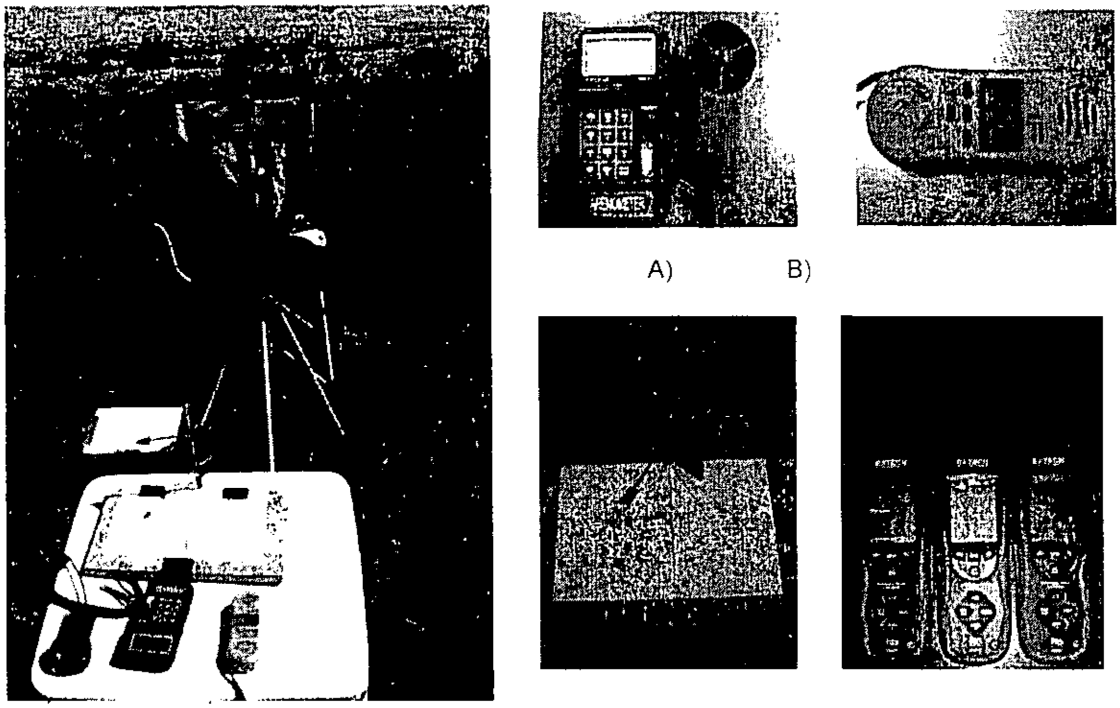
2.2 Methodology

2.2.1 Data Collection

Initially, the study sites presented in Table 2.1 were selected from a list of locations where the Kansas Department of Transportation (KDOT) had already installed CLRS. Five locations that had rectangular CLRS and five locations that had football-shaped CLRS were selected. The locations had a posted speed limit of 65 mph, and were specifically chosen in order to minimize the travel distance from Manhattan Kansas. Data were collected under dry, day time conditions, at flat and open space locations. Three noise meters with data logger systems were placed at 50, 100, and 150 feet orthogonally measured from the center line of the highways. Three Extech HD600 noise meters (type 2 acoustical instrument) were used for data collection. The noise meter had a range of 30 to 130 dB and accuracy of 1.4 dB. The noise meters were calibrated before each series of measurements per location. The wind direction was measured using a wind vane / angle sheet equipment. A Prova AVM-07 anemometer was used to measure wind speed. Temperatures and humidity levels were measured at the beginning of the series of measurements per location and whenever perceptible changes in the weather occurred. A CE LM-81HT thermometer / anemometer / humidity meter was used to measure humidity and temperatures. Figure 2.2 shows the equipment used during the data collection. The rumble strip depth dimension was measured with a caliper. For each location, the depth was determined by averaging five measurements. The tire pressure for each test vehicle was measured at cold tire conditions.

Table 2.1: List of study sites selected

Location	County Name	Highway	Rumble Strip Type	Length (Miles)	KDOT Asphalt Classification
1	Chase	US-50	Football	19.0	Overlay 3",Ultrathin Bonded Asp Surf
2	Ellsworth	KS-156	Football	14.9	New Construction (IFD=3)
3	Brown	US-75	Football	13.0	Cold Mill 1", Overlay 1.5"
4	Doniphan	US-36	Football	6.1	Cold Mill .5", Overlay 1.5"
5	Reno	US-50	Football	9.7	Cold Mill 4", Recy Hot 6", Overlay .75"
6	Jefferson	US-24	Rectangular	6.7	Surface Recy 2", Overlay 1"
7	Chase	US-50	Rectangular	7.4	Surf Recy 2",Ultrathin Bonded Asp Surf
8	Osage	US-75	Rectangular	9.6	Surf Recy 2",Ultrathin Bonded Asp Surf
9	Barton	US-56	Rectangular	9.7	Cold Mill 1", Overlay 1.5"
10	Harvey	US-50	Rectangular	17.5	Overlay 1"



A) Prova AVM-07 anemometer. B) CE LM-81HT thermometer / anemometer / humidity meter.
C) Wind vane / angle sheet equipment. D) Extech HD600 noise meters.

Figure 2.2: Equipments used during data collection

Exterior noise data were collected per "base level run" or "rumble strip run". The base level run consisted of a test vehicle traveling over smooth asphalt pavement at two different speed levels, 40 mph and 65 mph, in a 393 feet (120 meter) straight segment of highway. The rumble strip run had the test vehicles traveling over CLRS at two different speed levels, 40 mph and 65 mph, in a 393 feet straight segment of highway. The segment of highway at which the noise data were collected per location was marked with two traffic cones, as shown in Figures 2.3 and 2.4. Runs that had another vehicle traveling within the 393 feet segment of highway were not considered, in order to avoid noise contamination. Three runs of each vehicle, pavement, and speed combination were recorded to insure pure experimental error. The order of the runs and the position of the three noise meters were randomly assigned per location. At one specific location, noise levels of 14 semi-trucks were collected at smooth pavement condition and highway operation speeds.

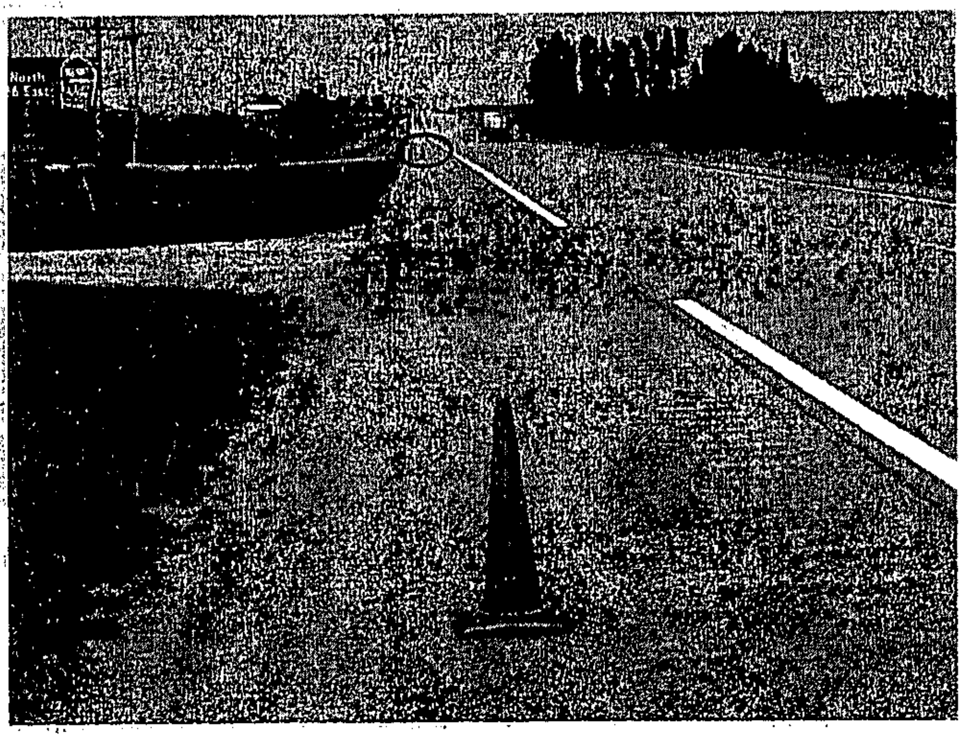


Figure 2.3: Traffic cones delimiting the experimental unit – 393 feet of highway

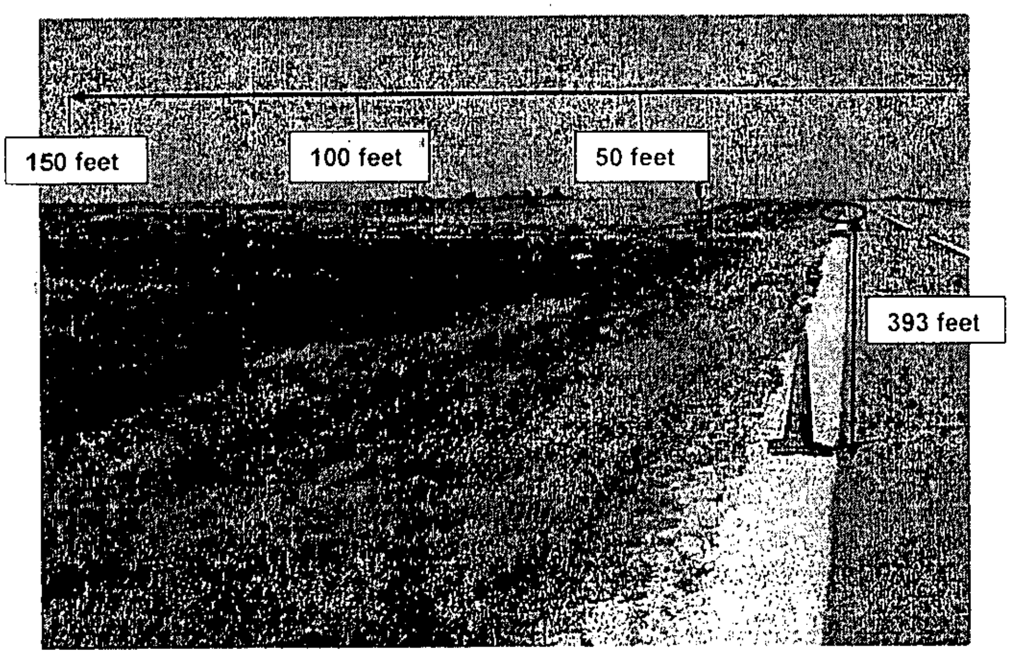


Figure 2.4: Set up of the experiment

The data point associated with each run was the highest noise level recorded at the fast response (125 ms), and using dBA scale, added to the wind contribution factor, to get "corrected noise" values. The wind contribution was calculated using Equation 2.1, given by Cho et. al (2004).

$$A_{wind} = - [0.88 * \log_{10} (L / 15)] * U * \cos \theta \qquad \text{Equation 2.1}$$

Where:

L = distance horizontal in meters, from the source of the noise to the instrument;

U = wind speed, in m/s;

θ = angle in radian, between the wind direction and the line from the vehicles to the instrument.

