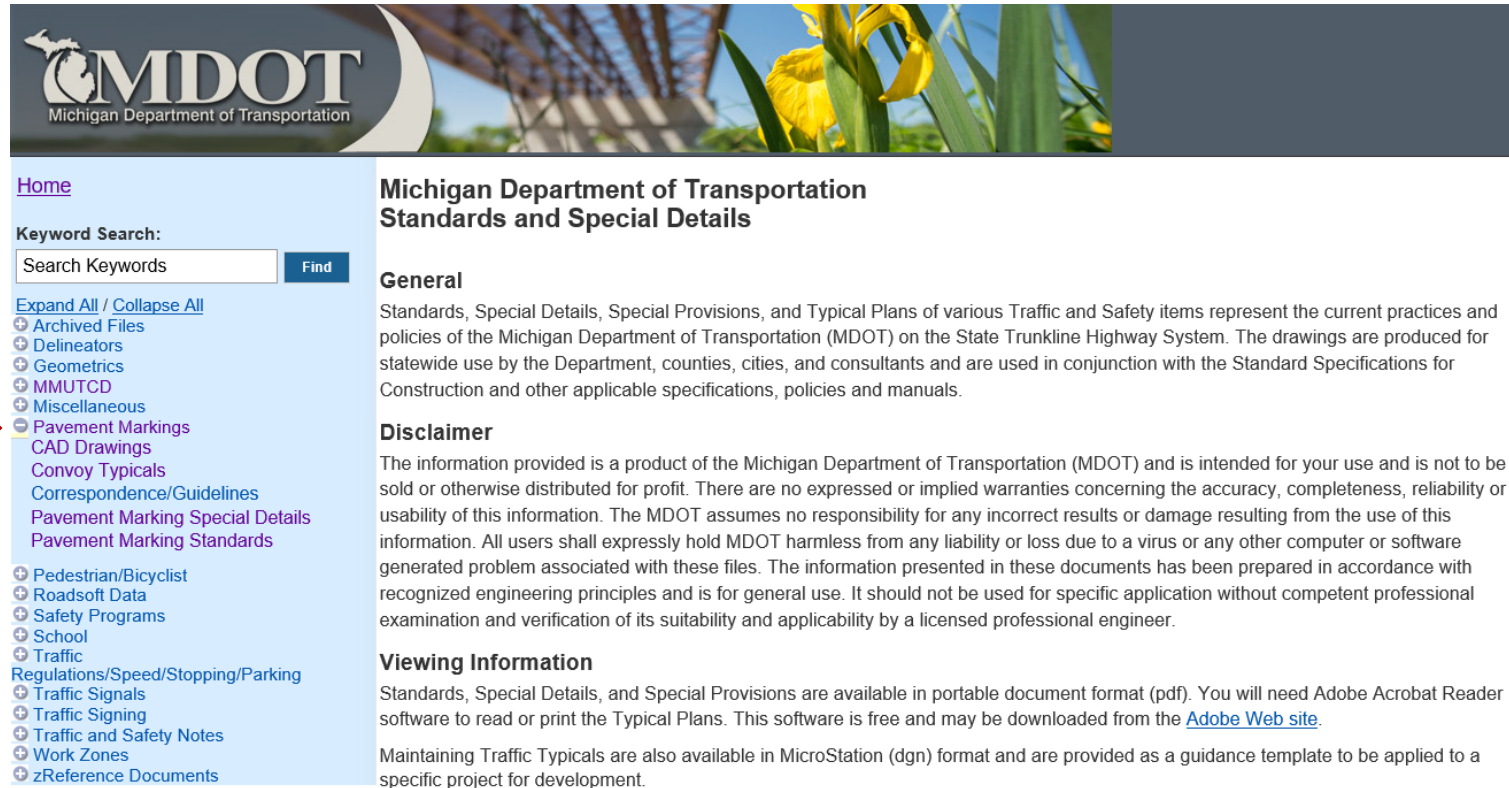


Pavement Markings: Design Tips

Casey White & Mary Bramble, P.E.
October 2018

Online Resources

<https://mdotjboss.state.mi.us/TSSD/tssdHome.htm>



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Michigan Department of Transportation Standards and Special Details

General

Standards, Special Details, Special Provisions, and Typical Plans of various Traffic and Safety items represent the current practices and policies of the Michigan Department of Transportation (MDOT) on the State Trunkline Highway System. The drawings are produced for statewide use by the Department, counties, cities, and consultants and are used in conjunction with the Standard Specifications for Construction and other applicable specifications, policies and manuals.

Disclaimer

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Viewing Information

Standards, Special Details, and Special Provisions are available in portable document format (pdf). You will need Adobe Acrobat Reader software to read or print the Typical Plans. This software is free and may be downloaded from the [Adobe Web site](#).

Maintaining Traffic Typicals are also available in MicroStation (dgn) format and are provided as a guidance template to be applied to a specific project for development.

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Correspondence/Guidelines

Click on the individual link below to download the file.

Sub-Category	Plan	Title - Download
Correspondence/Guidelines	0-CHANGES_PM_Corrs_Guide	Change List for Correspondence/Guidelines mdot_changes_pave_mark-correspguide.pdf (13.7 KB)
Correspondence/Guidelines	Optical Speed Bars	Optical Speed Bars mdot_optical_speed_bars.pdf (425.03 KB)
Correspondence/Guidelines	Pavement Marking Materials	Pavement Marking Material Selection Guidelines mdot_pavement_marking_material_guide.pdf (78.19 KB)
Correspondence/Guidelines	Route Shield Markings	Route Shield Markings mdot_route_shield_markings.pdf (224.43 KB)
Correspondence/Guidelines	Plan Pavement Marking Guidance	Plan Pavement Marking Guidance

Online Resources

http://mdotwiki.state.mi.us/design/index.php/Pavement_Markings



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Pavement Markings

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Longitudinal Markings

- ▶ Edgelines
 - 6" width on all MDOT roadways
 - Often 4" width on local roads – should verify with locals
- ▶ Lane Lines
 - 4" width
 - Must be wet-reflective on freeways
- ▶ Centerlines
 - 4" width
 - Can still be recessed in the presence of rumble strips
- ▶ Gore Markings
 - 12" Width
 - Present at most merge/diverge locations



Longitudinal Markings

▶ Color

◦ White

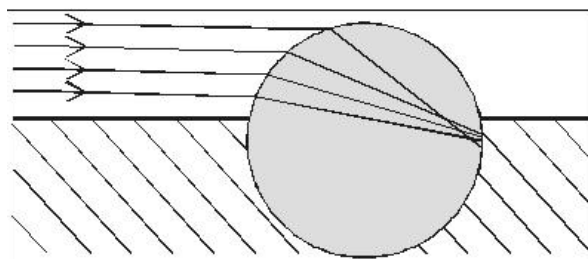
- Right side of roadways and ramps
- Separate traffic moving in the same direction

