

Technical Memorandum

To: Electronic Distribution Recipients

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Division Director, Engineering Services



Subject: Rumble Strips and Stripes on Rural Trunk Highways

Expiration

This Technical Memorandum supersedes No. 14-07-T-01 (Rumble Strips and Stripes on Rural Trunk Highways) and shall remain in effect until August 21, 2022 unless superseded prior to this date or incorporated into the MnDOT Standard Plans, the Road Design Manual, and/or Traffic Engineering Manual.

Implementation

The guidance herein shall be in effect for all programmed rural highway projects where the paved surface is constructed, reconstructed, or overlaid. This does not include preventive maintenance projects such as chip seals and microsurfacing; however, preventive maintenance projects on surfaces that have existing rumble strips or stripes shall ensure that these are perpetuated in accordance with the standards within this Technical Memorandum, particularly with respect to depth. An exception to this would be partial depth repairs on concrete rehabilitation projects. Any paving constructed by MnDOT forces is exempt from the requirements of this Technical Memorandum.

These requirements apply to all projects on Rural Trunk Highways where the posted speed limit is 55 mph or higher. For the purpose of this technical memorandum a Rural Trunk Highway is defined in the Definitions section. Districts may implement this policy on Urban Trunk Highways.

While these requirements provide for standards that will require an increased use of rumble strips and stripes, it also provides for more flexibility and discretion on the part of the District. Notably, the District has the discretion for the preferred lateral placement and width of the shoulder rumble strip in order to abate noise concerns, accommodate bicyclists, acknowledge pedestrian use, and manage pavement conditions.

Introduction

Detailed crash analysis has shown that lane departure crashes, such as run off the road, sideswipe and head-on crashes, on rural two-lane two-way highways in Minnesota result in an over represented number of fatalities and serious injuries.

Both traditional pavement markings and rumble strips are used to decrease the number of lane departure crashes. Following the lead of other states, MnDOT experimented with combining traditional pavement markings and rumble strips into a “rumble stripe,” where the pavement marking is installed on the rumble strip.

The NCHRP Report 641 *Guidance for the Design and Application of Shoulder and Centerline Rumble Strips* shows that the use of rumble strips both on the shoulder and beneath the centerline result in a significant reduction of targeted crashes. This report can be found at the following URL:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_641.pdf.

NCHRP Synthesis 490 *Practices of Rumble Strips and Rumble Stripes* found that all of the responding 41 agencies reported that they used rumble strips and 37 of those agencies indicated that they have a policy or guidance specific to the application of rumble strips. This synthesis can be found at the following URL:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_490.pdf. Additionally, numerous states in the region

have enacted systematic policies to require rumble strips and rumble stripes on their trunkline roadways.

Michigan, Missouri, and North Dakota have policies requiring centerline rumble stripes, plus edgeline rumble stripes or shoulder rumble strips, on most of their rural trunkline roadways.

Studies have shown that the ambient noise decibel level generated by a vehicle driving over a properly constructed rectangular corrugated rumble strip is comparable to that of a truck passing by on a standard, non-rumbled surface. The noise from rectangular corrugated rumble strips may be more noticeable as the public is more accustomed to truck traffic, the frequency of the sound is different, and rumble hits tend to be more of an impulse noise.

Due to these noise concerns, MnDOT investigated a rumble design that utilizes a sinusoidal pattern, a design which has been found to reduce external nuisance noise. In order to find a sinusoidal rumble design that would minimize external nuisance noise, while keeping the in-vehicle noise at a level that would capture a driver's attention, MnDOT conducted and published the *Sinusoidal Rumble Strip Design Optimization Study, June 2016*. This study can be found at the following URL: <http://www.dot.state.mn.us/research/TS/2016/201623.pdf>. The study recommended the sinusoidal design with a 14" long wavelength that oscillates between 1/16" below the pavement surface to 1/2" below the pavement surface. This recommended design generates an internal noise above the minimum recommended levels from NCHRP Report 641 – significantly higher for passenger cars. The internal noise generated by the rectangular corrugated design is more noticeable for pickup trucks. Another advantage of the recommended sinusoidal rumble design is that it allows for a fully recessed pavement marking, which is anticipated to increase the life of the pavement marking.

The *Sinusoidal Rumble Strip Design Optimization Study* also found that the surveyed motorcyclists are often uncomfortable with crossing split design rumble strips. The split design rumble requires the motorcycle to traverse a rumble, a centerline joint, and another rumble. Motorcyclists had much greater comfort traversing the single centerline rumble. The study recommended that centerline rumbles consist of a single longitudinal rumble. MnDOT Materials has raised valid concerns with constructing rumbles across a longitudinal concrete joint, so this Tech Memo will require a single centerline rumble be installed on bituminous pavements and the split rumble be installed on concrete pavements.

A concern has been raised that the pavement marking within a centerline sinusoidal rumble stripe may not be visible when the rumble strip is filled with water. Due to this, any pavement marking installed within a sinusoidal rumble will need to include wet-reflective media. An intermittent sinusoidal centerline rumble stripe has been installed at a few locations in District 2. This design places the centerline markings of any no passing areas in the sinusoidal rumble; however, in areas where passing is allowed in both directions, the sinusoidal rumble is gapped for the placement of the broken line (though the line is still recessed) and the sinusoidal

rumble is placed in the gaps between the broken line segments. This intermittent sinusoidal centerline rumble stripe design may be considered.

Purpose

To provide centerline rumble stripes and/or shoulder rumble strips on all Rural Trunk Highways to reduce lane departure crashes, to provide increased centerline visibility during rainy conditions, and to guide motorists during weather conditions when striping visibility is poor.

Definitions

Rectangular Corrugated Rumble Strip

A rumble strip design that consists of rectangular shaped, semicircular plunge cuts into the pavement. See Figure 1A for design details.

Rumble Stripes

Rumble stripes are defined as a rumble strip that contains a pavement marking stripe. These will be referred to as either **edgeline rumble stripes** or **centerline rumble stripes**.

Rural Trunk Highway

This is defined as a roadway segment that has minimal residential or commercial development, with little or no further development anticipated in the future. Officially, rural segments will be defined by language in Chapter 2 of the MnDOT Access Management Manual. (Refer to the attached Reference 1, which shows the rural definition on page 10 in Chapter 2 of the MnDOT Access Management Manual.)

Shoulder Rumble Strips

These are defined as rumble strips outside of the edgeline.

Sinusoidal Rumble Strip

A rumble strip designed to produce less nuisance exterior noise than the rectangular corrugated rumble strip. The sinusoidal design was researched to allow the use of rumble strips in noise sensitive areas. See Figure 1B for design details.

Structural Rumble Strip

A rumble strip designed to keep heavy commercial vehicles 12" from the edge of a widen edge concrete design. The structural rumble is not intended for a safety benefit.

Requirements

Shoulder Rumble Strips

Shoulder rumble strips shall be placed on all rural highway construction and maintenance projects where shoulders are constructed, reconstructed, or overlaid; where the posted speed limit is 55 mph or greater, and the paved shoulder width is 4 feet or greater. Shoulder rumble strips may also be placed on rural trunk highways on shoulders less than 4 feet in width. The District Materials Engineer should be consulted regarding the placement of shoulder rumbles.

The location of the shoulder rumble strip will depend upon the width of the shoulder – see Figure 2 (Two-Way Bituminous Roadway with Paved Shoulder – Section View), Figure 3 (Two-Way Concrete

Roadway with Paved Shoulder – Section View) and Figure 4 (Shoulder Rumble Strip on Divided Roadways – Section View) for typical dimensions. The District Traffic Engineer has discretion for the lateral placement of the shoulder rumble strip in order to abate noise concerns and to accommodate bicyclists.

Shoulder rumble strips shall also be placed on the left shoulder of multi-lane divided roads.

The District Traffic Engineer may use either the rectangular corrugated or the sinusoidal rumble for shoulder rumble strips. On shoulders where the paved width is less than 5 feet, the sinusoidal rumble design may be considered as it is less jarring to bicyclists. The sinusoidal rumble design may also be used for edgeline rumble stripes.

Centerline Rumble Stripes

Centerline rumble stripes shall be placed on all rural highway construction and maintenance projects where pavement is constructed, reconstructed, or overlaid and where the posted speed limit is 55 mph or greater. This applies to both multi-lane undivided and two-lane undivided highways. See Figure 2 (Two-Way Bituminous Roadway with Paved Shoulder – Section View) and Figure 3 (Two-Way Concrete Roadway with Paved Shoulder – Section View) for typical dimensions.

The District Traffic Engineer may use either the rectangular corrugated or the sinusoidal rumble for centerline rumble stripes on bituminous pavements. The sinusoidal rumble is required on concrete pavements.

Sinusoidal Rumble Stripes

Sinusoidal rumble strips may fill with water in rainy conditions; due to this, pavement markings installed within a sinusoidal rumble shall include wet-reflective media.

Appropriate Breaks

An intermittent pattern which includes a 12' gap in each 60' cycle of rumble installation should be used for shoulder rumble strips and edgeline rumble stripes on non-freeway segments. Refer to Figures 5B and 6B. Districts may increase the gap from 12' in downhill sections with the approval of the State Traffic Engineer. The continuous pattern may be used when the shoulder rumble is installed on shoulders with a width of less than 4 feet and the rumble is placed near the edge of paved surface. Refer to Figures 2C and 3C.