The two vehicles used are presented in Figure 2.5. They were the 2006 Ford Taurus, and the 2008 Chevrolet Express - 15 passenger van, which weighs approximately 10,000 lbs.

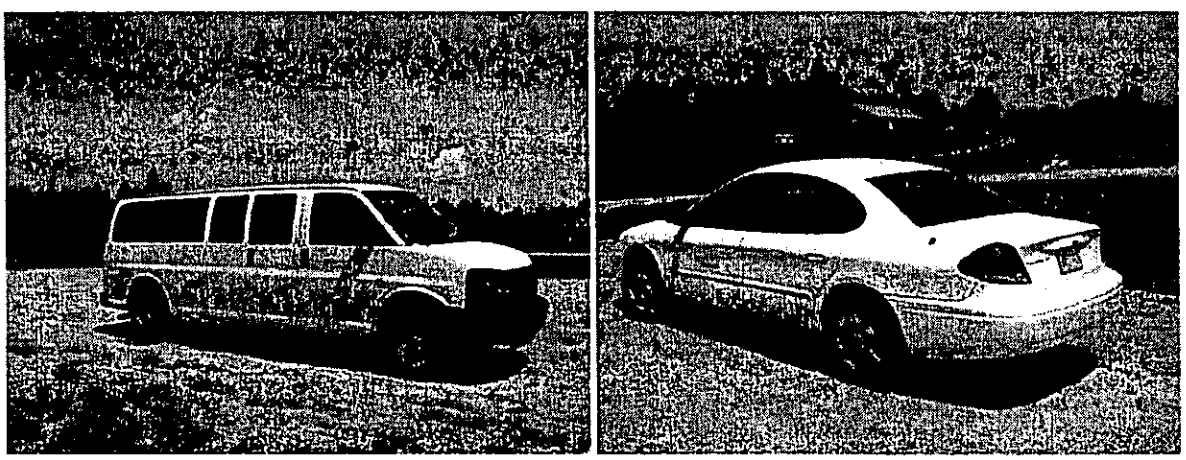


Figure 2.5: Vehicles used in the experiment

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The purpose of this analysis was to verify the effects of type of vehicle, speed, and pavement conditions (football or rectangular rumble strips, or smooth) on the exterior noise. According to Meyer and Walton, (2002) humans can discern noise differences of at minimum 3dBA. Noise levels from 24 runs per location were taken, and the total number of runs was 240. The data points per run were collected, corresponding to distances of 50, 100, and 150 feet.

This experiment was analyzed as a split-plot design. The whole-plot level had a completely randomized block design with three treatment factors: vehicle (VEH), speed (SPD), and LP (factor that contained information about location and pavement). The error term for the whole-plot level was the three-way interaction. The split-plot level had the distance factor (DIST) because the noise levels at different distances in a straight line from the source were assumed to be correlated with each other. The error term for the split plot level was the four-way interaction. Since three replicates of each run were taken, this experiment had a pure error term. The Mixed Procedure in SAS was used to analyze the data.

Four different models were built. The first model had no covariate. The second model had humidity as a covariate, the third had temperature as a covariate, and the fourth had both humidity and temperature as covariates. The best model was without covariates, as shown in Tables 2.2 and 2.3.

Table 2.2: ANOVA Table - Model without covariates

Effect	NUM DF	DEN DF	F Value	Pr > F
LP	19	19	23.74	<.0001 *
VEH	1	19	57.45	<.0001 *
SPD	1	19	269.17	<.0001 *
VEH*LP	19	19	1.47	0.2040
SPD*LP	19	19	2.05	0.0629
VEH*SPD	1	19	5.15	0.0351 *
DIST	2	38	1102.18	<.0001 *
DIST*LP	38	38	2.61	0.0019 *
VEH*DIST	2	38	0.44	0.6487
SPD*DIST	2	38	2.63	0.0855
VEH*DIST*LP	38	38	0.47	0.9895
SPD*DIST*LP	38	38	0.51	0.9791
VEH*SPD*DIST	2	38	0.84	0.4413

*Statistically significant at 0.05 level

Table 2.3: Orthogonal contrasts

Contrast #	Label	Num DF	Den DF	F Value	Pr > F
1	SMOOTH F vs. SMOOTH R	1	19	4.07	0.0581
2	RUMBLE STRIPS vs. SMOOTH	1	19	307.70	< 0.0001 *
3	FOOTBALL vs. RECTANGULAR	1	19	0.05	0.8318
4	SMOOTH F vs. FOOTBALL RS	1	19	132.96	< 0.0001 *
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Figure 2.6 shows the individual values of corrected noise, according to distances, speed levels, vehicles, and pavement types.

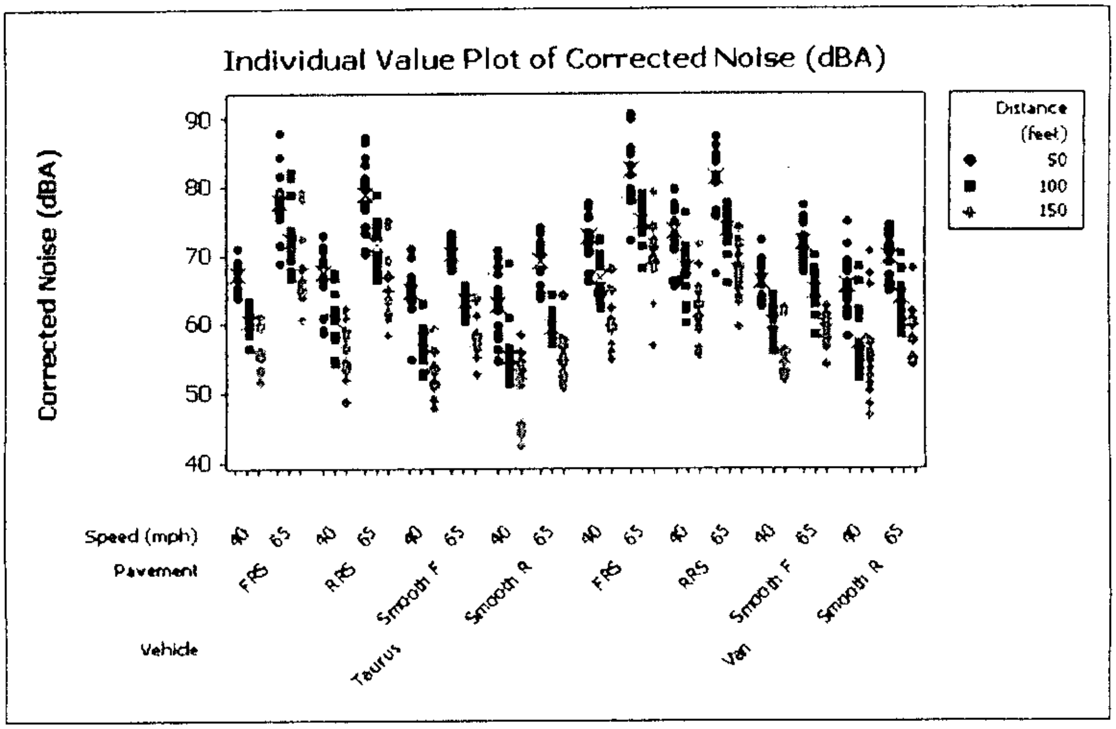

Figure 2.6: Individual values of corrected noise

Table 2.4 presents the mean levels of noise, and the differences between rumble strips and baseline runs.

Table 2.4: Mean levels of noise and differences between rumble strips and baseline runs

Corrected noise (dBA) at:			50 feet	100 feet	150 feet	Corrected noise (dBA) at:				50 feet	100 feet	150 feet
Taurus	40	FRS	67.12	60.26	55.77	Van	40	FRS	50	72.49	66.57	60.88
Taurus	40	Smooth F	64.63	57.8	52.38	Van	40	Smooth F	50	65.93	60	54.86
Difference			**2.48**	**2.46**	**3.39**	**Difference**				**6.56**	**6.57**	**6.02**
Taurus	40	RRS	67.45	60.67	55.41	Van	40	RRS	50	73.36	67.84	61.82
Taurus	40	Smooth R	62.81	55.07	50.99	Van	40	Smooth R	50	65.4	57.23	56.23
Difference			**4.64**	**5.6**	**4.42**	**Difference**				**7.96**	**10.61**	**5.6**
Taurus	65	FRS	77.91	72.18	67.26	Van	65	FRS	50	82.36	74.87	69.98
Taurus	65	Smooth F	70.27	63.21	57.75	Van	65	Smooth F	50	71.7	64.7	58.64
Difference			**7.64**	**8.97**	**9.51**	**Difference**				**10.66**	**10.16**	**11.34**
Taurus	65	RRS	78.82	71.59	65.89	Van	65	RRS	50	81.46	73.66	67.53
Taurus	65	Smooth R	69	59.57	55.7	Van	65	Smooth R	50	69.59	63.84	58.55
Difference			**9.82**	**12.03**	**10.19**	**Difference**				**11.87**	**9.83**	**8.98**

2.3 KEY FINDINGS

- The Taurus mean level of noise (63.37 ± 0.31 dBA) was significantly lower compared to the mean level noise of the Chevrolet van (66.71 ± 0.31 dBA); the P-value of this test was smaller than 0.001. However, the highest difference in levels of noise of rumble strips, in comparison to smooth pavement, was measured at 100 feet when the Taurus was traveling at 65 mph.
- Overall, the mean level of noise at 40 mph (61.42 ± 0.31 dBA) was significantly lower compared to the mean level of noise at 65 mph (68.65 ± 0.31 dBA); the P-value of this test was smaller than 0.0001.
- Overall, the mean level of noise at 50 feet (71.27 ± 0.26 dBA) was significantly higher than the noise at 100 feet (64.50 ± 0.27 dBA) and 150 feet (59.34 ± 0.26 dBA), which were also different from each other; the P-values of these tests were smaller than 0.0001.
- In general, mean noise levels dropped 9.5 percent from 50 to 100 feet and 8.0 percent from 100 to 150 feet.
- The mean level of noise generated by smooth pavement at locations with football CLRS (61.17 dBA) were not significantly different from the noise levels on smooth pavement at locations with rectangular rumble strips (61.80 dBA); the P-value of this test was 0.0581.
- The levels of noise generated by CLRS (68.90 dBA) was significantly greater than the noise generated by smooth pavement (61.17 dBA); the P-value of this test was smaller than 0.0001.