◦ Yellow

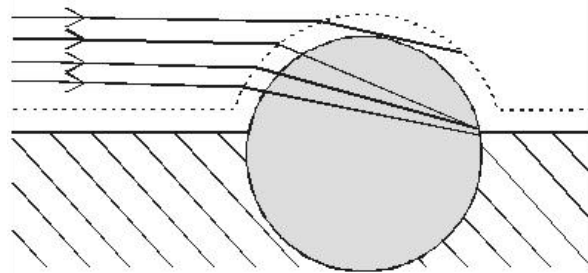
- Left side of divided roadways and ramps
- Separate traffic moving in opposite directions



Addressing Visibility



(a) Dry Bead at Optimum 60% Embedment



(b) Same Bead with Water Film Preventing Retroreflection

- ▶ A common question:
 - Why can't we see pavement markings at night in the rain?
- ▶ A simple enough answer:
 - Typically light from headlights is reflected back to the driver via glass beads in the stripe, but when the markings are covered by water the light instead scatters and generates glare.
- ▶ A mitigation effort:
 - Specify wet-reflective pavement markings
 - Tape (811Q) or liquid (811K)

Addressing Visibility



Special Markings

- ▶ Symbols
- ▶ Legends
- ▶ Stop Bars
- ▶ Crosswalks
- ▶ Cross Hatching
- ▶ Turning Guide Lines



Merge Arrows

- ▶ Required at lane reduction locations where the speed limit is 45 mph or above
 - Optional at lower speeds
- ▶ Can be used in unusually long acceleration lanes
 - Engineer's discretion
- ▶ Details for placement in PAVE-971



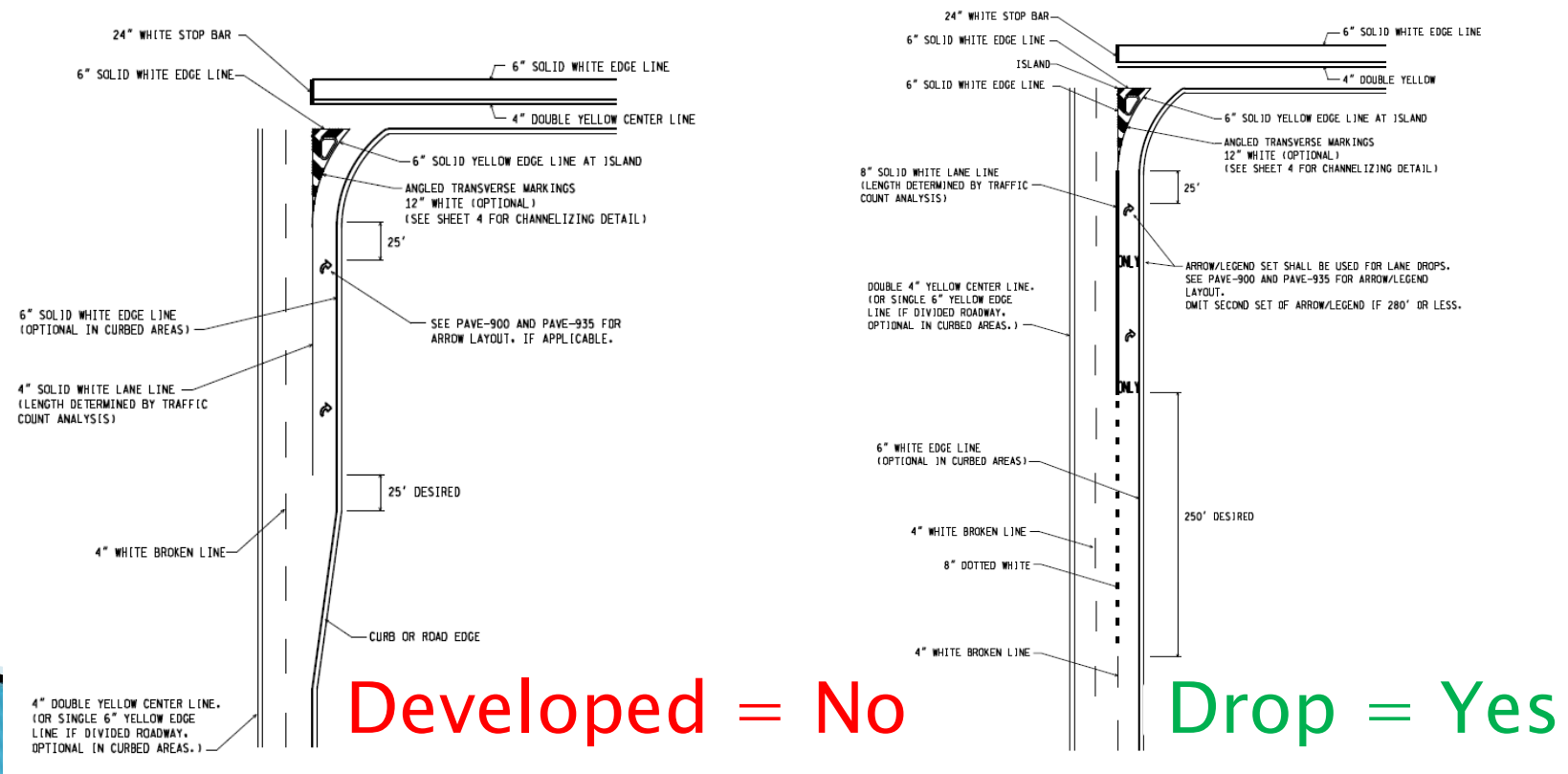
ONLY Legend

- ▶ Not used in developed turn lanes
 - Policy change in 2015
- ▶ Required in all drop lanes
- ▶ Examples where required and omitted shown in PAVE-935