The District Traffic Engineer may gap rumbles on bridge structures, approach panels, and adjacent to guardrail/cable barrier.

Additional breaks for roadway entrances and exits may be found in Figure 10 (Shoulder Rumble Strip – Appropriate Breaks), Figure 11 (Centerline Rectangular Corrugated Rumble Stripe – Appropriate Breaks), and Figure 12 (Centerline Sinusoidal Rumble Stripe – Appropriate Breaks). As shown in Figure 12, when sinusoidal centerline rumbles are used, they may continue through intersections in which pavement markings are installed.

Exceptions

The District Traffic Engineer may use an intermittent sinusoidal centerline rumble stripe to enhance the visibility of the pavement marking skip in two-direction passing zone areas. In areas where either direction is marked as a no passing zone, then a continuous centerline rumble is placed. In areas where

passing is allowed in both directions, the intermittent centerline rumble strip is placed. The intermittent sinusoidal centerline rumble stripe utilizes the standard sinusoidal pattern between the single skips and the single skip area is recessed 1/16" for the width of the rumble strip pattern (typically 14").

Based on engineering judgment, the District Traffic Engineer may gap shoulder rumbles on the inside of a horizontal curve with nearby residences if a Safety Edge or wider shoulder is installed.

On rural highways where the lane width is 11 feet or less, or the paved shoulder width is 2 feet or less, shoulder rumble strips or edgeline rumble stripes may be placed on both sides of the road in lieu of a centerline rumble stripe.

In all cases, edgeline rumble stripes may be substituted for shoulder rumble strips and still meet the standards within this Technical Memorandum.

Shoulder rumble strips are not required in areas where there is a bus shoulder. However, it is assumed that bus shoulders will usually be installed in areas that are not defined as rural trunk highways in the Access Management Guide.

There may be some locations where rumble strips are not feasible to install or replace – such as with partial depth repairs on concrete pavements. The discontinuation of rumble strips along any roadway requires consultation with the State Traffic Engineer.

Even in cases where shoulder rumble strips are not required due to a narrow paved shoulder width, their installation, or the installation of an edgeline rumble stripe, is encouraged for proactive safety reasons.

All rumble strips on bituminous pavements shall be milled, not rolled. Sinusoidal rumbles installed on concrete pavements shall be milled with a diamond-tipped blade.

Districts may place centerline rumble stripes and shoulder rumble strips at locations on which no construction, reconstruction, or overlay projects are scheduled in the near future as a systematic proactive safety measure. The District Materials Engineer should make recommendations regarding the structural adequacy of the in-place roadway and/or shoulder to receive rumble strips.

Width of rumble strips

Shoulder rumble strips are within the range of 8-12" in width. A 16" shoulder rumble strip is required on freeway segments. Any design of shoulder rumble strips that are smaller than 8" in width, or that deviate from the details on Figure 1 shall require approval by the State Traffic Engineer.

The standard width of centerline rumble strips on bituminous pavements is 14". The standard design of centerline rumbles on concrete pavements is two 6" wide sinusoidal rumbles on either side of the centerline joint, each 2" away from the joint. Any deviation from this width requirement or that deviate from the details on Figure 1 shall require approval by the State Traffic Engineer.

The placement of shoulder rumble strips and edgeline rumble stripes with respect to the traveled lane shown in Figures can be deviated from at the discretion of the District Traffic Engineer.

Modifications for concrete pavement

On concrete paved roadway surfaces there are two options for how to install shoulder rumble strips. They include:

- Installing 3' long structural rumble strips on alternating panels, and also shoulder rumble strips on the adjacent paved bituminous shoulder. (Refer to Figures 3A and 8).
- Milling in either continuous or intermittent shoulder rumble strips outside the edgeline, but on the concrete surface. (Refer to Figures 3C, 5B, and 9).

The standard design of centerline rumble stripes on concrete pavement is: two 6" wide sinusoidal rumbles on either side of the centerline joint, each 2" away from the joint. The sinusoidal rumbles shall be milled with a diamond-tipped blade. Any deviation from this design requirement or from the details on Figure 8 or 9 shall require approval by the State Traffic Engineer.

Transverse joints should be avoided when installing rumbles. See Figures 8 and 9 for details.

Bicycle travel on shoulders

Shoulder widths that provide less than 4 feet of clear space with rumble strips are generally not considered adequate for safe and comfortable bicycle travel outside of the travelled lane. Where practical and feasible, Districts are encouraged to provide a minimum of a 6 foot paved shoulder where shoulder rumble strips will be placed on trunk highways with existing or potentially significant bicycle travel.

In order to meet the needs of bicyclists, flexibility has been built in to this Tech Memo. As stated above and reflected in the attachments, rumble strips as narrow as 8" as well as edgeline rumble stripes may be used at the discretion of the District. Also, while the dimensions in Figures 2 through 4 indicate the typical lateral placement of the shoulder rumble strip, the District has the discretion to deviate from this configuration with input from the State Bicycle Coordinator. Quality control of the lateral placement of rumble strips on these sections must be ensured.

Questions

Any questions regarding the technical provisions of this Technical Memorandum can be addressed to the following:

Ken Johnson, State Work Zone, Pavement Marking & Traffic Devices Engineer at **(651) 234-7386**

Any questions regarding publication of this Technical Memorandum should be referred to the Design Standards Unit, DesignStandards.DOT@state.mn.us. A link to all active and historical Technical Memoranda can be found at <http://techmemos.dot.state.mn.us/techmemo.aspx>.

To add, remove or change your name on the Technical Memoranda mailing list, please visit the web page <http://techmemos.dot.state.mn.us/subscribe.aspx>

Attachments:

Reference 1

Figures 1-12

REFERENCE 1: Rural Definition from the MnDOT Access Management Manual

Mn/DOT Access Management Manual

Subcategory A – Rural

This subcategory is intended for trunk highway segments that extend through agricultural, open, or forested areas with limited development. It is also assigned to areas planned for long-term, low-density development, characterized by scattered, large-lot residential development and limited commercial or industrial use. Highway segments outside municipalities are generally designated as Rural (Subcategory A), unless the area is undergoing or planned for urban-scale development. Highways in this subcategory are generally expected to operate at speeds of 50 mph or more; however, in areas lacking a complete supporting local road network, these highways will also be required to provide direct access to adjacent property.

Special attention should be given to transition areas on the fringe of growing municipalities where local zoning may permit urban-type development without corresponding requirements for streets and utilities. Since the private access allowance in Rural (Subcategory A) areas is more permissive than in Urbanizing (Subcategory B) areas, it is important to appropriately categorize these transition areas in order to maintain long-term safety and mobility goals for the corridor.

In some geographically-large municipalities, full urbanization may not be anticipated within the next 20 (or more) years. Highway segments extending through areas of municipalities planned to remain rural in character are designated Rural (Subcategory A).

Figure 2.3 illustrates a municipal area with both a Rural (Subcategory A) segment that extends into an area that is not planned for development and an Urbanizing (Subcategory B) segment that extends into a transition area outside the city's boundary.