- The interaction between speed and vehicle was significant. The P-value of this test was 0.0351. It means that the levels of noise of the Taurus and the Chevrolet van have different trends, according to the speed, as shown in Figure 2.7.

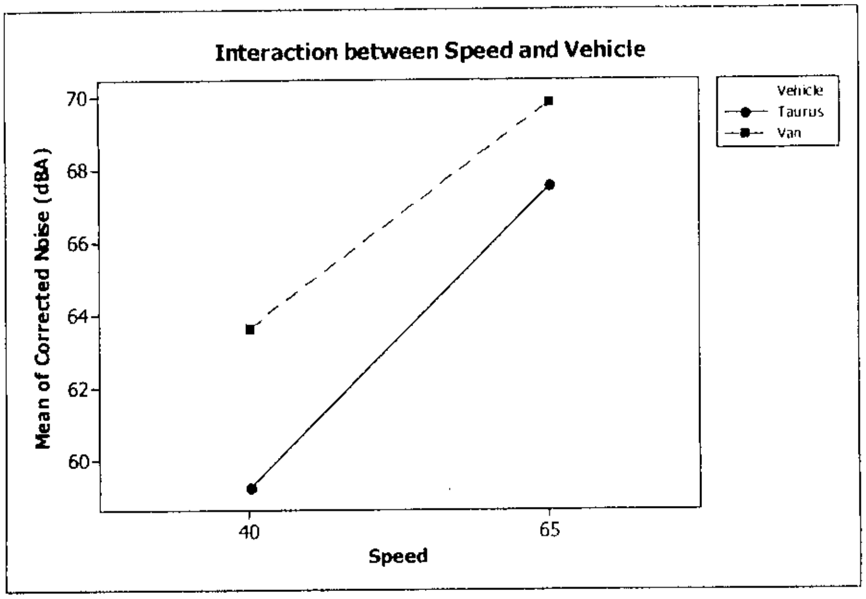

Figure 2.7: Interaction plot between speed and vehicle factors

- The interaction between distance and LP was significant. It means that the variation of noise per level of distance was different across the locations. Probably due to differences between types of asphalt.
- There was no significant difference between rectangular (68.83 dBA) and football (68.97 dBA) CLRS; the P-value of this test was 0.8318.
- Semi-trucks traveling at operational speeds (approximately 65 mph) over smooth pavement produced higher levels of noise compared to the Taurus and the Chevrolet van traveling over rumble strips, as shown in Table 2.5.

Table 2.5: Comparison to semi-trucks

Mean Corrected Noise (dBA)			
Distance (feet)	Taurus RS	Van RS	**Semi-Trucks**
50	78.36	81.91	**83.89**
100	71.89	74.27	**76.4**
150	66.58	68.76	**73.14**

- In order to predict the critical distance at which the levels of noise produced by rumble strips would be at acceptable levels, four regression models were built. The first model described the variation of noise for the Taurus traveling over rumble strips at 65mph. The second model had data from the Taurus traveling over smooth pavement at 65 mph. The third model had data of the Chevrolet van traveling over rumble strips at 65 mph, and the forth model had data from the Chevrolet van over smooth pavement at 65 mph. The predictor of each model was distance. Table 2.6 shows the regression analysis results.

Table 2.6: Regression models results

Model 1: Noise = 84.1 - 0.118 * Distance				**Model 2: Noise = 75.5 - 0.129 * Distance**			
Distance	**Prediction**	**Real Average**	**Difference**	**Distance**	**Prediction**	**Real Average**	**Difference**
50	78.17	78.36	-0.19	50	69.07	69.61	-0.54
100	72.28	71.89	0.40	100	62.61	61.46	1.15
150	66.40	66.58	-0.18	150	56.15	56.69	-0.54
200	60.51	*	*	200	49.69	*	*
Model 1: Noise = 84.1 - 0.118 * Distance				**Model 2: Noise = 75.5 - 0.129 * Distance**			
Distance	**Prediction**	**Real Average**	**Difference**	**Distance**	**Prediction**	**Real Average**	**Difference**
50	81.57	81.91	-0.34	50	70.56	70.68	-0.12
100	74.99	74.27	0.73	100	64.52	64.28	0.24
150	68.42	68.76	-0.34	150	58.48	58.60	-0.12
200	61.84	*	*	200	52.44	*	*

Table 2.7: Typical noise levels for common sounds

Event	Noise (dB)
Soft whisper	30
Refrigerator	40
Normal conversation	50
Television	60
Noisy restaurant	70
Dishwasher	75
Blow dryer	80
Electric razor	85
Lawn mower	90
Roar of crowd	95
Power tools	100
Stereo headset	110
Rock concert	120
.22 caliber rifle	130
Jet take-off	140

- According to Benekohal et al (1992) cited by Meyer (2002), the typical noise levels of common sound events are given by Table 2.7.The noise produced by rumble strips at 200 ft is comparable to the noise produced by a television, which should be considered acceptable.

2.4 CONCLUSIONS

From the analyses performed, it can be concluded that the external noise depends on the speed (the lower the speed, the lower the noise), type of vehicles (heavier vehicles have a tendency to produce more noise), and distance (the greater the distance, the lower the noise).

Both football and rectangular CLRS do increase the levels of external noise. Therefore, before installing CLRS, the distance from houses or businesses should be measured. Based on the analysis using only one light and one medium vehicle, a distance of 200 ft from the centerline should be considered. This is the distance where noise from CLRS is no greater than smooth pavement.

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CHAPTER 2 - A STUDY OF EXTERIOR NOISE

The objective of this study was to quantify the level of exterior noise created by CLRS and to discover if the mean level of noise created by CLRS is statistically different than the noise generated by vehicles driving over smooth pavement.

2.1 Literature review

Several studies have been conducted in order to verify if rumble strips increase noise levels and disturb residents, but no one provided definitive conclusions. Some of the studies are listed below.

- Higgins and Barbel (1984), tested several configurations of transverse rumble strips (TRS) in Illinois. Results: at 50 feet distance the increase in the noise levels was 7 dB compared to the base noise levels. Different configurations (formed and cut type) of TRS had no effect on exterior noise. The noise created by a commercial vehicle traveling over smooth pavement was slightly higher and had longer duration than the noise associated to cars traveling over TRS.
- Gupta (1993) measured the noise generated by cars and trucks at 10 feet when driven over smooth pavement and over rumble strips in Ohio. Results: rumble strips increased the maximum level of noise in 5 dB, compared to the base lane. This difference was 7 dB for trucks.
- Chen (1994) compared the exterior noise levels between a van driven over milled rumble strips and a truck driven over an asphalt surface without rumble strips in Virginia. Conclusion: at 200 feet the effect of the rumble strips noise on surrounding environments can be ignored.

- Sutton and Wray (1996) studied the increase of external noise associated with TRS in Texas. Results: at the edge of the pavement, the maximum difference in comparison to the base level noise was 12 dB. At 25 and 50 feet, the difference was 8 and 7dB, respectively. Conclusion: in order for the difference to be zero, the distance would be approximately 200 feet.
- Meyer and Walton (2002) compared "rumbler" (removable) and asphalt rumble strips at two different work zone locations in Kansas. Results: rumbler presented higher levels of noise, and it could be an efficient alternative for work zones due to its versatility.
- Finley and Miles (2007) measured the exterior noise produced by two types of vehicles (sedan and truck) traveling over five types of rumble strips applications at two different speeds (50 and 70 mph) in Texas. Results: 87 percent of the maximum baseline noise levels for trucks were greater than the peak rumble strips levels. Differences greater than 4 dB, in comparison to baseline conditions, occurred in more than half of rumble strips configurations. Differences were greater at 70 mph and lower for the truck. Pavement type (chip seal vs. hot mix asphalt) had significant effect on the noise levels. In addition, noise levels increased as milled rumble strips' width increased and as the spacing decreased.
- Kragh et al., (2007) compared the noise generated by five different types of milled CLRS in comparison to baseline conditions in Denmark. Three types of vehicles were driven at a speed of 80 km/h (49.7 mph), and the external noise was measured at 25 feet from the center line. Results: the

two tested patterns of sinusoidal strips (shown in Figure 2.1) presented the lowest difference, leading to an increase of only 0.5 – 1 dB in the external noise level. The rectangular strips presented the highest difference (3 – 7 dB).