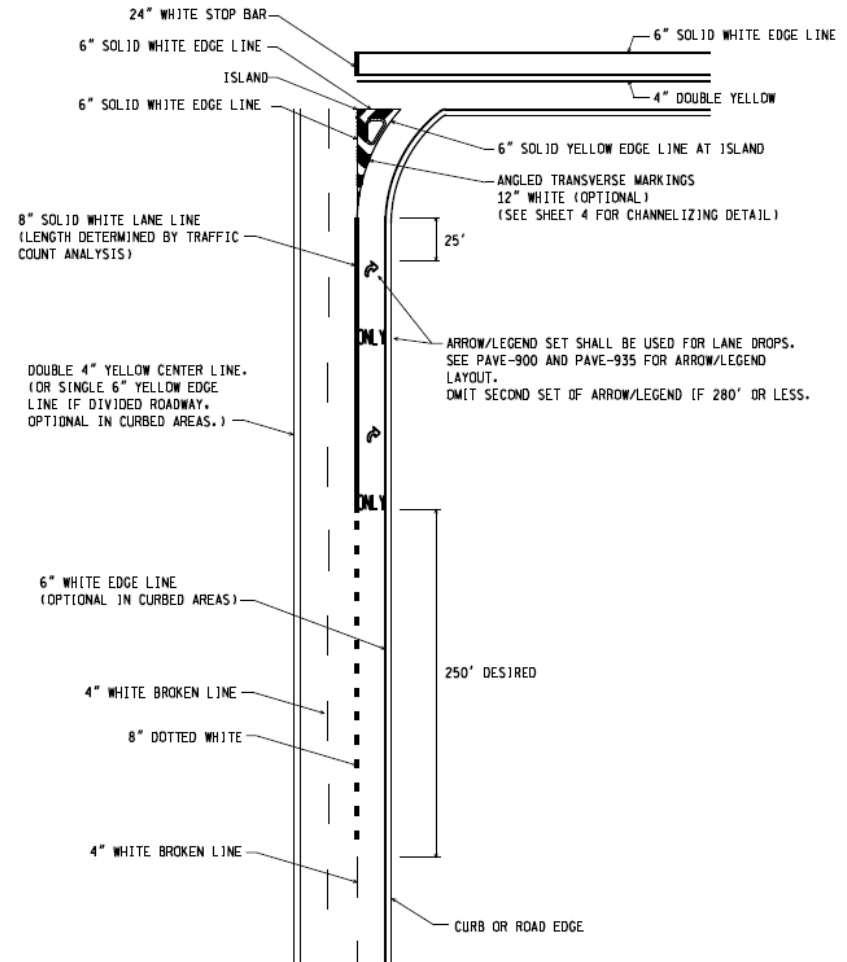
ONLY Legend Use

- ▶ No longer needed in developed turn lanes
- ▶ Still required for drop lanes



Drop Lane Markings

- ▶ Pattern changes
 - Broken → dotted → solid
- ▶ Width changes
 - Dotted and solid sections must be “wide” width, meaning **at least** twice as wide as the preceding
 - 8” on non-freeway, 12” on freeway



Stop Bars

- ▶ **Marking Width**
 - 24-Inch for all MDOT roadways
 - 18-Inch for local roadways
 - Recommend verifying with the local agency
- ▶ **Signalized Intersections**
 - Required on all legs
 - Placed 4 to 30 feet from nearest edge of the intersecting traveled way
 - Placed at least 4 feet in advance of crosswalk markings
- ▶ **Stop-Controlled Intersections**
 - MDOT does not place unless a concern exists (safety, compliance, etc.)
 - Placed adjacent to STOP sign
- ▶ May be staggered for sight distance or turning vehicle pathing



Crosswalks



- ▶ **Crossing Width**
 - Match approaching sidewalk/path width
 - 6-foot minimum

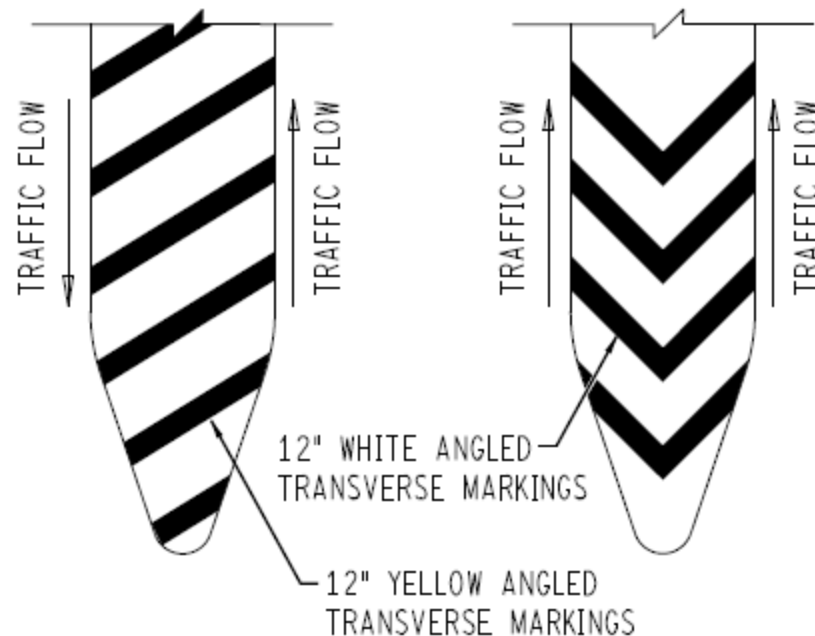
- ▶ **Special Emphasis Crosswalks (12-Inch longitudinal bars)**
 - Safe Routes to School
 - Mid-block or uncontrolled crossings
 - Other areas deemed necessary by the Engineer

- ▶ **Standard Crosswalks (6-Inch parallel transverse lines)**
 - All other marked crosswalks
 - Lines may be done as 12-Inch (not preferred)

Cross Hatching

▶ Direction

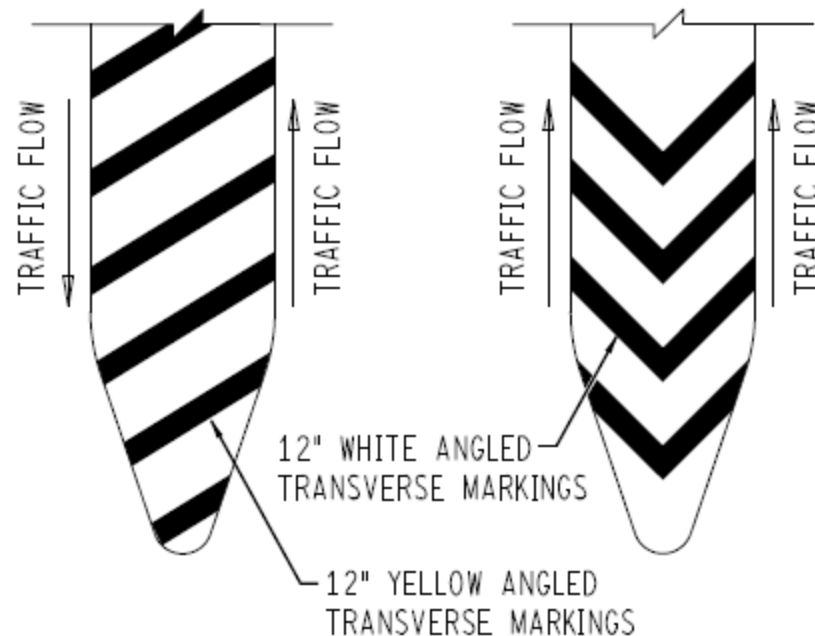
- Must angle “up” in the direction of adjacent traffic flow
 - May require straight lines or chevron patterns depending on location



Cross Hatching

▶ Color

- Yellow between traffic moving in opposite directions
- White between traffic moving in the same direction