Figure 2.3: Category Assignments in a City

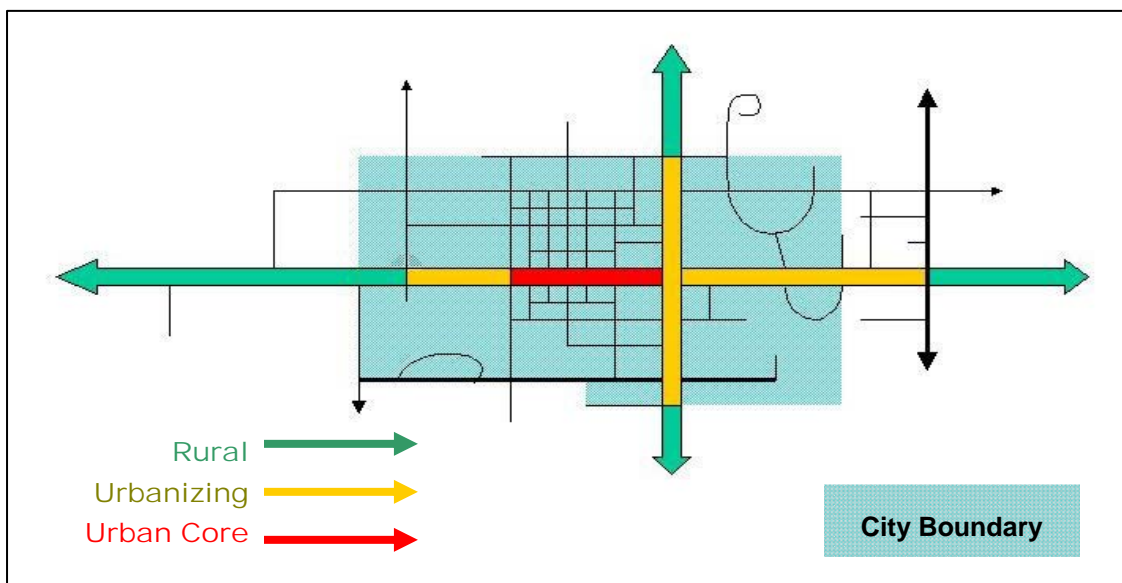


FIGURE 2 - TWO-WAY BITUMINOUS ROADWAY WITH PAVED SHOULDER - SECTION VIEW

FIGURE 2A - BITUMINOUS PAVEMENT OPTION 1: SHOULDER RUMBLE STRIPS

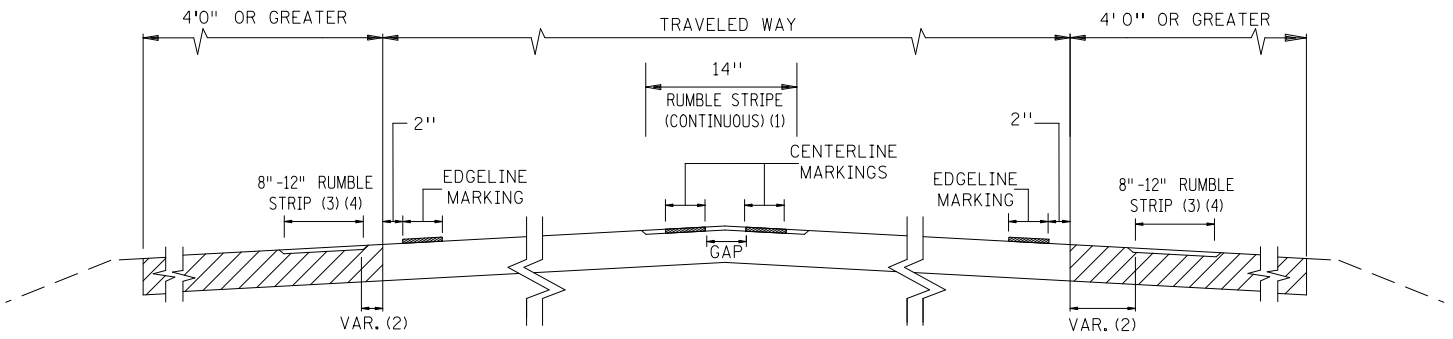


FIGURE 2B - BITUMINOUS PAVEMENT OPTION 2 - EDGELINE RUMBLE STRIPES

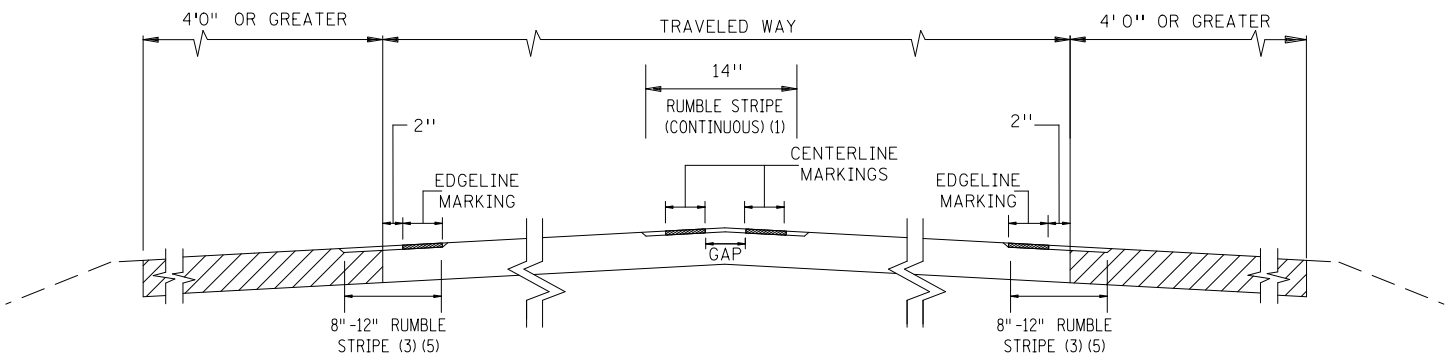
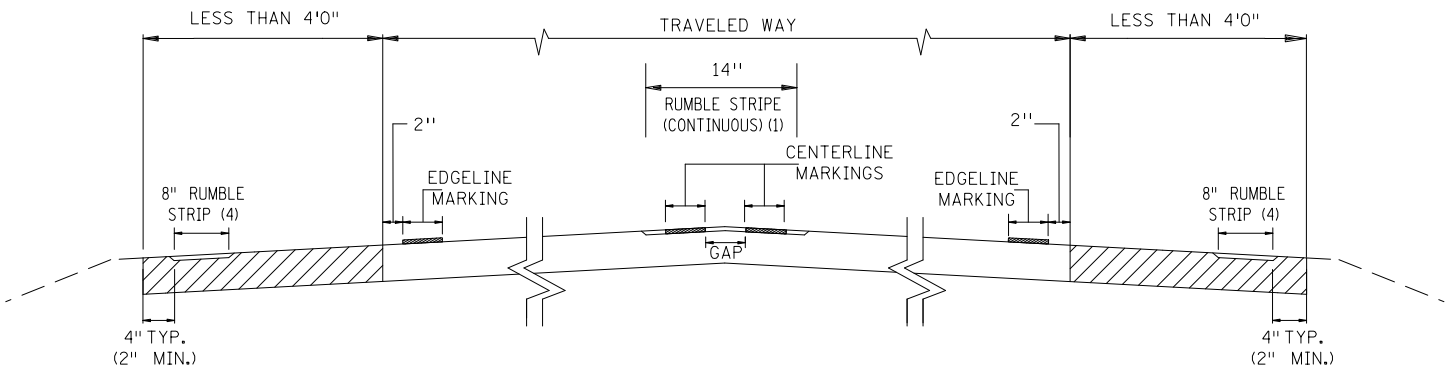


FIGURE 2C - BITUMINOUS PAVEMENT WITH LESS THAN 4' PAVED SHOULDERS



(1) SEE FIG. 7 FOR DETAILS.

(2) 2" WHERE SHOULDER WIDTH IS LESS THAN 6'; 12" WHERE SHOULDER WIDTH IS 6' OR GREATER.

(3) INTERMITTENT PATTERN. USE 8" RUMBLE STRIP/STRIPE WHERE SHOULDER WIDTH IS LESS THAN 6'.

(4) SEE FIG. 5 FOR DETAILS.

(5) SEE FIG. 6 FOR DETAILS.

FIGURE 3 - TWO-WAY CONCRETE ROADWAY WITH PAVED SHOULDER - SECTION VIEW

FIGURE 3A - CONCRETE PAVEMENT OPTION 1
(STRUCTURAL EDGELINE AND SHOULDER RUMBLE STRIPS)

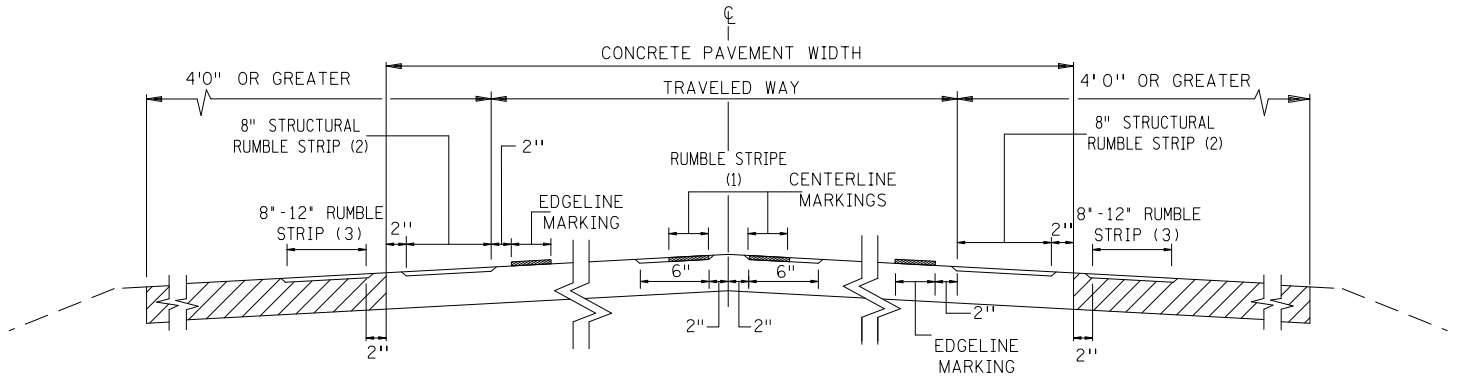


FIGURE 3B - CONCRETE PAVEMENT OPTION 2
(EDGELINE RUMBLE STRIPS)