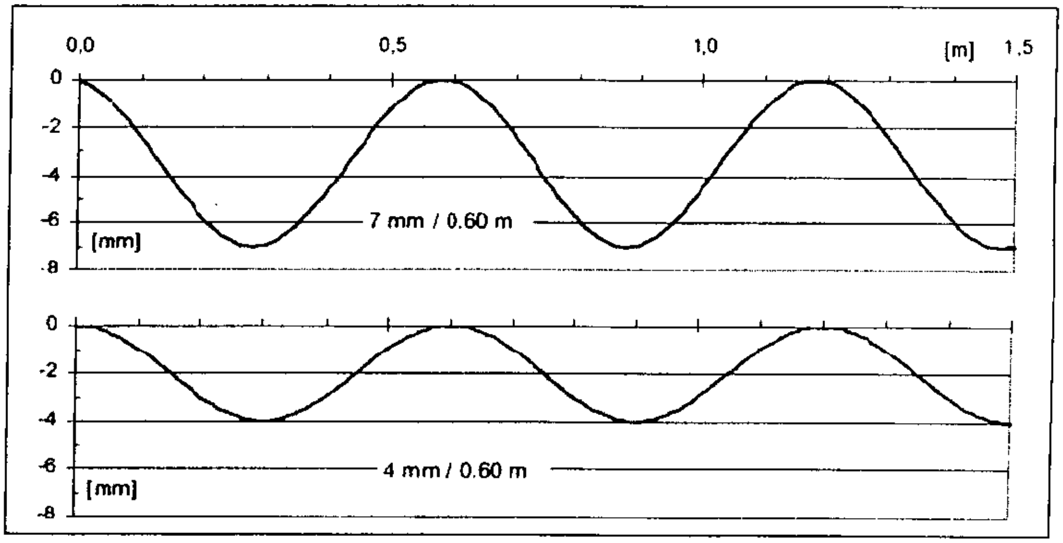

Figure 2.1: Sinusoidal strips. Source: Kragh et al. (2007)

2.2 Methodology

2.2.1 Data Collection

Initially, the study sites presented in Table 2.1 were selected from a list of locations where the Kansas Department of Transportation (KDOT) had already installed CLRS. Five locations that had rectangular CLRS and five locations that had football-shaped CLRS were selected. The locations had a posted speed limit of 65 mph, and were specifically chosen in order to minimize the travel distance from Manhattan Kansas. Data were collected under dry, day time conditions, at flat and open space locations. Three noise meters with data logger systems were placed at 50, 100, and 150 feet orthogonally measured from the center line of the highways. Three Extech HD600 noise meters (type 2 acoustical instrument) were used for data collection. The noise meter had a range of 30 to 130 dB and accuracy of 1.4 dB. The noise meters were calibrated before each series of measurements per location. The wind direction was measured using a wind vane / angle sheet equipment. A Prova AVM-07 anemometer was used to measure wind speed. Temperatures and humidity levels were measured at the beginning of the series of measurements per location and whenever perceptible changes in the weather occurred. A CE LM-81HT thermometer / anemometer / humidity meter was used to measure humidity and temperatures. Figure 2.2 shows the equipment used during the data collection. The rumble strip depth dimension was measured with a caliper. For each location, the depth was determined by averaging five measurements. The tire pressure for each test vehicle was measured at cold tire conditions.

Table 2.1: List of study sites selected

Location	County Name	Highway	Rumble Strip Type	Length (Miles)	KDOT Asphalt Classification
1	Chase	US-50	Football	19.0	Overlay 3",Ultrathin Bonded Asp Surf
2	Ellsworth	KS-156	Football	14.9	New Construction (IFD=3)
3	Brown	US-75	Football	13.0	Cold Mill 1", Overlay 1.5"
4	Doniphan	US-36	Football	6.1	Cold Mill .5", Overlay 1.5"
5	Reno	US-50	Football	9.7	Cold Mill 4", Recy Hot 6", Overlay .75"
6	Jefferson	US-24	Rectangular	6.7	Surface Recy 2", Overlay 1"
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8	Osage	US-75	Rectangular	9.6	Surf Recy 2",Ultrathin Bonded Asp Surf
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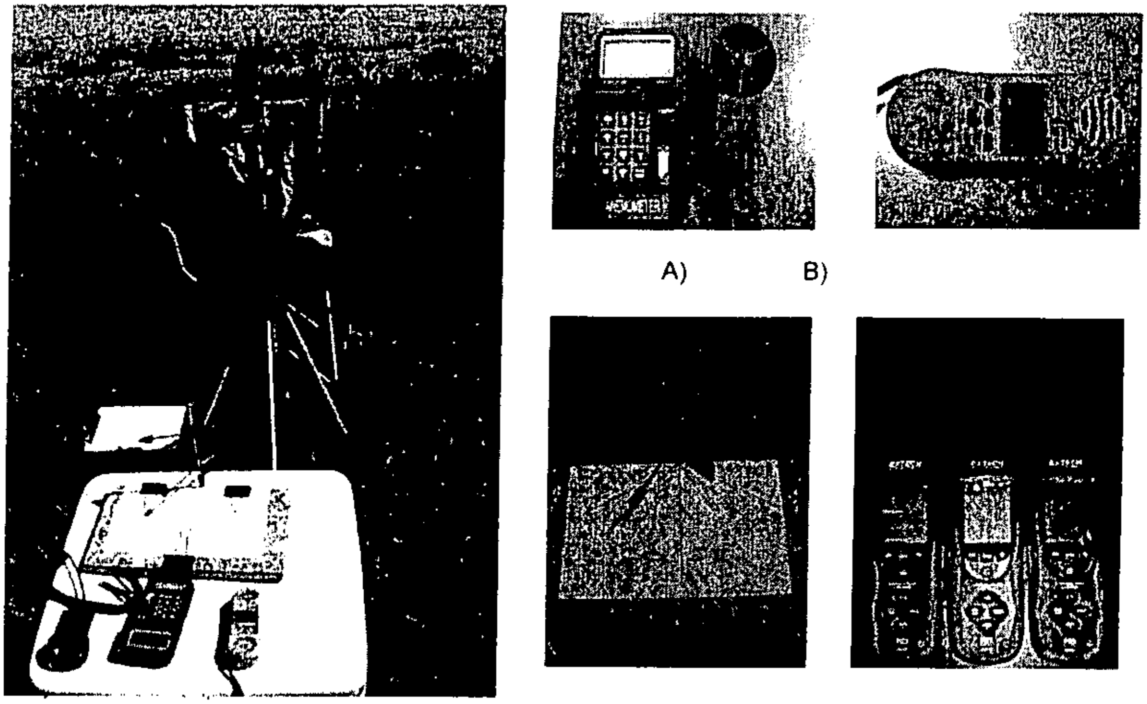
10	Harvey	US-50	Rectangular	17.5	Overlay 1"



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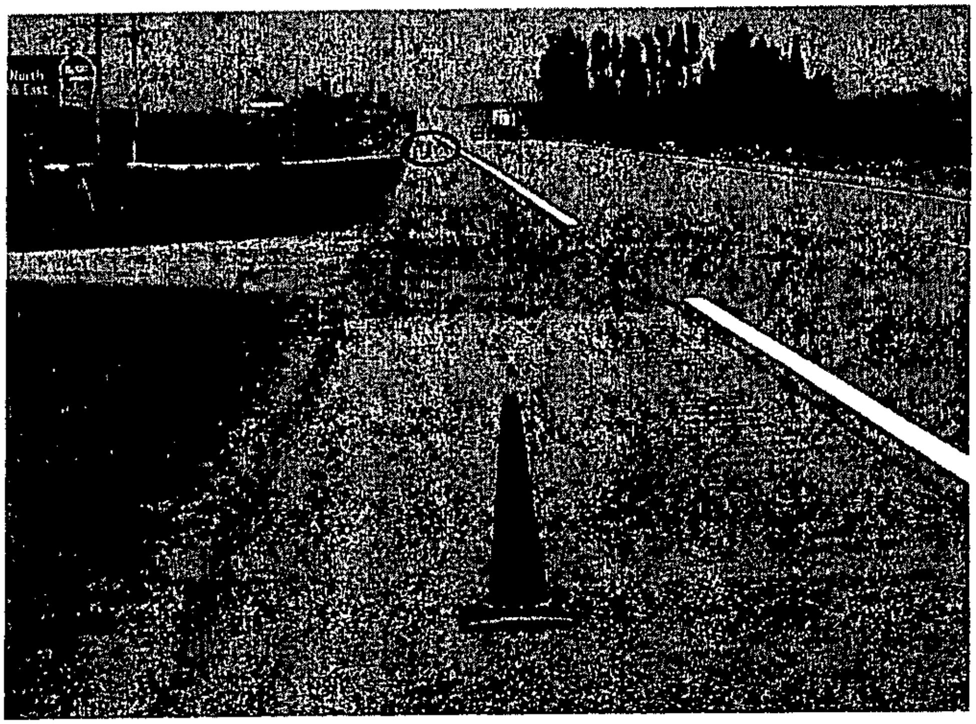

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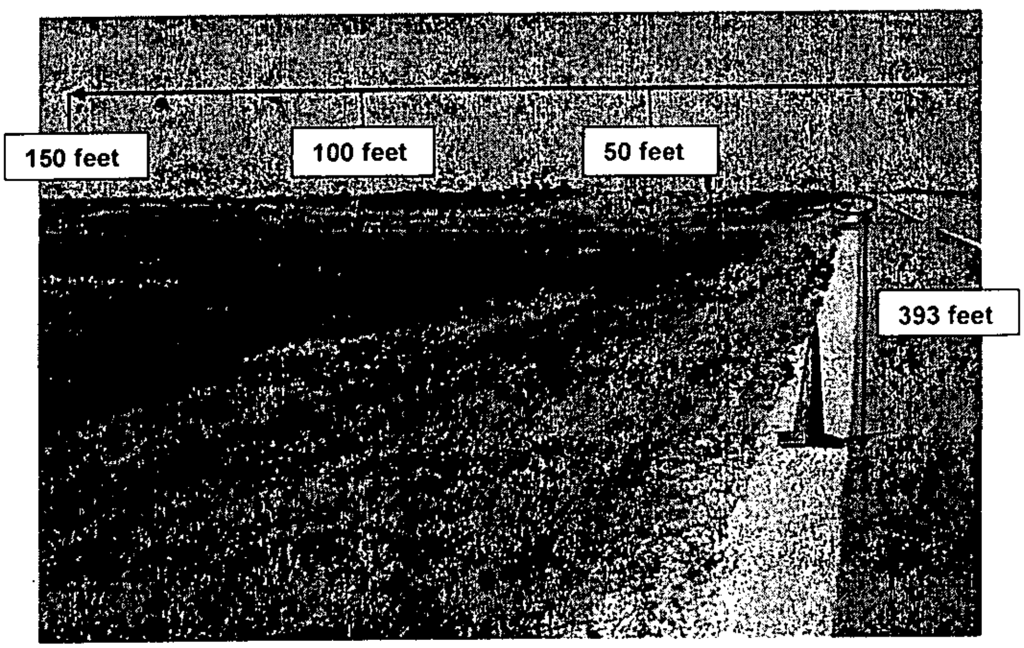