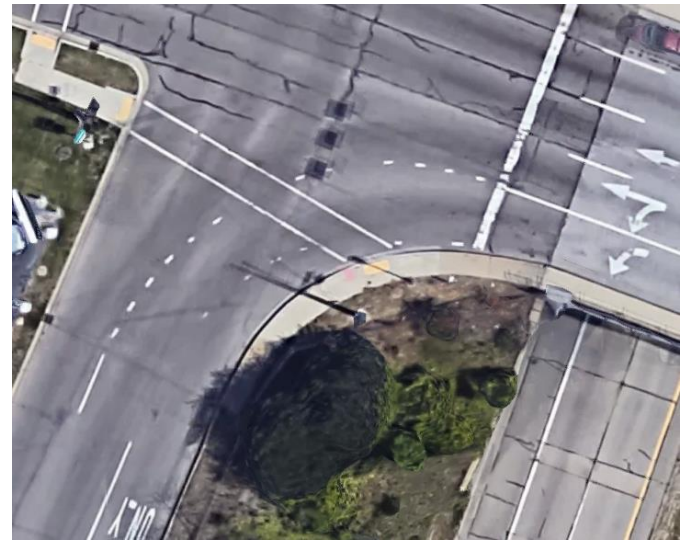
Turning Guide Lines

▶ Use

- Required at all locations where more than one lane from a single approach may turn the same direction
- Requires FUSP 8110

▶ Design

- Line cycle consists of 2-foot mark then 4-foot gap
- Single line even when extending a double yellow
- Recessing strongly recommended for durability



Turning Guide Lines

▶ Width

- Must be **at least** as wide as the line being extended
 - 6" can be used to extend a 4" line for greater visibility

▶ Color

- Must match the color of the line being extended (in the direction of traffic)
 - In rare instances this will not match the downstream color (or width)



Parking Lot Markings

- ▶ Specific waterborne pay items
- ▶ Are not required to be retroreflective
 - Do not receive beads during placement
- ▶ Placement details in PAVE-956



Parking Lot Markings

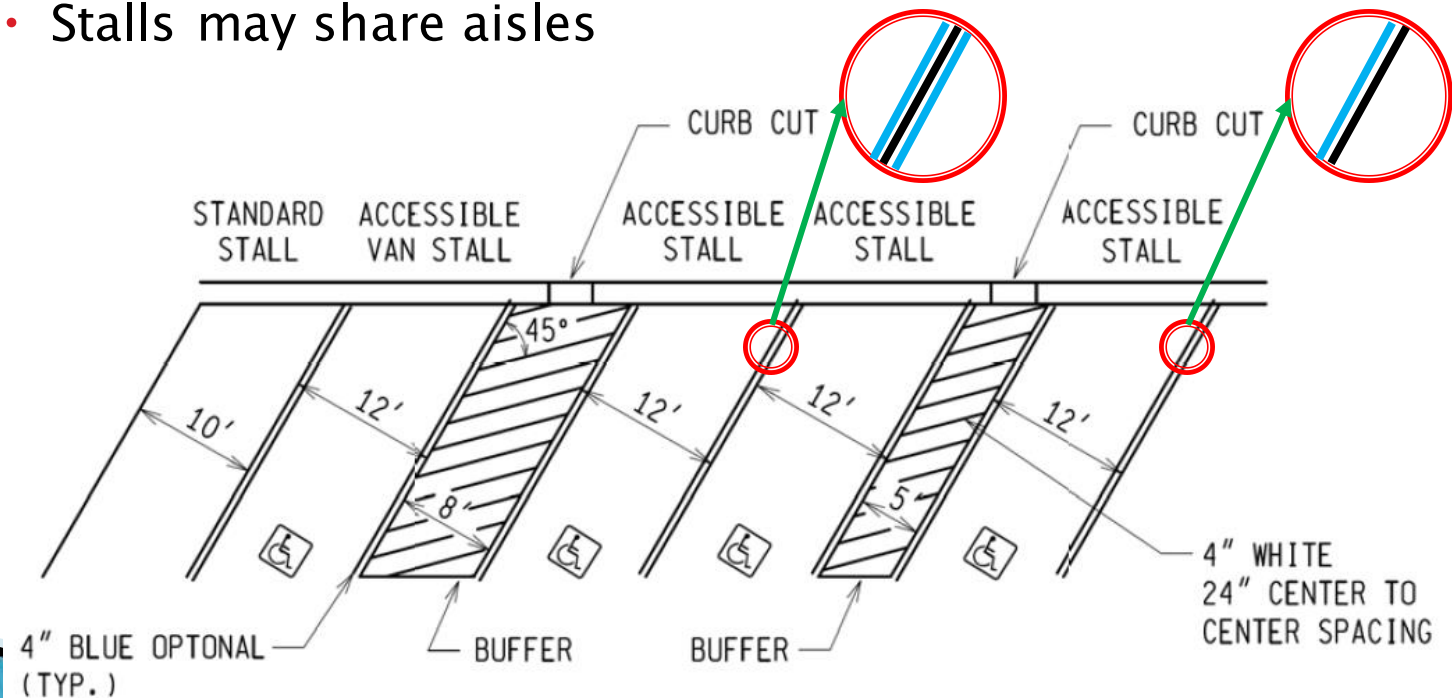
- ▶ Accessible Stalls
 - Number found in chart in PAVE-956
 - 1 in 6 must be van accessible (minimum of 1)

Total Parking in Lot	Required Minimum Number of Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1000	2 percent of total
1001 and over	20, plus 1 for each 100 over 1000

Parking Lot Markings

▶ Accessible Stalls

- Markings must be white
 - Blue can supplement, but not replace
- Each stall must be adjacent to an access aisle (buffer)
 - Stalls may share aisles

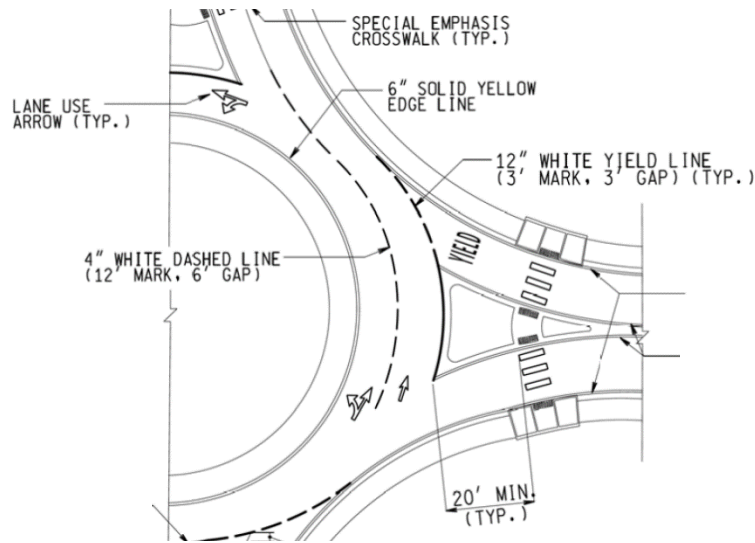


Roundabout Markings

- ▶ Detailed in PAVE-951
- ▶ Recommend a non-tape special marking material for the yield lines
 - 12" wide 3' mark, 3' gap line at entrance points
 - Can use any material but many will not hold up to being driven over and sheared
- ▶ Recommend a durable material for markings in the circulatory roadway
 - Tape will fail under the shearing forces