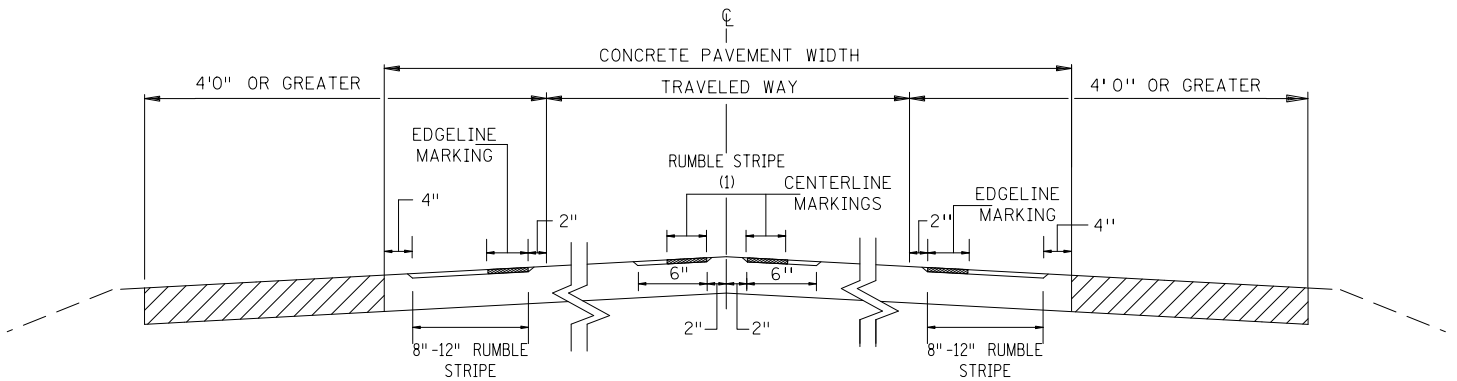
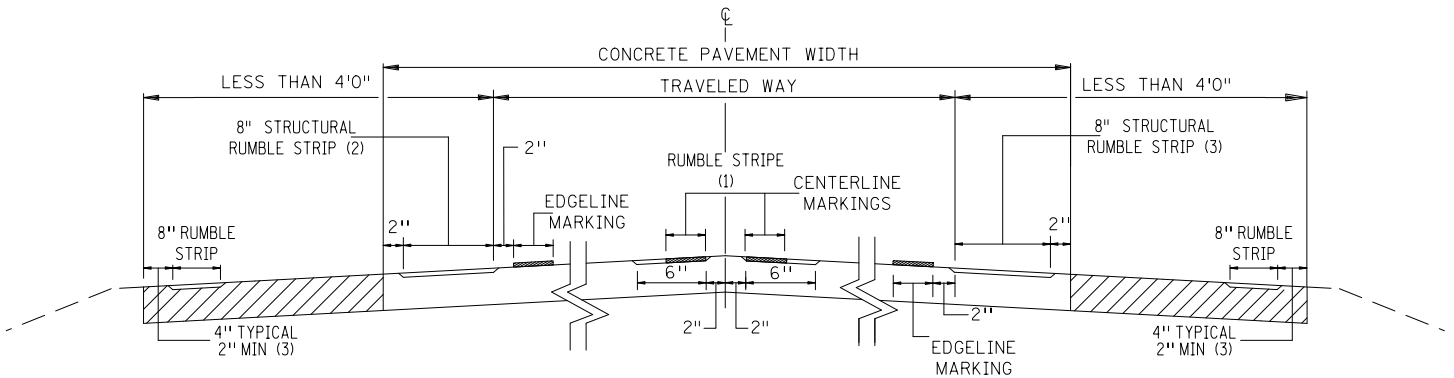


FIGURE 3C - CONCRETE PAVEMENT WITH LESS THAN 4' PAVED SHOULDERS



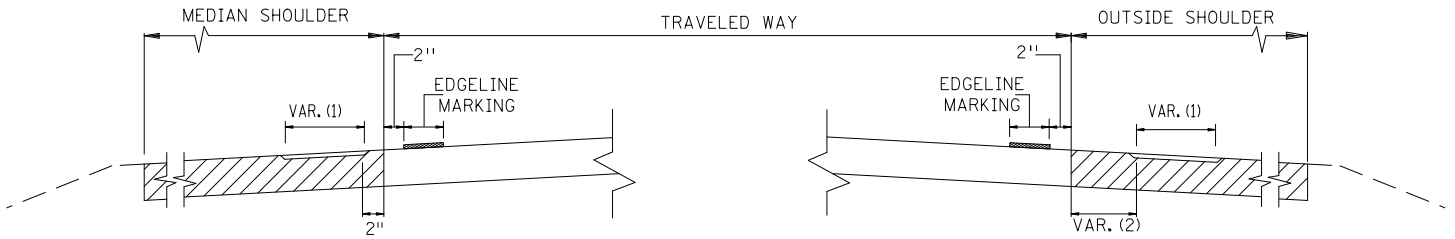
(1) SEE FIGS. 8 AND 9 FOR DETAILS.

(2) A RUMBLE IS REQUIRED TO PROTECT THE JOINT.
IF RUMBLE STRIP IS INSTALLED ON NON-TRAFFIC SIDE OF JOINT A STRUCTURAL RUMBLE IS REQUIRED.
SEE FIG. 8 AND 9 FOR RUMBLE STRIP OPTIONS, PLACEMENT, AND DIMENSIONS.

(3) IF PLACED IN BITUMINOUS, RUMBLE STRIPS MAY BE RECTANGULAR CORRUGATED OR SINUSOIDAL.

FIGURE 4 - SHOULDER RUMBLE STRIP ON DIVIDED ROADWAYS - SECTION VIEW

FIGURE 4A - BITUMINOUS FREEWAY/MULTI-LANE EXPRESSWAY
(ONE ROADWAY SHOWN)



8" STRUCTURAL RUMBLE STRIP

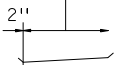


FIGURE 4B - CONCRETE FREEWAY/MULTI-LANE EXPRESSWAY OPTION A
(ONE ROADWAY SHOWN)

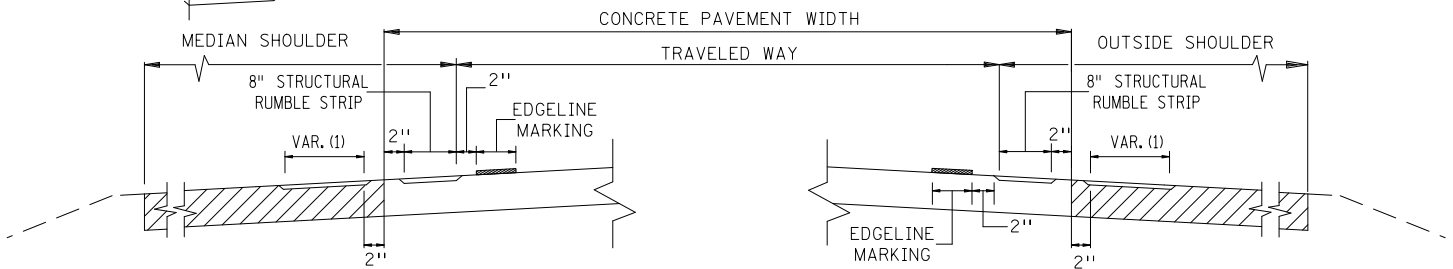
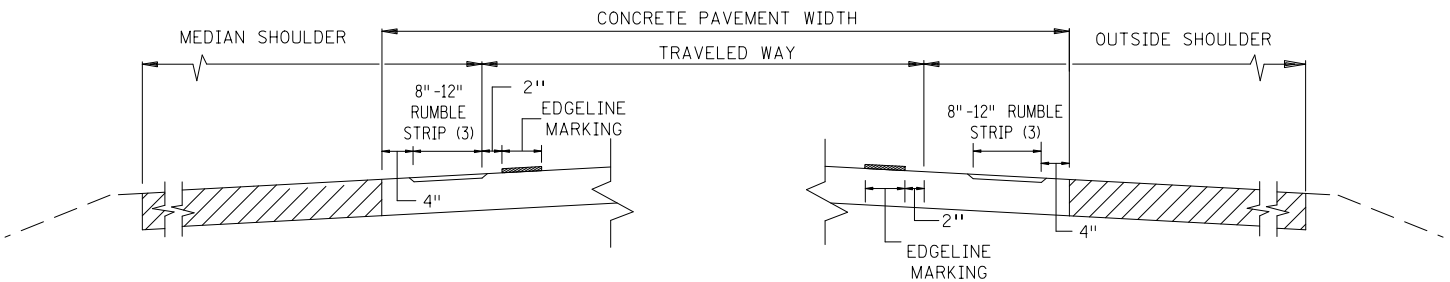


FIGURE 4C - CONCRETE FREEWAY/MULTI-LANE EXPRESSWAY OPTION B
(ONE ROADWAY SHOWN)



- (1) USE 8" INTERMITTENT WHERE SHOULDER WIDTH IS EQUAL TO OR GREATER THAN 4' AND LESS THAN 8'.
USE 12" INTERMITTENT WHERE SHOULDER WIDTH IS 8' OR GREATER.
USE 16" CONTINUOUS ON FREEWAY.
- (2) FOR BITUMINOUS FREEWAYS THE SPACING IS 24".
FOR BITUMINOUS MULTI-LANE EXPRESSWAYS THE SPACING SHOULD BE 2" WHERE SHOULDER WIDTH IS LESS THAN 6' AND 12" WHERE SHOULDER WIDTH IS 6' OR GREATER.
- (3) SEE FIG. 8 AND 9 FOR RUMBLE STRIP OPTIONS, PLACEMENT, AND DIMENSIONS.