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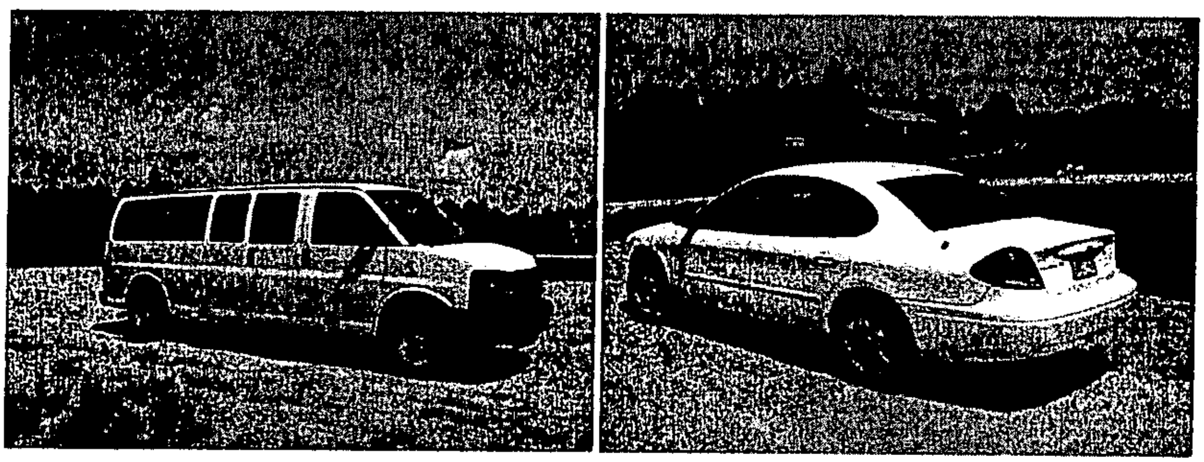

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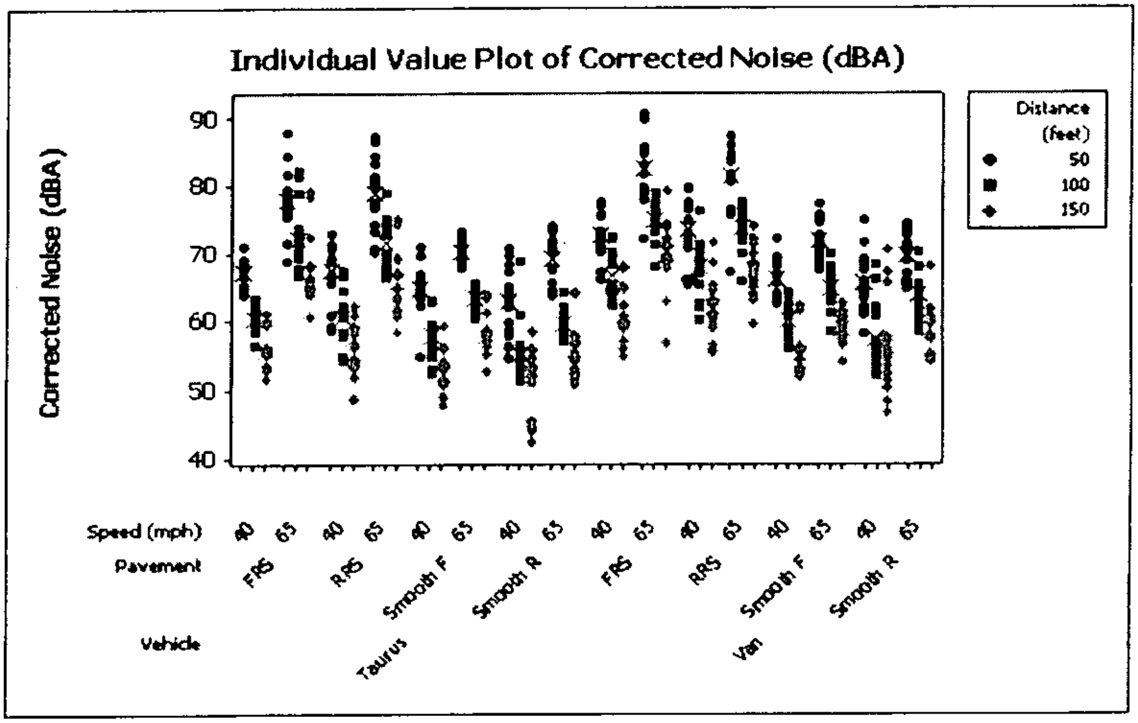

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Taurus	40	RRS	67.45	60.67	55.41	Van	40	RRS	50	73.36	67.84	61.82
Taurus	40	Smooth R	62.81	55.07	50.99	Van	40	Smooth R	50	65.4	57.23	56.23
Difference			**4.64**	**5.6**	**4.42**	**Difference**				**7.96**	**10.61**	**5.6**
Taurus	65	FRS	77.91	72.18	67.26	Van	65	FRS	50	82.36	74.87	69.98
Taurus	65	Smooth F	70.27	63.21	57.75	Van	65	Smooth F	50	71.7	64.7	58.64
Difference			**7.64**	**8.97**	**9.51**	**Difference**				**10.66**	**10.16**	**11.34**
Taurus	65	RRS	78.82	71.59	65.89	Van	65	RRS	50	81.46	73.66	67.53
Taurus	65	Smooth R	69	59.57	55.7	Van	65	Smooth R	50	69.59	63.84	58.55
Difference			**9.82**	**12.03**	**10.19**	**Difference**				**11.87**	**9.83**	**8.98**

2.3 KEY FINDINGS

- The Taurus mean level of noise (63.37 ± 0.31 dBA) was significantly lower compared to the mean level noise of the Chevrolet van (66.71 ± 0.31 dBA); the P-value of this test was smaller than 0.001. However, the highest difference in levels of noise of rumble strips, in comparison to smooth pavement, was measured at 100 feet when the Taurus was traveling at 65 mph.
- Overall, the mean level of noise at 40 mph (61.42 ± 0.31 dBA) was significantly lower compared to the mean level of noise at 65 mph (68.65 ± 0.31 dBA); the P-value of this test was smaller than 0.0001.
- Overall, the mean level of noise at 50 feet (71.27 ± 0.26 dBA) was significantly higher than the noise at 100 feet (64.50 ± 0.27 dBA) and 150 feet (59.34 ± 0.26 dBA), which were also different from each other; the P-values of these tests were smaller than 0.0001.
- In general, mean noise levels dropped 9.5 percent from 50 to 100 feet and 8.0 percent from 100 to 150 feet.
- The mean level of noise generated by smooth pavement at locations with football CLRS (61.17 dBA) were not significantly different from the noise levels on smooth pavement at locations with rectangular rumble strips (61.80 dBA); the P-value of this test was 0.0581.
- The levels of noise generated by CLRS (68.90 dBA) was significantly greater than the noise generated by smooth pavement (61.17 dBA); the P-value of this test was smaller than 0.0001.

- The interaction between speed and vehicle was significant. The P-value of this test was 0.0351. It means that the levels of noise of the Taurus and the Chevrolet van have different trends, according to the speed, as shown in Figure 2.7.

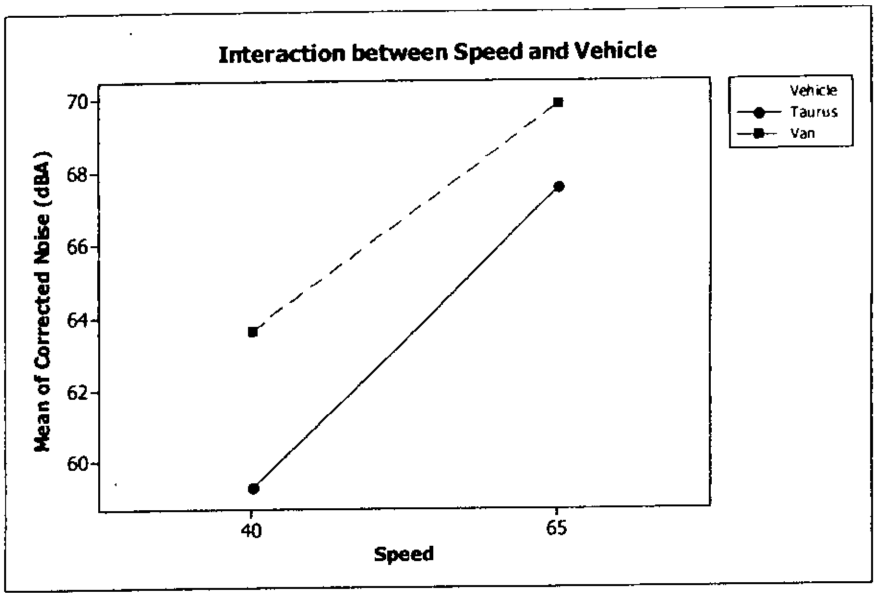


Figure 2.7: Interaction plot between speed and vehicle factors

- The interaction between distance and LP was significant. It means that the variation of noise per level of distance was different across the locations. Probably due to differences between types of asphalt.
- There was no significant difference between rectangular (68.83 dBA) and football (68.97 dBA) CLRS; the P-value of this test was 0.8318.
- Semi-trucks traveling at operational speeds (approximately 65 mph) over smooth pavement produced higher levels of noise compared to the Taurus and the Chevrolet van traveling over rumble strips, as shown in Table 2.5.