Roundabout Markings



- ▶ Unique lane line pattern in the circulatory roadway
 - 12' mark, 6' gap
- ▶ Place a yellow edge line on the inside of the circulatory roadway even though edgelines are optional with curbs

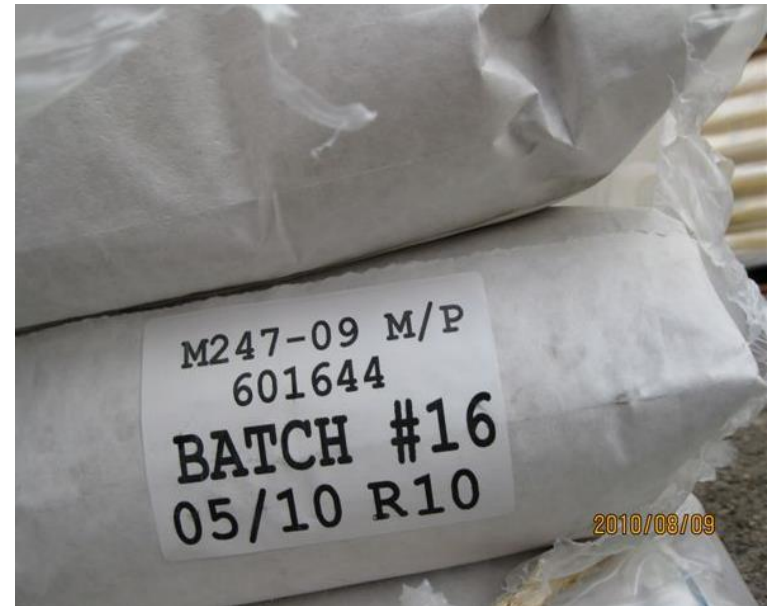
Special Marking Maintenance

- ▶ MDOT Trunkline
 - MDOT maintains all markings on the thru roadway
 - This does not include on-street parking markings
- ▶ Signalized Intersections
 - MDOT will maintain stop bars and crosswalks on all legs
 - Arrows and legends on non-trunkline crossroads are the responsibility of the local agency
- ▶ Stop-Controlled Intersections
 - MDOT will maintain special markings on the trunkline legs only
- ▶ All Intersections with Trunkline
 - MDOT will maintain turning guide lines



Materials

- ▶ Waterborne
- ▶ Sprayable Thermoplastic
- ▶ Regular Dry
- ▶ Polyurea
- ▶ Modified Urethane
- ▶ Cold Plastic
- ▶ Thermoplastic
- ▶ Preformed Thermoplastic
- ▶ Methyl Methacrylate (MMA)
- ▶ Multipolymer Thermoplastic (HPS-8)



Waterborne



- ▶ Basic paint
- ▶ Least expensive product
- ▶ Maintenance product
- ▶ Used for longitudinal lines

Sprayable Thermoplastic

- ▶ Aerosolized thermoplastic
 - Comes to site in granular form and is heated and sprayed
- ▶ Used over waterborne when there are tracking concerns during placement
 - Fast dry time
- ▶ Maintenance product
- ▶ Used for longitudinal lines
 - Does not bond well to concrete, but with the limited life expectancy it is acceptable to use



Regular Dry

- ▶ Solvent-based paint
 - Contains VOCs
 - Not environmentally friendly
- ▶ Used over waterborne when markings have to be placed out of season
 - Only specify when you are sure of this condition
 - Otherwise FUSP 811D covers the change
- ▶ Maintenance product
- ▶ Used for longitudinal lines



Polyurea



- ▶ Plural component product
- ▶ Durable product in long line applications
- ▶ Used for longitudinal lines and special markings
 - Basic marking for special markings
 - Holds up to shear better than cold plastic

Modified Urethane

- ▶ Plural component product
- ▶ Durable product in long line applications
- ▶ Used for longitudinal lines
 - May show up as special markings when crossing state lines



Cold Plastic

- ▶ Preformed product
 - Comes to site in rolls or pre-punched shapes
- ▶ Durable product in long line applications
 - Wet-reflective long line products
 - Shadow tape
- ▶ Used for longitudinal lines and special markings
 - Baseline material for special markings
 - Does not do well under shearing forces



Thermoplastic



- ▶ Extruded thermoplastic
 - Thick application at 90–120 mils
 - Comes to site in granular form and is heated

- ▶ Would be a durable product in long line applications

- ▶ Used primarily for special markings
 - More durable than cold plastic or polyurea
 - Does not bond well to concrete

Preformed Thermoplastic

- ▶ Preformed material
 - Comes to site in pieces
- ▶ Can be any color(s)
 - Accessible symbols
 - Route shields
 - Bike lanes
- ▶ Used for special markings
 - Highly durable but long placement time
 - Skid resistant
 - Can have difficulty bonding to concrete
 - Recommend recessing



Methyl Methacrylate (MMA)



- ▶ Plural component material
- ▶ Placed in a “sandwich” application
- ▶ Used for special markings
 - Touted as the most durable marking material in existence
 - Can be difficult to work with
- ▶ Included via template SP

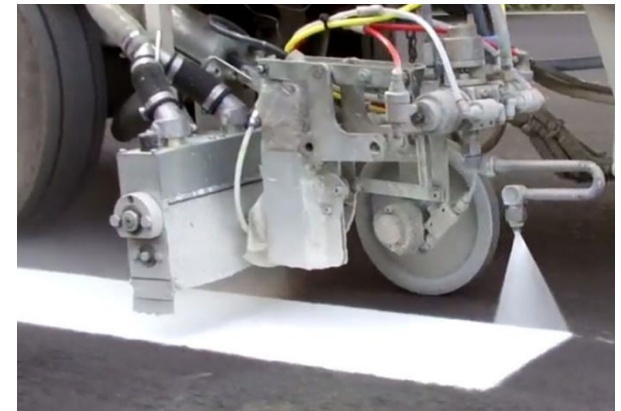
Multipolymer Thermoplastic (HPS-8)

- ▶ Different formulation of thermoplastic
- ▶ Extruded and placed thick (90+ mils)
- ▶ Used for long line and special markings
 - Bonds to both asphalt and concrete
 - 50% bead intermix



Thermopl vs. Sprayable Thermopl

- ▶ Even though they can share some products on the QPL, these are not the same
- ▶ Thermoplastic is extruded and thick
 - 90–120 mils of binder
 - Suitable for intersection special markings
 - Would be considered a durable product
- ▶ Sprayable Thermoplastic is placed in a thin pressurized spray
 - 30 mils of binder
 - **Cannot** be used for special markings
 - Maintenance product