FIGURE 5 - BITUMINOUS SHOULDER RUMBLE STRIP

FIGURE 5A - CONTINUOUS PATTERN

RECTANGULAR CORRUGATED OR SINUSOIDAL RUMBLE STRIP (1)

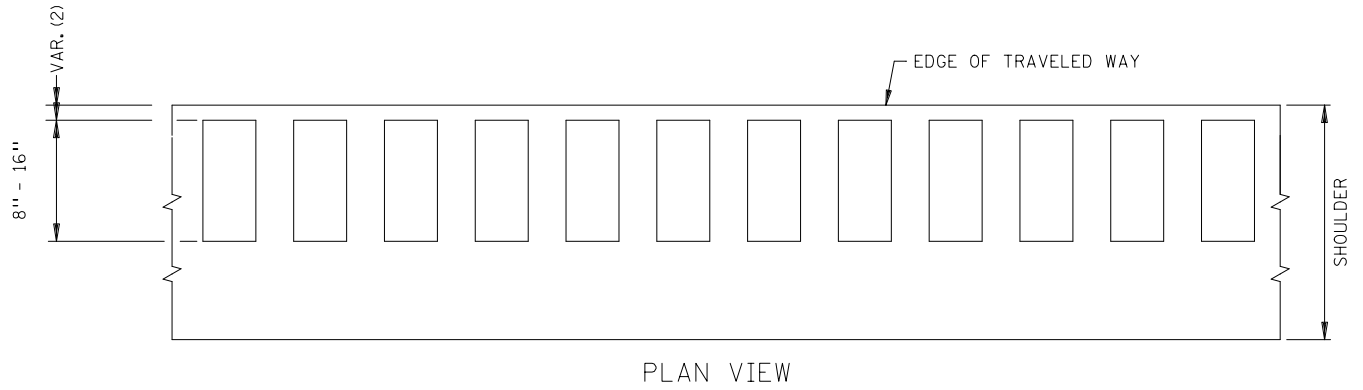
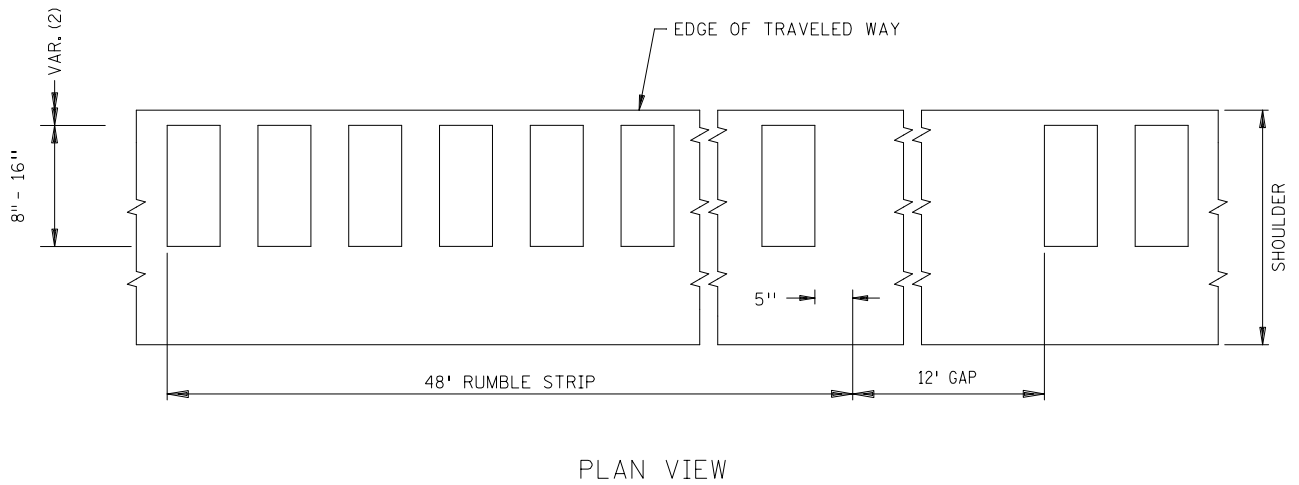


FIGURE 5B - INTERMITTENT PATTERN

RECTANGULAR CORRUGATED OR SINUSOIDAL RUMBLE STRIP (1)

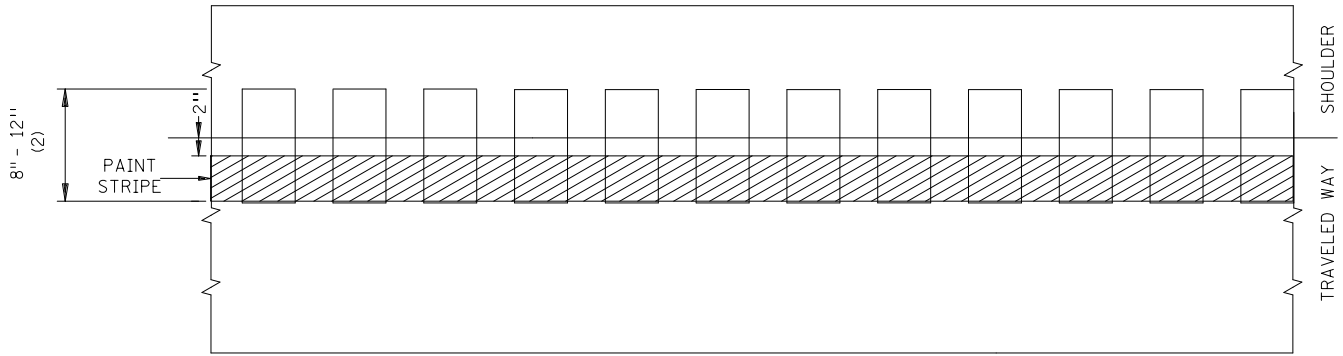


(1) REFER TO FIGURES 1A AND 1B FOR RUMBLE STRIP DESIGN SPECIFICATIONS
(2) REFER TO FIGURES 2-4 FOR SPECIFIC APPLICATIONS.

FIGURE 6 - BITUMINOUS EDGELINE RUMBLE STRIPE

FIGURE 6A - CONTINUOUS PATTERN

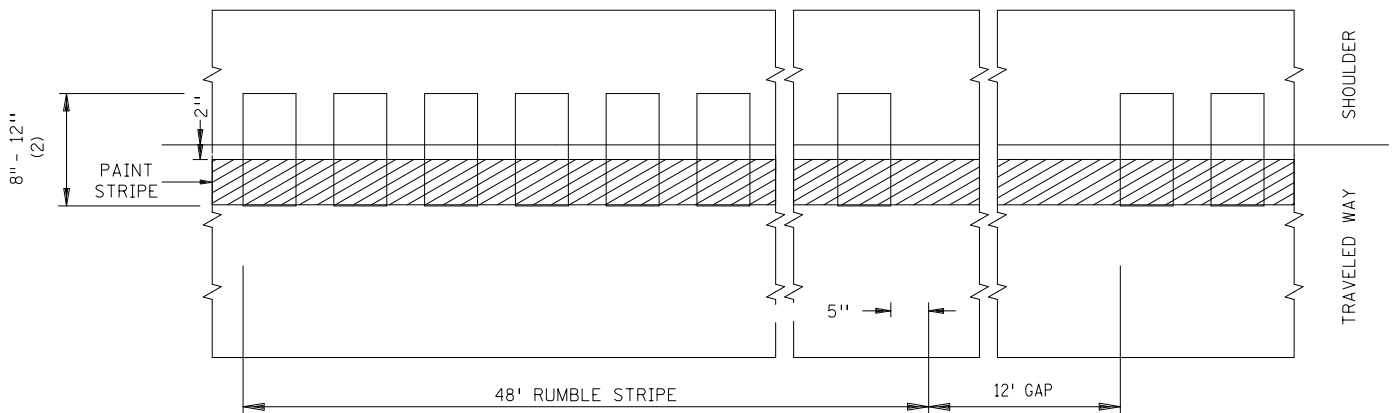
RECTANGULAR CORRUGATED OR SINUSOIDAL RUMBLE STRIP (1)



PLAN VIEW

FIGURE 6B - INTERMITTENT PATTERN

RECTANGULAR CORRUGATED OR SINUSOIDAL RUMBLE STRIP (1)