Table 2.5: Comparison to semi-trucks

Mean Corrected Noise (dBA)			
Distance (feet)	Taurus RS	Van RS	**Semi-Trucks**
50	78.36	81.91	**83.89**
100	71.89	74.27	**76.4**
150	66.58	68.76	**73.14**

- In order to predict the critical distance at which the levels of noise produced by rumble strips would be at acceptable levels, four regression models were built. The first model described the variation of noise for the Taurus traveling over rumble strips at 65mph. The second model had data from the Taurus traveling over smooth pavement at 65 mph. The third model had data of the Chevrolet van traveling over rumble strips at 65 mph, and the forth model had data from the Chevrolet van over smooth pavement at 65 mph. The predictor of each model was distance. Table 2.6 shows the regression analysis results.

Table 2.6: Regression models results

Model 1: Noise = 84.1 - 0.118 * Distance				Model 2: Noise = 75.5 - 0.129 * Distance			
Distance	Prediction	Real Average	Difference	Distance	Prediction	Real Average	Difference
50	78.17	78.36	-0.19	50	69.07	69.61	-0.54
100	72.28	71.89	0.40	100	62.61	61.46	1.15
150	66.40	66.58	-0.18	150	56.15	56.69	-0.54
200	60.51	*	*	200	49.69	*	*
Model 1: Noise = 84.1 - 0.118 * Distance				**Model 2: Noise = 75.5 - 0.129 * Distance**			
Distance	**Prediction**	**Real Average**	**Difference**	**Distance**	**Prediction**	**Real Average**	**Difference**
50	81.57	81.91	-0.34	50	70.56	70.68	-0.12
100	74.99	74.27	0.73	100	64.52	64.28	0.24
150	68.42	68.76	-0.34	150	58.48	58.60	-0.12
200	61.84	*	*	200	52.44	*	*

Table 2.7: Typical noise levels for common sounds

Event	Noise (dB)
Soft whisper	30
Refrigerator	40
Normal conversation	50
Television	60
Noisy restaurant	70
Dishwasher	75
Blow dryer	80
Electric razor	85
Lawn mower	90
Roar of crowd	95
Power tools	100
Stereo headset	110
Rock concert	120
.22 caliber rifle	130
Jet take-off	140

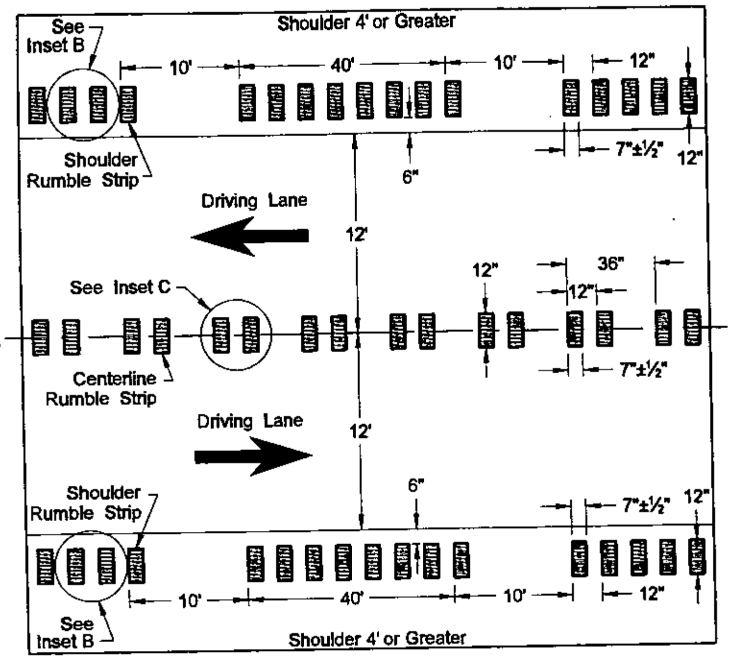
- According to Benekohal et al (1992) cited by Meyer (2002), the typical noise levels of common sound events are given by Table 2.7.The noise produced by rumble strips at 200 ft is comparable to the noise produced by a television, which should be considered acceptable.

2.4 CONCLUSIONS

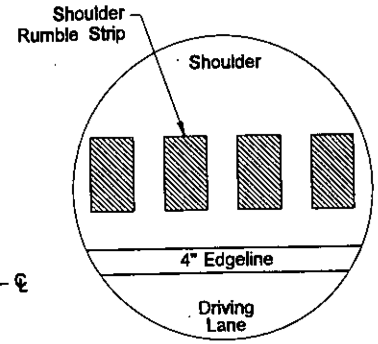
From the analyses performed, it can be concluded that the external noise depends on the speed (the lower the speed, the lower the noise), type of vehicles (heavier vehicles have a tendency to produce more noise), and distance (the greater the distance, the lower the noise).

Both football and rectangular CLRS do increase the levels of external noise. Therefore, before installing CLRS, the distance from houses or businesses should be measured. Based on the analysis using only one light and one medium vehicle, a distance of 200 ft from the centerline should be considered. This is the distance where noise from CLRS is no greater than smooth pavement.

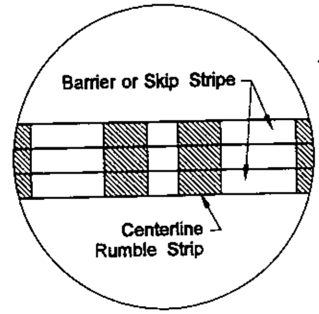
MBLE STRIPS
UNDIVIDED HIGH (SHOULDERS 4'OR GREATER)



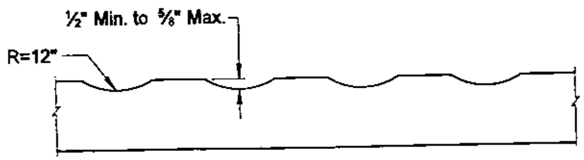
Undivided Highways (Shoulders 4' or Greater)



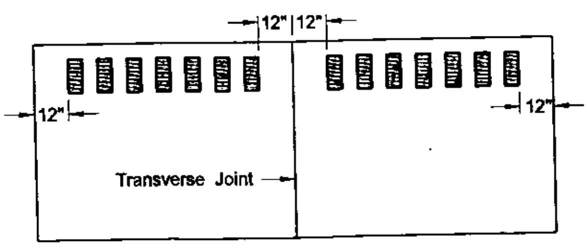
Inset B - Shoulder Rumble Strip



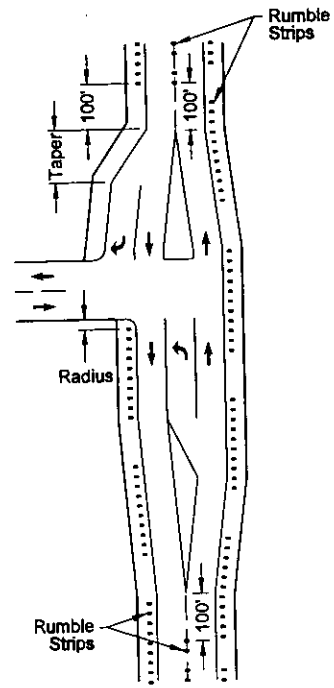
Inset C - Centerline Rumble Strip



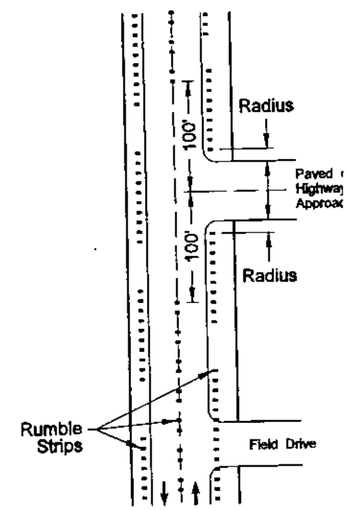
Profile of Rumble Strips - Bituminous and PCC Pavements



Discontinue rumble strip approx. 12" on both sides of PCC transverse joint



Turn Lane
(Right & Left)



Entrance Roadways

NOTES:

1) Rumble strips sh
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2) Rumble strips mi
shall be fog sealed
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4) Discontinue rum
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All rumble strips sh
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Centerline rumble
Weigh in Motion

5) Discontinue sho
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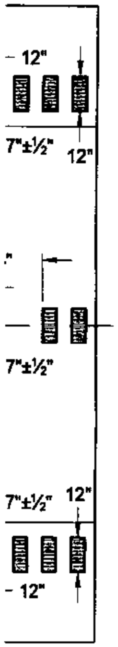
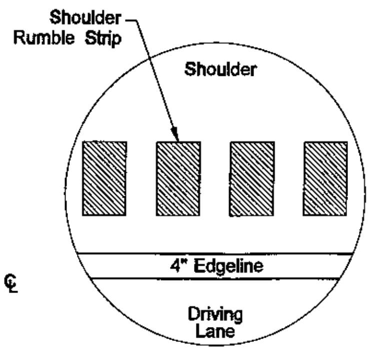
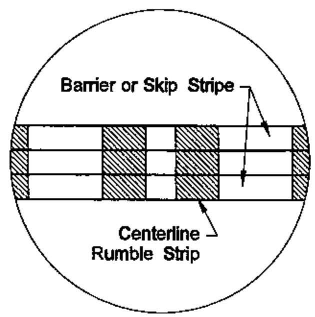
D-960-3

RUMBLE STRIPS
UNDIVIDED HIGHWAYS (SHOULDERS 4' OR GREATER)





Inset B - Shoulder Rumble Strip



Inset C - Centerline Rumble Strip

NOTES:

1) Rumble strips shall be milled into the bituminous and concrete paved shoulders. All milled materials shall be swept off of the driving lanes and paved shoulders using a mechanical sweeper. All costs for sweeping shall be included in the price bid for rumble strips.

2) Rumble strips milled into new or existing bituminous pavements shall be fog sealed across the full width of the milling with an application of SS-1h or CSS-1h emulsified asphalt at a rate of about 0.10 Gal/SY. All costs for fog sealing shall be included in the price bid for rumble strips.