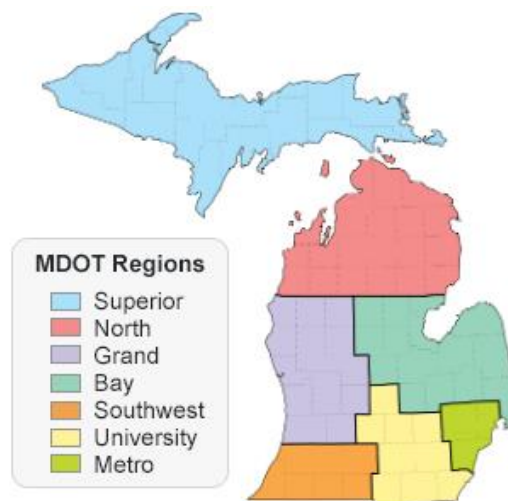
Specific Material Recommendations



- ▶ Cold plastic tapes
 - Not recommended for longitudinal markings aside from wet-reflective tape skips on major roadways
 - Higher cost than other durable materials without notably greater longevity
- ▶ Accessible symbols
 - Only placed in preformed thermoplastic
 - Higher cost than older materials but significantly better performance
 - Specified through inclusion of FUSP 8110 and standard pay item
- ▶ High-shear locations (inside roundabouts, turn lane stop bars and crosswalks, etc.)
 - Recommend liquid special markings over cold plastic tapes due to failure of tape under shearing forces
 - Less of an issue with low-volume movements
 - Evaluate by location

Pavement Marking Inventories

- ▶ If your project is changing any markings from the existing layout, that needs to be passed along
 - If you don't know who in your Region maintains the inventories, please contact us
- ▶ Inventories are used to develop the annual Regionwide projects, and must be kept accurate



Pavement Marking Callbacks

- ▶ Packets of special request locations for the contractor to go do
- ▶ Typically just in the annual projects, but can appear in others
- ▶ Mobilization and Intermediate Transportation
 - Mobilization to the first site on a list, intermediate transportation to the other locations
 - Each new list given follows this pattern



Pavement Marking Callbacks

- ▶ Separate callbacks if:
 - Multiple materials being requested
 - Longitudinal and special markings being requested
 - Parking markings with accessible symbols are the exception
 - Multiple surface preparation techniques are needed for a single material
 - Ex. - removal + recessing
- ▶ Each callback should consist of one material and up to one surface preparation
 - Removal, recessing, scarifying


$$1 + 1 = 1$$

Recessing Pavement Markings

- ▶ Required for long line markings on all 3R/4R projects
 - Regardless of marking material selected
- ▶ Required for all durable long line materials
- ▶ Optional for special markings to increase durability
 - Use caution as the grooves can trap water/debris



Recessing Pavement Markings

- ▶ Eliminates the need to remove curing compound
- ▶ Can go through a single layer of paint
 - Such as Type NR temporary markings



Which Recessing Pay Items?

- ▶ Recessing Longit only covers long line markings
 - Edgelines
 - Lane lines
 - Centerlines
 - Gore markings



- ▶ Turning guide lines have their own pay item
- ▶ Everything else goes under Reccessing Transv
 - This includes “line style” special markings
 - Crosswalks, stop bars, cross hatching, etc.

Removing Pavement Markings

- ▶ Needed to eliminate conflicting markings
- ▶ Necessary when changing materials at a location
 - Ex. – existing cold plastic and proposed polyurea
- ▶ Required before recessing if more than one layer of paint is present



Which Removal Pay Items?

- ▶ Longit __ Rem only covers long line markings

- Edgelines
- Lane lines
- Centerlines
- Gore markings



- ▶ Everything else goes under Rem Spec Mrkg

- This includes “line style” special markings
 - Crosswalks, stop bars, cross hatching, etc.
- Turning guide lines should be included here
 - Often intersection machines will do the work

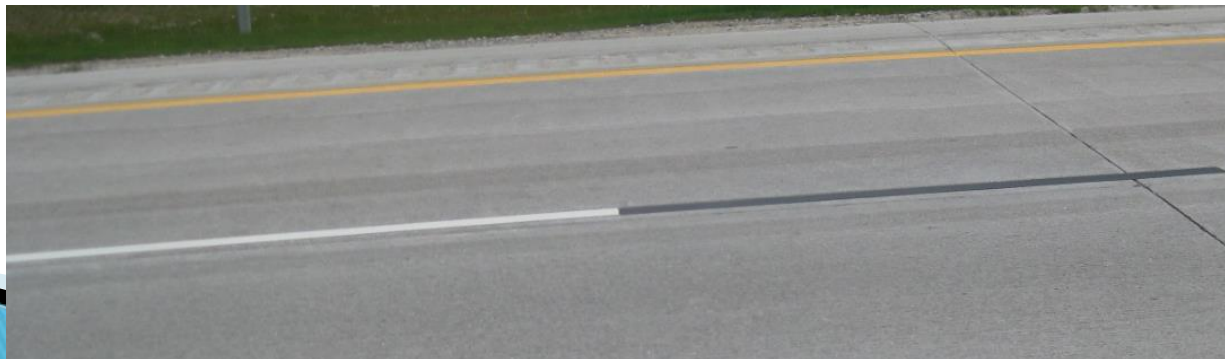
Removal of Curing Compound

- ▶ Necessary prior to surface placement of any pavement markings (temporary or permanent) on new concrete
 - No marking material adheres to the “chalky” curing compound
- ▶ Not needed when the markings are recessed, since grooving already removes the curing compound
- ▶ Standard pay items for longitudinal markings (by width) and special markings
 - Longitudinal only covers edgelines, lane lines, centerlines, and gore markings
 - All other markings utilize the special markings item



Shadow Markings

- ▶ Refers to black markings that trail or “shadow” white broken or dotted lines
 - Also referred to as “tiger tail” markings
- ▶ Required where broken lane lines are placed on new concrete
 - Regardless of material
- ▶ Can be installed as a retrofit to address visibility
- ▶ Placement details in PAVE–906



Contrast Markings

- ▶ Refers to a black border or background for white markings to make them stand out against the pavement
 - Useful for new concrete or aged asphalt