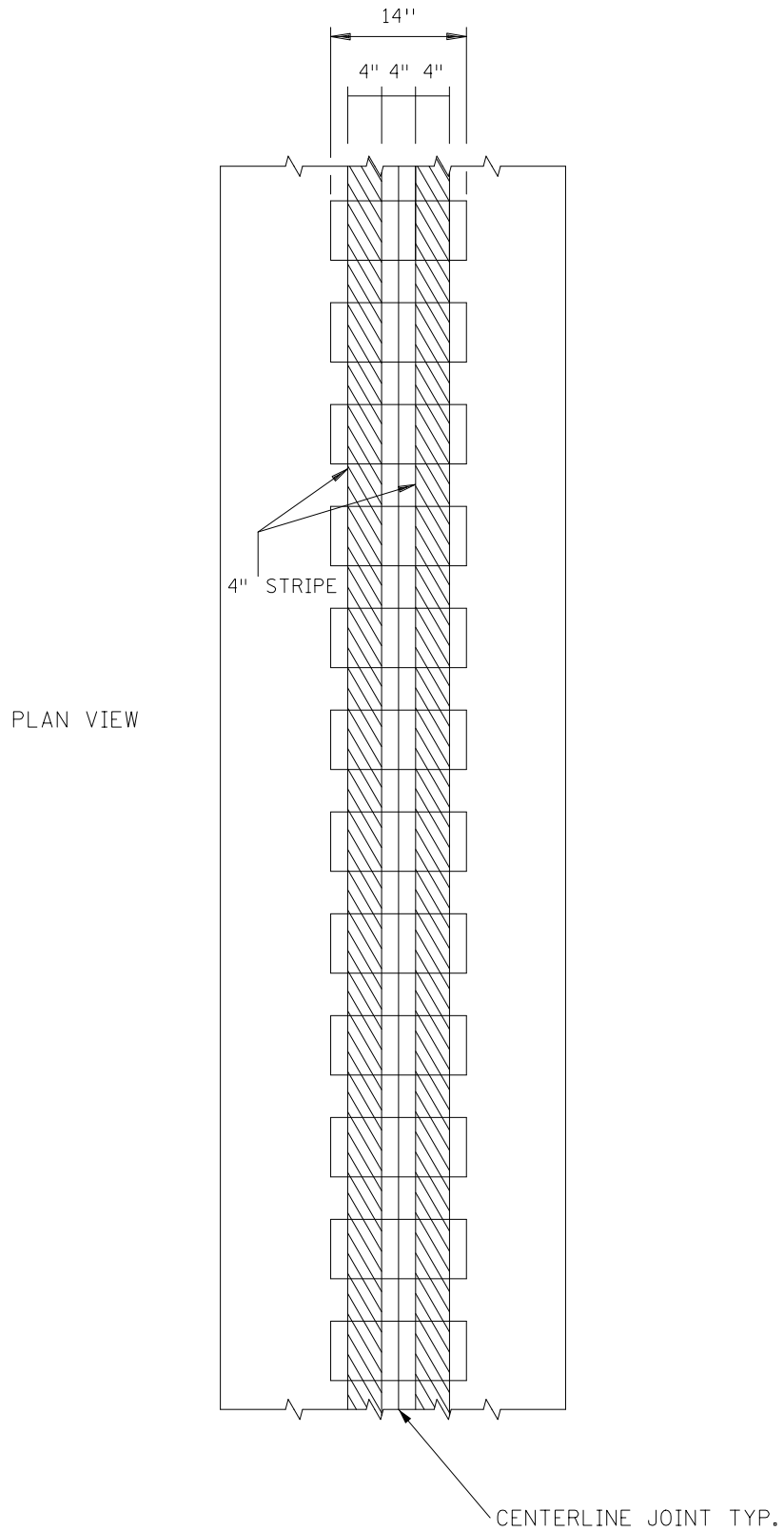


PLAN VIEW

(1) REFER TO FIGURES 1A AND 1B FOR RUMBLE STRIP DESIGN SPECIFICATIONS
(2) USE 8" RUMBLE STRIPE WHERE SHOULDER WIDTH IS LESS THAN 6'.

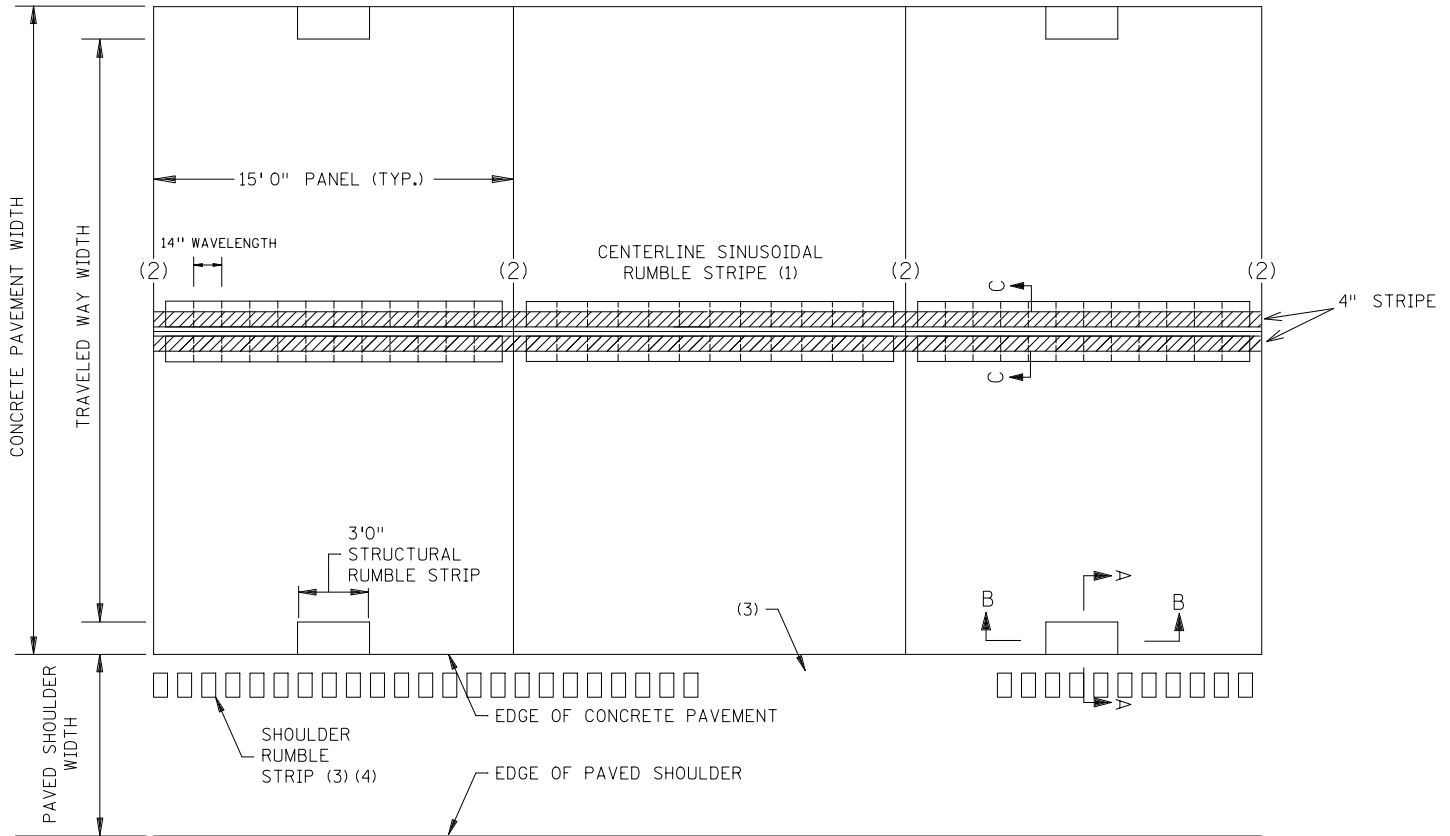
FIGURE 7 - BITUMINOUS CENTERLINE RUMBLE STRIPE

RECTANGULAR CORRUGATED OR SINUSOIDAL RUMBLE STRIP (1)