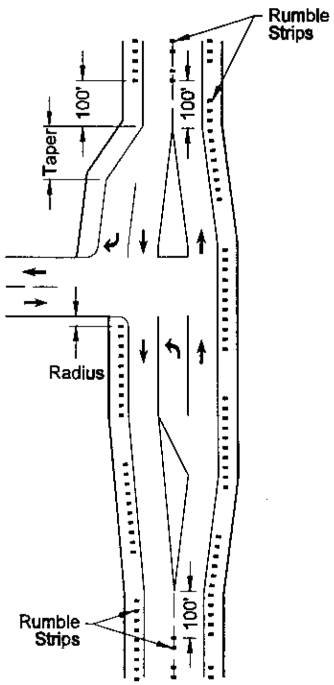
3) Discontinue rumble strips across bridge decks & approach slabs, adjacent to guardrail, and ½ mile on either side of:

- -highways with posted speeds 45 mph or less
- -all urban areas
- -areas with curb and gutter

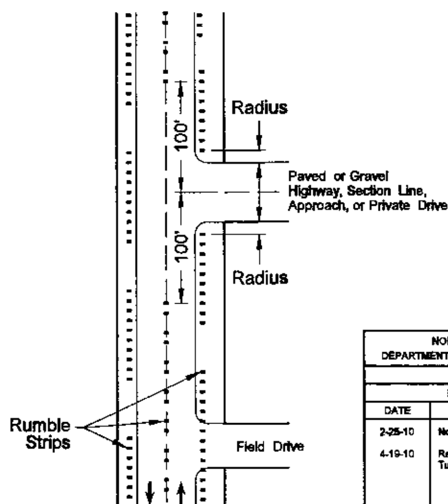
4) Discontinue rumble strips near Automated Traffic Recorders (ATR), Weigh In Motion (WIM) and Roadway Weather Information Systems (RWIS). All rumble strips shall discontinue 10' before and after any ATR or RWIS system. Shoulder rumble strips shall be discontinued 300' before and 100' after in the direction of travel for any Weigh In Motion equipment. Centerline rumble strips shall be discontinued 300' before and after any Weigh in Motion equipment.

5) Discontinue shoulder rumble strips through the entire length of right turn lanes, 100' before right turn lane tapers, and at the radius of a paved or gravel highway, section line, approach, or private drive.

6) Discontinue centerline rumble strips through the entire length of left turn lanes, 100' before left turn lane tapers and median islands, and 100' before and after a paved or gravel highway, section line, approach, or private drive.



Turn Lane
(Right & Left)



Entrance Roadways

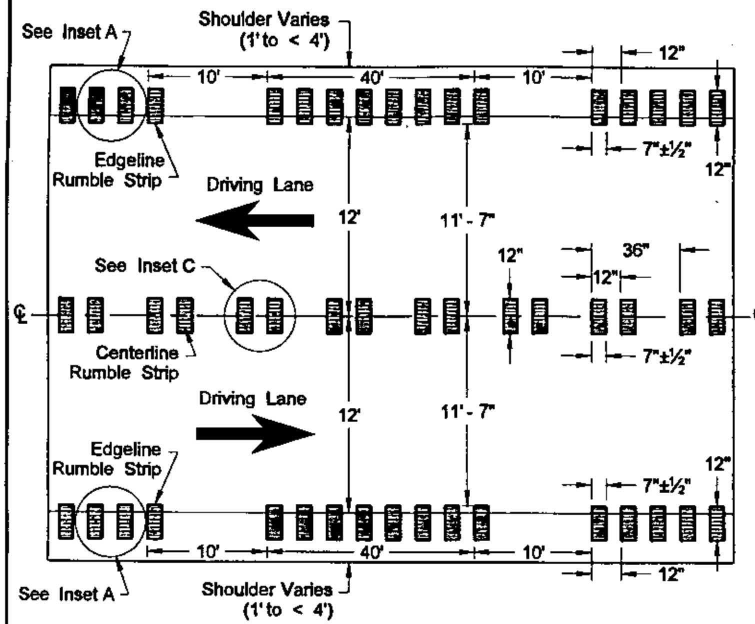
Pavements

CC transverse joint

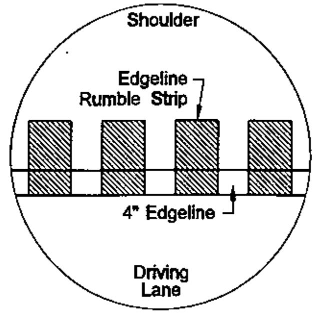
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION	
12-20-09	
REVISIONS	
DATE	CHANGE
2-25-10	Note 4 was added.
4-19-10	Revised Note 5, Note 6, and Turn Lane (Right & Left).

This document was originally issued and sealed by Roger Weigel, Registration Number PE- 2930, on 4/19/10 and the original document is stored at the North Dakota Department of Transportation

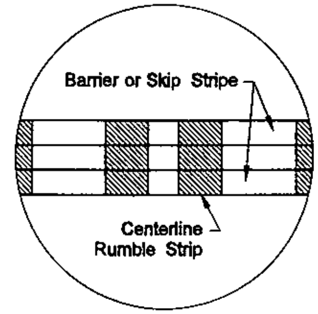
MBLE STRIPS
UNDIVIDED HIGHWAYS (SHOULDERS LESS THAN 4')



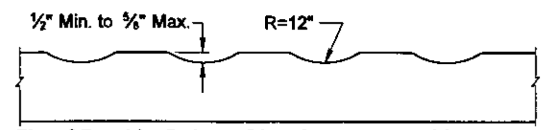
Undivided Highways (12' Driving Lanes & Shoulders 1' to < 4')



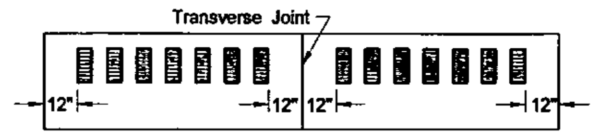
Inset A - Edgeline Rumble Strip



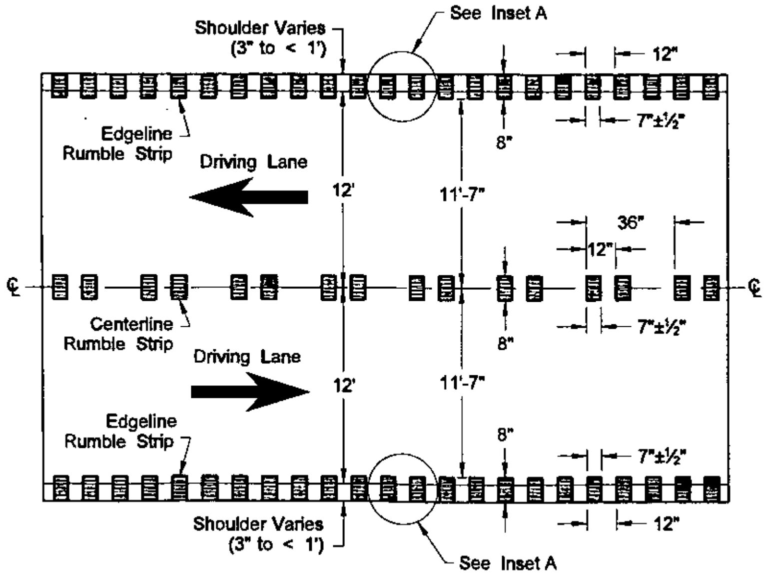
Inset C - Centerline Rumble Strip



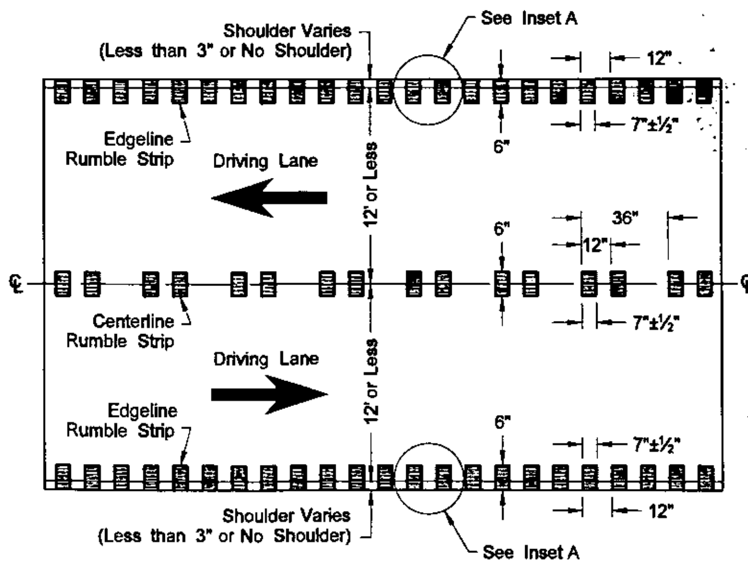
Profile of Rumble Strips - Bituminous and PCC Pavements



Discontinue rumble strip approx. 12" on both sides of PCC transverse joint



Undivided Highways (12' Driving Lanes & Shoulders 3" to < 1')



Undivided Highways (12' Driving Lanes or Less & Shoulders 3" or Less)

NOTES:

1) Rumble strips shall be mille
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2) Rumble strips milled into n
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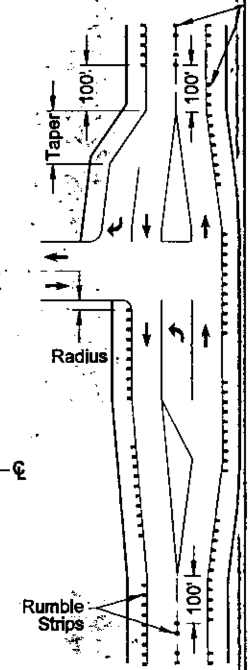
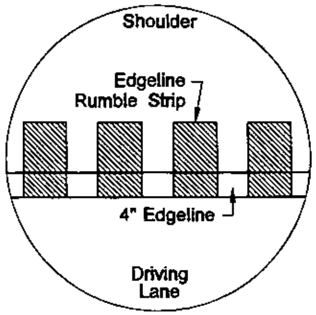
6) Discontinue centerline rumb
100' before left turn lane tape
gravel highway, section line, ap