- ▶ Currently no requirements to use, but is an option
 - SP forthcoming

Decorative Crosswalks

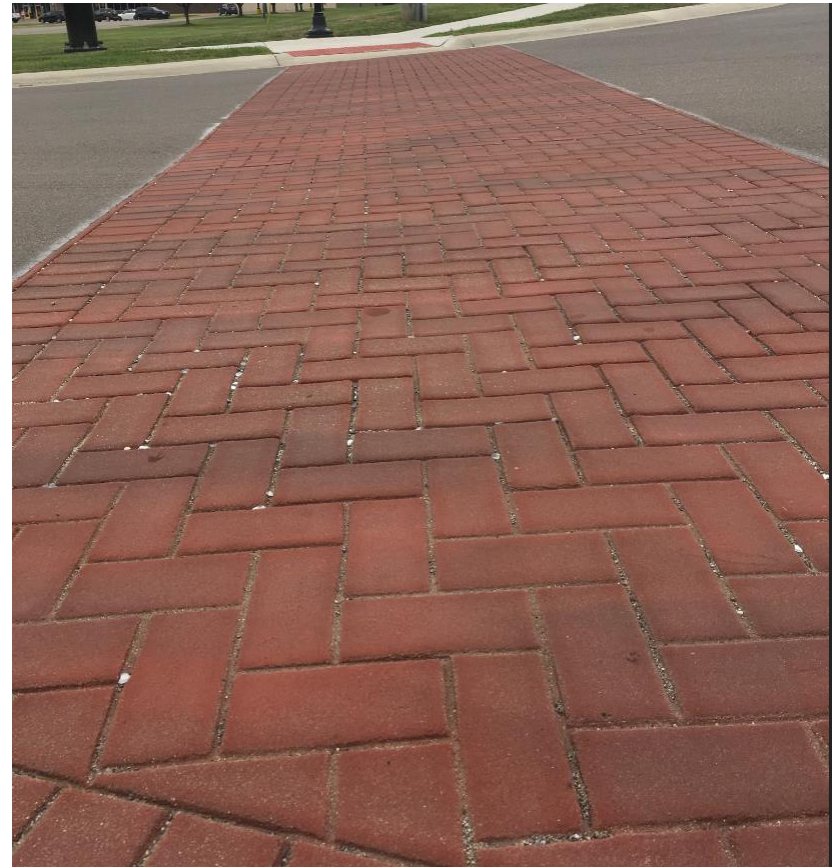


- ▶ Per the MUTCD:
 - “Colored pavement located between crosswalk lines should not use colors or patterns that degrade the contrast of white crosswalk lines, or that might be mistaken by road users as a traffic control application.”

- ▶ FHWA Interpretation:
 - Degradation would occur except with “subdued-colored paving bricks, paving stones, or materials designed to simulate such paving.”

Decorative Crosswalks

- ▶ Unless the crosswalk is well-lit, the white retroreflective crosswalk markings are still required
 - SP forthcoming
- ▶ Multiple promising products on the market
 - SP forthcoming



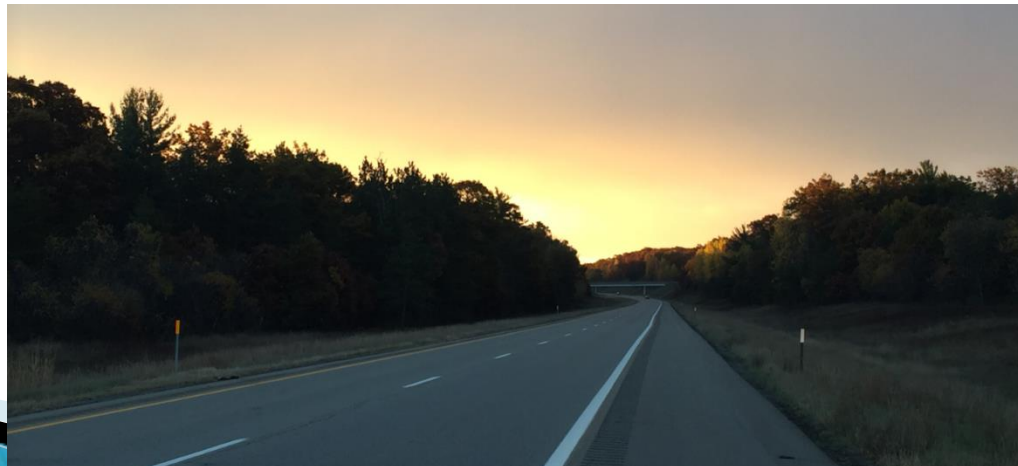
Post-Mounted Delineators



- ▶ Rigid or flexible posts with a mounted reflective element
- ▶ Enhance visibility of roadway limits and geometry in all weather conditions
 - Even when pavement markings can't be seen
- ▶ Placement defined in R-127

Post-Mounted Delineator Pay Items

- ▶ Steel post delineators – 810 standard items
 - Post, Rigid, Delineator
 - Delineator Reflector, (color)
- ▶ Rebounding delineators – 810 standard items
 - Post, Flexible, Delineator
 - Delineator, Reflective Sheeting, 3 inch by 12 inch, (color)



Enhanced Delineation

- ▶ Guardrail or concrete barrier delineators above and beyond the standard tabs or reflectors
- ▶ Specific products rather than generic mass producible items
- ▶ Mechanically fastened for longevity



Enhanced Delineation

<https://mdotjboss.state.mi.us/SpecProv/specProvHome.htm>

*Select a Special Provision category from the drop down menu

Special Provisions - 2012 Recommended
Special Provisions - 2012 Templates
Special Provisions - 2012 Previously Approved
Special Provisions - 2012 Real Estate Demolition
Special Provisions - 2012 ITS
Special Provisions - Innovative Contracting

Division 4 - Drainage Features

Division 5 - Hot Mix Asphalt Pvmnt & Surface Trtmt

Division 6 - Portland Cement Concrete Pavements

Division 7 - Structures

Division 8 - 803 Conc Sidewalks, Sidewalk Ramps, and Steps

Division 8 - 807 Guardrails, Guardrail Terminals, and Misc Post

Division 8 - 810 Permanent Traffic Signs and Supports

Division 8 - 811 Permanent Pavement Markings

[Bidirectional Enhanced Delineation - Concrete Barrier Side Mount-12RC811-A585-02-10-28-16.pdf](#)

[Bidirectional Enhanced Delineation - Concrete Barrier Top Mount-12RC811\(A580\).pdf](#)

[Bidirectional Enhanced Delineation - Guardrail Channel Mount-12RC811\(A595\).pdf](#)

[Bidirectional Enhanced Delineation - Guardrail Post Mount-12RC811\(A590\).pdf](#)

[Pavement Markings on, CPM, Cold Mill and One Course HMA Overlay and One Course HMA Overlay Projects-12RC811-A475.pdf](#)

[Polyurea Surface Preparation with Existing Polyurea Markings-12RC811\(A605\).pdf](#)

[Raised Island Painting-12RC811-A455-01-07-31-15.pdf](#)

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[Unidirectional Enhanced Delineation - Concrete Barrier Top Mount-12RC811\(A560\).pdf](#)

[Unidirectional Enhanced Delineation - Guardrail Channel Mount-12RC811\(A575\).pdf](#)

[Unidirectional Enhanced Delineation - Guardrail Post Mount-12RC811\(A570\).pdf](#)

Division 8 - 812 Temp Traffic Control for Constr Zone Operation

Division 8 - 813 Slope Protection

Division 8 - 815 Landscaping

Division 8 - 816 Turf Establishment

Enhanced Delineation Pay Items

- ▶ Pay item names are listed in the related SPs
- ▶ Use pay item code 8117001 to create the pay item in AP Preconstruction
 - Standard items coming in the future
- ▶ Quantity is by the feet of guardrail or barrier to be delineated