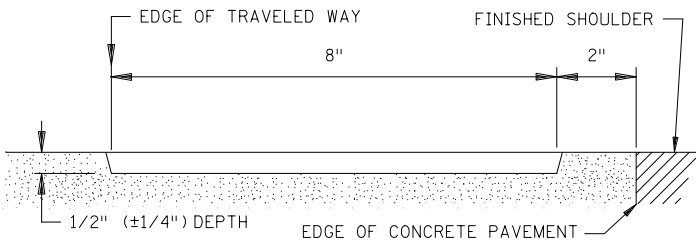


(1) REFER TO FIGURES 1A AND 1B FOR RUMBLE STRIP DESIGN SPECIFICATIONS

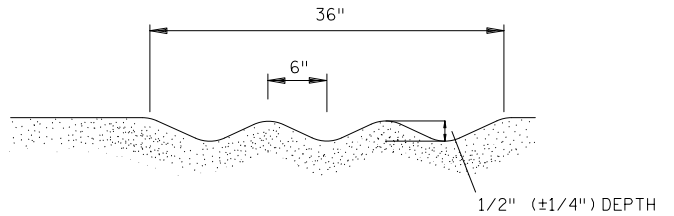
FIGURE 8 - CONCRETE PAVEMENT OPTION A - STRUCTURAL RUMBLE STRIP



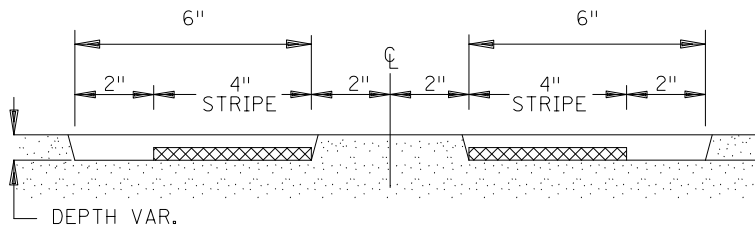
PLAN VIEW



SECTION A-A



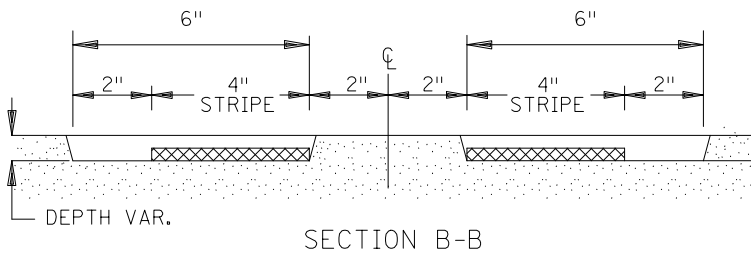
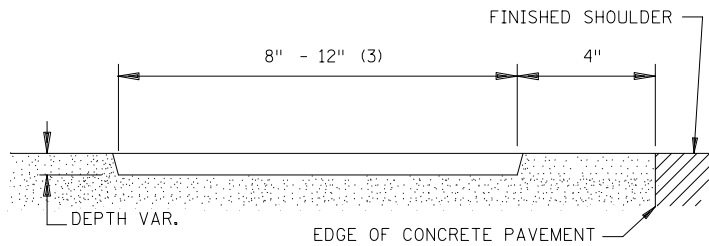
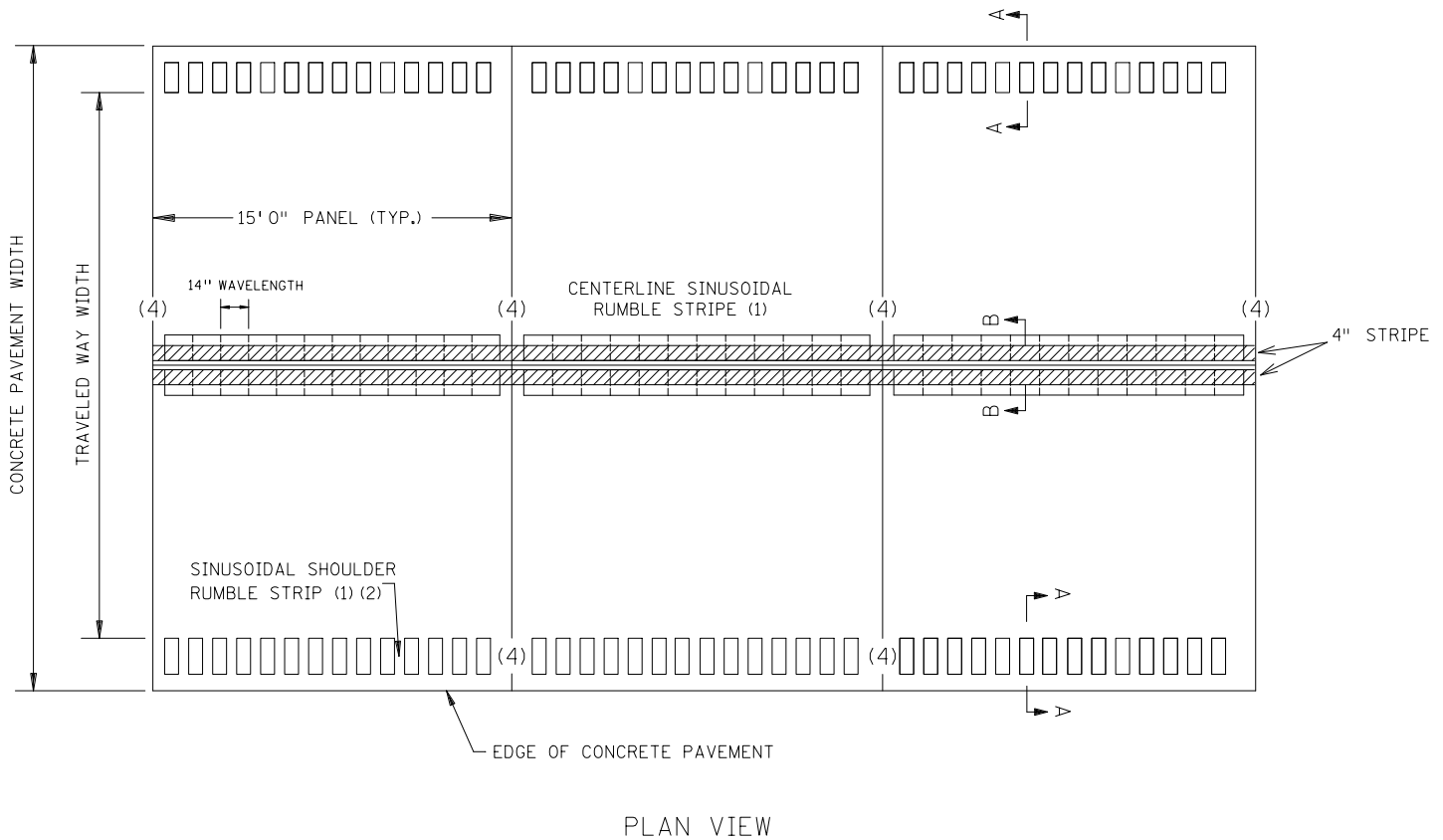
SECTION B-B



SECTION C-C

- (1) REFER TO FIGURE 1B FOR RUMBLE STRIP DESIGN SPECIFICATIONS.
- (2) GAP RUMBLE STRIPS SO THAT THERE IS AT LEAST 6" CLEARANCE ON EITHER SIDE OF THE TRANSVERSE JOINT.
- (3) INTERMITTENT DESIGN SHOWN FOR ILLUSTRATION PURPOSES. REFER TO FIGURE 5B FOR INTERMITTENT PATTERN.
- (4) SHOULDER RUMBLES MAY BE RECTANGULAR CORRUGATED OR SINUSOIDAL DESIGN. REFER TO FIGURE 1 FOR DETAILS.

FIGURE 9 - CONCRETE PAVEMENT OPTION B - CONCRETE RUMBLE STRIP



- (1) REFER TO FIGURE 1B FOR SINUSOIDAL RUMBLE STRIP DESIGN SPECIFICATIONS.
- (2) CONTINUOUS DESIGN SHOWN FOR ILLUSTRATION PURPOSES. REFER TO FIGURE 5B FOR INTERMITTENT PATTERN.
- (3) REFER TO FIGURES 3 AND 4 FOR SPECIFIC APPLICATIONS.
- (4) GAP RUMBLE STRIPS SO THAT THERE IS AT LEAST 6" CLEARANCE ON EITHER SIDE OF THE TRANSVERSE JOINT.