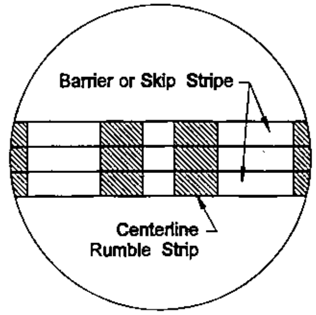


Turn Lane (Right & Left

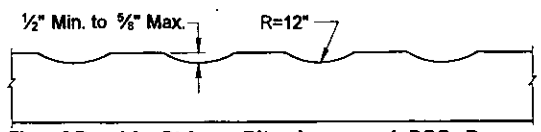
RUMBLE STRIPS
UNDIVIDED HIGHWAYS (SHOULDERS LESS THAN 4')



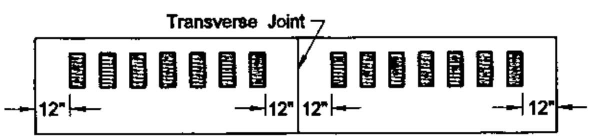
Inset A - Edgeline Rumble Strip



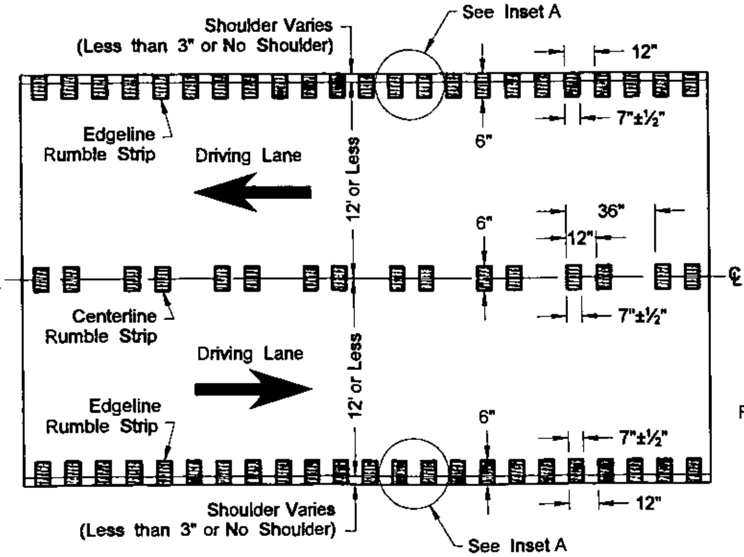
Inset C - Centerline Rumble Strip



Profile of Rumble Strips - Bituminous and PCC Pavements



Discontinue rumble strip approx. 12" on both sides of PCC transverse joint



Undivided Highways (12' Driving Lanes or Less & Shoulders 3" or Less)

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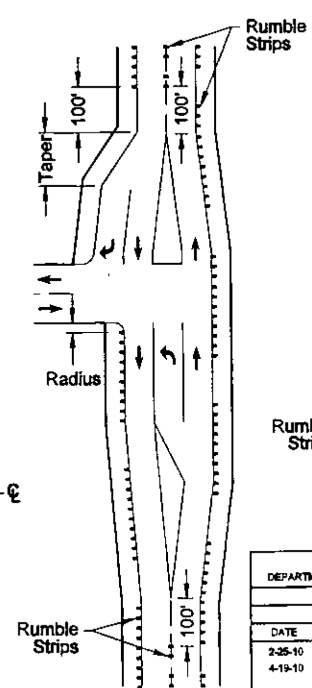
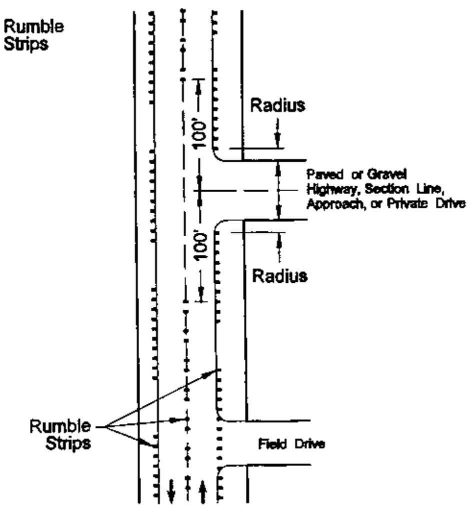


Turn Lane (Right & Left)



Entrance Roadways

D-960-4

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION	
12-29-09	
REVISIONS	
DATE	CHANGE
2-25-10	Note 4 was added.
4-19-10	Revised Note 5, Note 6, and Turn Lane (Right & Left).

This document was originally issued and sealed by Roger Weigel, Registration Number PE- 2930, on 4/19/10 and the original document is stored at the North Dakota Department of Transportation

#4

Testimony – House Bill 1358
House Transportation Committee
Submitted by
Jody Skogen, NDHP

January 27, 2011

Good afternoon, Chairman Ruby, and members of the House Transportation Committee. I am Lieutenant Jody Skogen and I serve as the Safety and Education Officer for the North Dakota Highway Patrol. I am here today to testify on behalf of Superintendent James Prochniak in opposition to House Bill 1358.

Driving is a full-time responsibility. The North Dakota Highway Patrol believes that through education and enforcement we can minimize behaviors that contribute to crashes. We also understand that even the safest drivers have momentary lapses of judgment, and these lapses of judgment place motorists at risk. Centerline rumble strips provide instant notification to motorists that a corrective action may be necessary to prevent a crash. Our agency firmly believes that the centerline rumble strip program has and will save lives. Centerline rumble strips are an important element that will reduce the occurrences of head-on collisions.

The North Dakota Highway Patrol supports the continued installation of these important traffic safety features.

This concludes my testimony. I would be happy to answer any questions you may have.

#5

Charles W. Murphy
Chairman

Mike Faith
Vice Chairman

Adele M. White
Secretary

TRIBAL COUNCIL
(AT LARGE)

Jesse "Jay" Taken Alive

Margaret M. Gates

Avis Little Eagle

Dave Archambault II

Joseph McNeil Jr.

Jesse McLaughlin

TRIBAL COUNCIL
(DISTRICTS)

Sharon Two Bears
Cannonball District

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Errol D. Crow Ghost
Bear Soldier District

Milton Brown Otter
Rock Creek District

Frank Jamerson Jr.
Running Antelope District

Samuel B. Harrison
Porcupine District

January 26, 2011

Honorable Dan Ruby
Chairman
House Committee on Transportation
4620 46th Avenue, NW
Minot, ND 58703-8711

Re: House Bill No. 1358

Dear Chairman Ruby:

On behalf of the Standing Rock Sioux Tribe I write to express my opposition to House Bill No. 1358. If enacted as written, with limited exception, the proposed House bill would prohibit the North Dakota Department of Transportation (NDDOT) from placing life-saving and cost-effective rumble strips "inside the edge stripe" to warn motorists that they are drifting over the center line.

It is the view of respected officials within the Federal Highway Administration (FHWA), NDDOT, other State Departments of Transportation, the Transportation Research Board (TRB), respected engineers and this Tribe that rumble strips save lives by reducing the incidence of lane departures. I ask the House Committee on Transportation to vote no on House Bill No. 1358.

Shoulder, inside edgeline, centerline and saw slotted rumble strips are a cost-effective road safety countermeasure that alerts distracted and fatigued drivers of potential danger caused by leaving a driving lane through an audible rumbling and vibration.

On the Standing Rock Sioux Reservation, in partnership with the NDDOT and the BIA, we have ND Highway #6, ND Highway #24, and ND Highway #1806 of rumble strips along State and BIA System roads to warn motorists that they are drifting from their travel lane and need to make an immediate correction. We have seen fewer accidents and a reduction in the seriousness of accidents following the installation of rumble strips on the Reservation. We are working cooperatively with NDDOT and our FHWA partners to make cost-effective road safety improvements and are educating our members to drive safely and ensure the safety of those driving with them. Through safety countermeasures and behavioral changes, we are reducing highway and pedestrian injuries and fatalities, especially among our young members.

In June, I met with Transportation Secretary Ray LaHood and NDDOT Director Francis Ziegler in Bismarck at an FHWA "Reauthorization Outreach Tour." I and Tribal Transportation Planning and Development Director Pete Red Tomahawk spoke to Secretary LaHood of the importance to Indian tribes of road safety, especially in rural States like North Dakota. Native Americans lose their lives on roadways at numbers 2, 3 and 4 times State and national averages. With limited resources and personnel and the great distances persons involved in road accidents must travel to receive medical treatment following an accident, States, counties and Indian tribes need every sensible safety countermeasure available to them to prevent serious highway accidents and death. Rumble strips play an important role in helping to keep our motorists safe. We have advocated to Congress and the Obama Administration to increase safety funding in the next surface transportation bill.

The NDDOT, in its 2010 Strategic Highway Safety Plan, noted that there was an average of 851 lane departure injury crashes over the five year period 2004-2008. Over this same five-year period, there was an average of 57 lane departure fatalities each year. In its Strategic Safety Plan, NDDOT has identified effective safety countermeasures as including improved road maintenance, enhanced shoulder or in lane delineation or markings, and the installation of rumble strips.

In 2007, the Tribe testified before the United States Congress concerning Tribal transportation issues in Indian country. In that testimony, we cited a 2005 estimate by the National Safety Council which estimated that the economic cost for highway fatalities in terms of lost wages, medical expenses, motor vehicle and property damage, and employer costs exceeded $1.1 million for each life lost and over $50,000 for every person injured. In 2005, for North Dakota alone, those estimates translated to $360 million for the State's 123 traffic fatalities ($140.2 million) and 4,360 traffic injuries ($218 million). See "North Dakota Vehicle Crash Facts for 2005," NDDOT, Crash Facts.

Using NDDOT's 2004-2008 average for lane departure fatalities and injuries, the 57 ND lane departure fatalities translate to $62.7 million in economic cost and the 851 average lane departure injuries translates to $42.55 million in economic cost for a total of over $100 million in economic cost to the State for a single year. These figures highlight the wisdom of continuing to install cost-effective rumble strips along the State's roadways to save lives and reduce the incidence of serious road accidents.

For the above stated reasons, I must respectfully oppose House Bill No. 1358.

Sincerely,

Charles W. Murphy, Chairman