Rumble Strips (Corrugations)



- ▶ Ground into the pavement
- ▶ Provide audible and tactile feedback to the driver
 - Alerts drivers that stray from their lane
- ▶ Placed on freeways and high-speed rural routes
- ▶ Placement detailed in R-112

Traditional Rumble Strips

- ▶ Individual grooves in the pavement
- ▶ Generate fairly loud noise
 - Noise complaints from residents are not uncommon
- ▶ Have been in use nationwide for decades
 - States have some variation in dimensions, but the designs are all quite similar



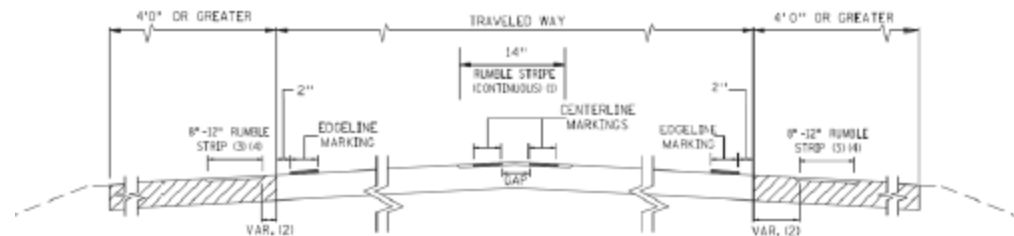
Sinusoidal Rumble Strips



- ▶ Nicknamed “mumble strips”
- ▶ Continuous sinewave pattern ground into the pavement
- ▶ Generate reduced exterior noise while still sufficiently alerting the driver
- ▶ Fairly new design that only a handful of contractors can currently produce

Rumble Strip Locations

- ▶ Shoulder
- ▶ Centerline
- ▶ Edgeline

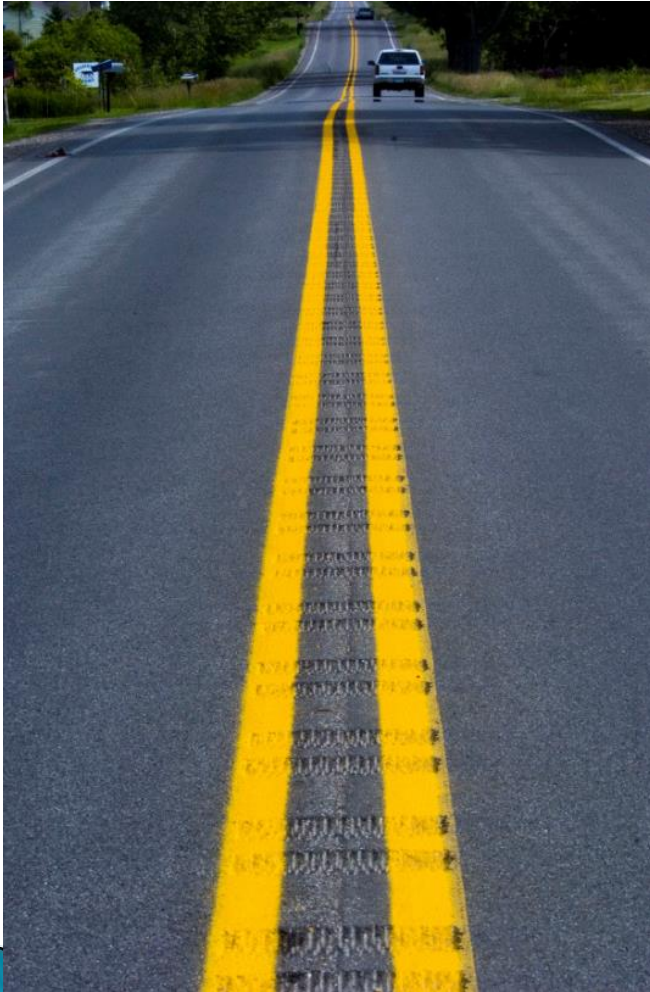


Shoulder Rumble Strips

- ▶ Have been around the longest of the types
- ▶ Proven countermeasure to run-off-the-road crashes
- ▶ Freeway
 - Required where the paved shoulder is at least 4'
 - Continuous pattern
- ▶ Non-Freeway
 - Required where posted speed is 55mph or greater and the paved shoulder is at least 6'
 - Should be considered with narrower shoulders dependent on bicycle traffic in the area
 - Gapped pattern for bicycle traffic
 - Cyclical 48' of rumble strip followed by 12' of gap



Centerline Rumble Strips



- ▶ Michigan installed statewide on eligible routes from 2008–2010
- ▶ Proven countermeasure for vehicles crossing the centerline
 - 51% fatality reduction
 - Reduces head-on collisions and sideswipes
- ▶ Used on rural 2- and 4-lane trunklines
 - Speed 55 mph or greater
 - Paved lane + shoulder width > 13' (beyond rumble)

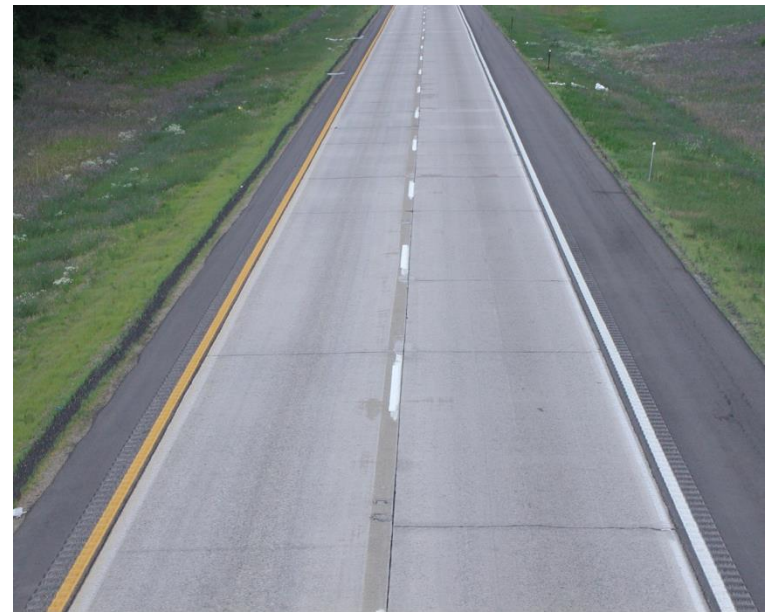
Centerline Rumble Strips

- ▶ Striping over the centerline rumble strips creates a rumble stripe
 - This provides some wet-reflective properties
- ▶ Markings can (and should) now be recessed in the presence of centerline rumble strips



Edgeline Rumble Strips

- ▶ Rumble strips in alignment with the striped edgeline
 - Creates a rumble stripe by nature
- ▶ Have not been used much in Michigan
 - Emerging with the pilot of “mumble strips”
- ▶ Provides wet-reflective properties to the stripe



Questions?

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