FIGURE 10 - SHOULDER RUMBLE STRIP - APPROPRIATE BREAKS

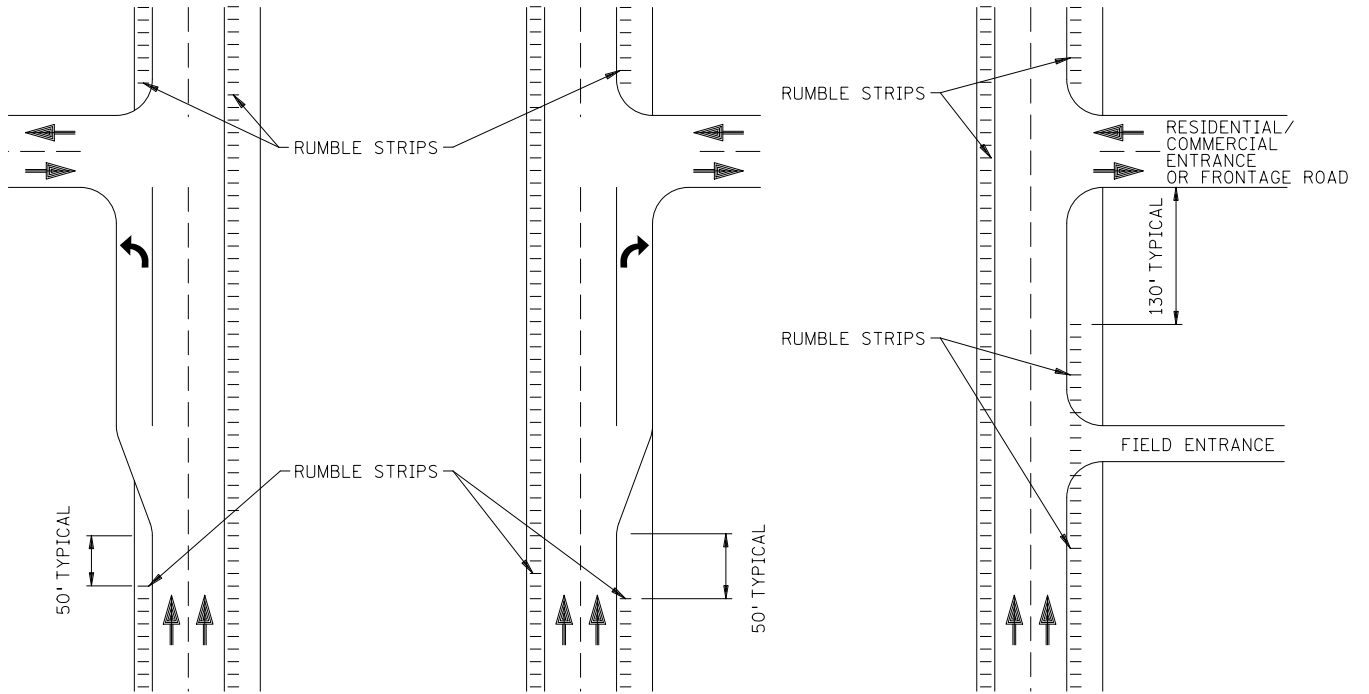


FIGURE 9A
LEFT TURN LANE

FIGURE 9B
RIGHT TURN LANE

FIGURE 9C
ENTRANCE ROADS

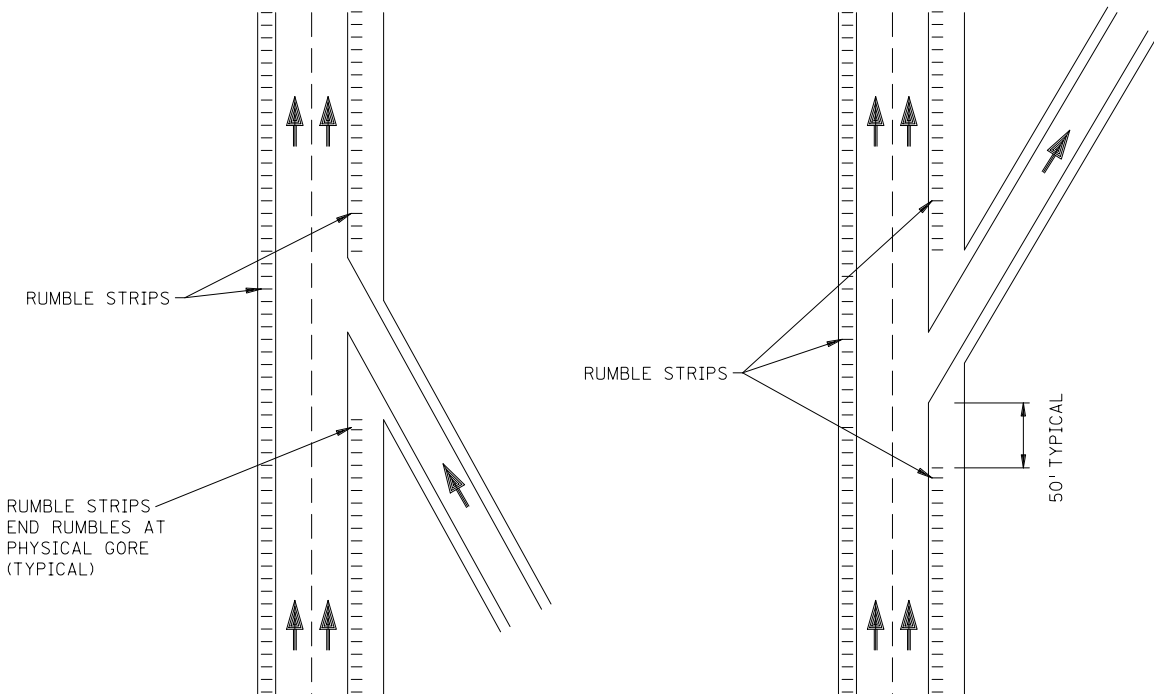
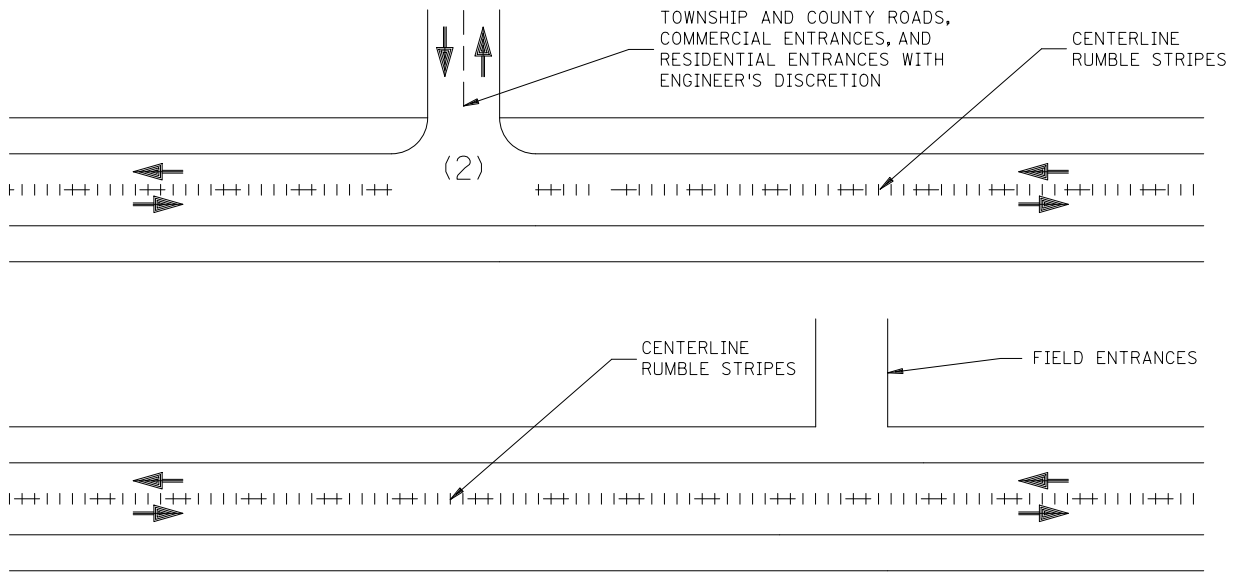


FIGURE 9D
ENTRANCE RAMP

FIGURE 9E
EXIT RAMP

FIGURE 11 - CENTERLINE RECTANGULAR CORRUGATED RUMBLE STRIPE - APPROPRIATE BREAKS (1)



(1) PAVEMENT MARKINGS AND STRIPING SHALL BE COMPLIANT WITH THE CURRENT TRAFFIC ENGINEERING MANUAL (TEM) AND THE CURRENT MINNESOTA MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES (MN/MUTCD).

(2) THE TYPICAL RUMBLE STRIP GAP STARTS AND ENDS AT THE MAINLINE RADII POINTS.

FIGURE 12 - CENTERLINE SINUSOIDAL RUMBLE STRIPE - APPROPRIATE BREAKS (1)

FIGURE 12A
INTERSECTIONS IN WHICH PAVEMENT MARKING IS CONTINUED THROUGH THE INTERSECTION

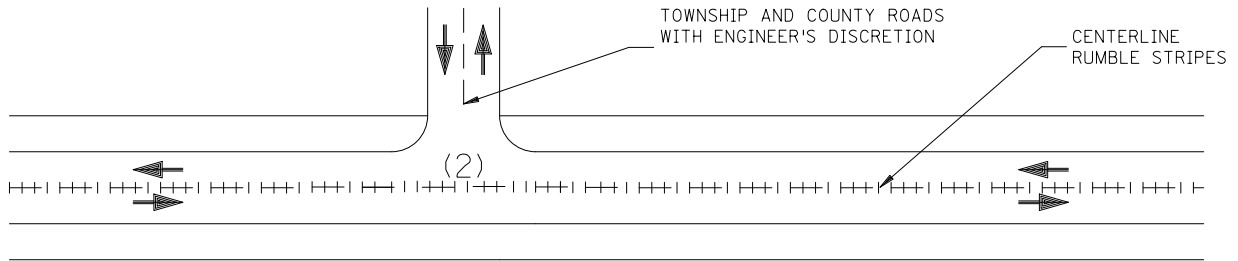


FIGURE 12B
INTERSECTIONS IN WHICH PAVEMENT MARKING IS GAPPED

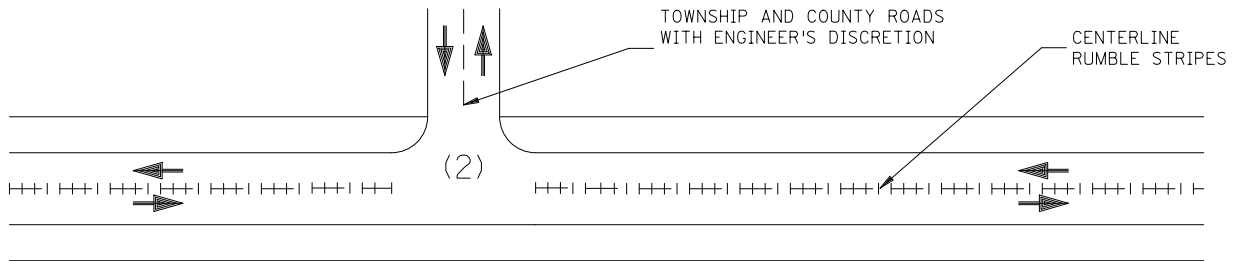
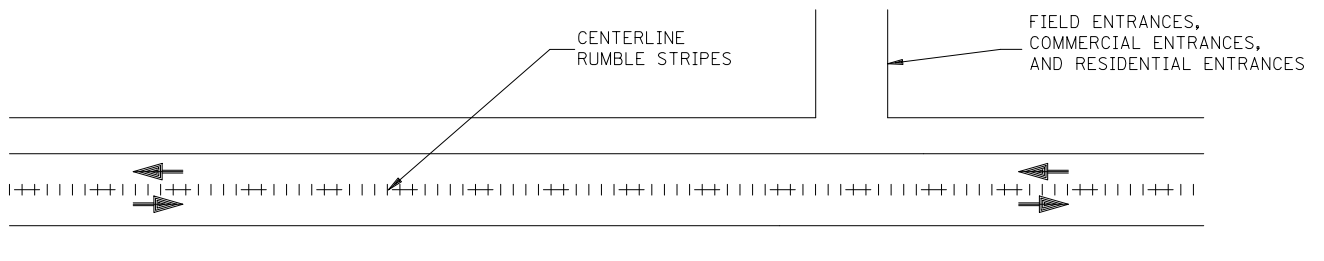


FIGURE 12C
OTHER INTERSECTIONS



(1) PAVEMENT MARKINGS AND STRIPING SHALL BE COMPLIANT WITH THE CURRENT TRAFFIC ENGINEERING MANUAL (TEM) AND THE CURRENT MINNESOTA MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES (MN/MUTCD).

(2) THE ENGINEER HAS DISCRETION TO GAP THE CENTERLINE SINUSOIDAL RUMBLE STRIPES AT INTERSECTIONS. TYPICALLY, THIS GAP WILL COINCIDE WITH THE PAVEMENT MARKING GAP (IF PROVIDED) OR THE GAP WILL START AND END AT THE MAINLINE RADI POINTS.