Session 123
Rumble Stripes: Opportunity to Improve Safety and Retroreflectivity

Presented
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by
Alan Plunkett, INDOT
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US-231 MOTIVATION FOR INSTALLATION OF CENTER AND EDGE LINE RUMBLE STRIPES
DISLODGED RAISED PAVEMENT MARKERS
INDOT Struck by Loose RPM, Picture from Stacey Flick

• January 2011
• LaPorte District
FHWA SAFETY COUNTERMEASURES
Longitudinal Rumble Strips and Stripes on 2-Lane Roads
FHWA SAFETY COUNTERMEASURES
Longitudinal Rumble Strips and Stripes on 2-Lane Roads
SAFETY BENEFITS
Longitudinal Rumble Strips on 2-Lane Roads

• Center line rumble strips on two-lane roads
  – Provide a **45% reduction** of head on / fatal and injury crashes

• Edgeline rumble strips on two-lane roads
  – Provide a **35% Reduction** of target crashes
SAFETY BENEFITS
Tactile and Audible Responses to Vehicle Leaving Lane

- Alerting distracted, drowsy drivers
- Providing Indication of Lane Location during adverse weather conditions
SAFETY BENEFITS

Tactile and Audible Responses to Vehicle Leaving Lane
SAFETY BENEFITS
Tactile and Audible Responses to Vehicle Leaving Lane
• Three notable incidents occurred between April and May 2012, two of which were fatal head-on crashes.
FIELD DEPLOYMENT ON US231

Typical Existing Pavement Marking/Lane Layout Retrofit

- Contract Letting: 8/8/12
- Completion: 10/31/12

Existing RPM

11’ 0”

4” White Line

4” LINE
8” SPACE
4” LINE
FIELD DEPLOYMENT ON US 231

Installation Limits

- US-231 is a two lane rural highway
- ADT > 8,000 VPD between Lafayette and Crawfordsville

- Project Limits ~18.5 Miles
- Not placed in towns due to low speed conditions

- Romney
- Linden

CR 500 S

231
**US-231**

**Special Provisions**

Section II: Summary Special Provisions from Contract R-35162:

**CRAWFORDSVILLE DISTRICT Contract No. R-35162 (PAGES 81-84)**

**SECTION 412 - FOG SEAL**

**412.01 Description**
This work shall consist of applying asphalt emulsion to the pavement surface in accordance with 105.03.

**MATERIALS**

**412.02 Materials**
Materials shall be in accordance with the following:
- Asphalt Emulsion AE-F: 902.07(b)
- Fine Aggregate: 804.02

**CONSTRUCTION REQUIREMENTS**

**412.03 Equipment**
A distributor in accordance with 409.03(a) shall be used.

**412.04 Weather Limitations**
Fog seal operations shall not be conducted on a wet pavement, when the ambient air or pavement temperature is below 50°F, or when other unstable conditions exist, unless approved by the Engineer.

**412.05 Preparation of Surface**
Surfaces shall be clean and free of any foreign or loose material. All cuttings, dector humps, and unplaceable raised pavement markers shall be covered to prevent coating with the fog seal prior to application of the fog seal. Those coverings shall be removed prior to opening to traffic.

**412.06 Application of Asphalt Material**
The asphalt material shall be applied uniformly at the rate of 0.06 to 0.07 gallon/yd². Asphalt material shall be applied such a way as to ensure even and uniform coverage to the pavement surface.

**412.07 Protection of Surface**
Fine aggregate or other approved binding material shall be applied to pedestrian crosswalks, driveways or other areas as directed by the Engineer. Brooming of paved areas shall be performed prior to opening to traffic on treated surfaces, as directed. Traffic shall not be permitted on the freshly sealed surface until the asphalt material has sufficiently cured to prevent trafficking.

**412.08 Method of Measurement**
Fog seal shall be measured by the square yard complete in place.

**412.09 Basis of Payment**
Fog seal shall be paid for at the contract unit price per square yard. Payment will be made under:

- **Pay Item Pay Unit Symbol**
  - Fog Seal

  The cost of all asphalt materials, fine aggregate, surface preparation, and all other necessary incidentals shall be included in the cost of the pay item.

**FOG SEAL CURE TIME**
Fog Seal shall be allowed to cure for eight (8) days prior to application of permanent pavement markings.

**MILLED CORRUGATION DEBRIS**
All debris resulting from the installation of the milled corrugations shall require vacuum cleanup.

**CENTERLINE AND EDGE LINE CORRUGATIONS**
The cost of installing centerline and edge line corrugations shall be paid for as 'Milled Centerline Corrugations'.

**CENTERLINE TRAFFIC CONTROL**
Some centerline operations will require equipment to be over the centerline (in both lanes). A minimum of four total flagmen will be required during these operations (2 flagmen to control traffic and 2 flagmen to flag near the equipment).

**PAVEMENT MARKINGS**
The Contractor shall make a record of the existing pavement markings so that such markings may be replicated later. This record must show longitudinal and transverse dimensions. The record must be submitted to and approved by the District Traffic Engineer prior to the removal or covering of existing pavement markings. The District Traffic Section shall be notified two weeks prior to painting or applying pavement markings so as to allow the District Traffic Section to verify the pavement marking plan. The contact person for the District Traffic Section is Nathan Amsrud, Traffic Construction Liaison at 561-361-5608.

**LINE, REMOVE**
Existing durable pavement markings directed to be removed shall be removed to the fullest extent possible without materially damaging the pavement surface. Removal of existing durable pavement markings shall be removed to a level even with the existing pavement surface. Existing non-durable pavement markings directed to be removed shall be removed to the fullest extent possible without materially damaging the pavement surface. Waterblasting shall be the method used to remove existing non-durable pavement markings that are directed to be removed.

**SNOWPLOWABLE RPM REMOVAL**
The area disturbed during the removal of the snowplovable RPMs shall not exceed 6 inches in depth along 10 to 13 inches from each side of the centerline base. The resulting holes from removal of the snowplovable RPMs shall be filled with HMAC Patching material. The cost of filling the holes from removal of the snowplovable RPMs shall be included in the cost of 'Snowplovable Raised Pavement Markers, Remove'. The holes to be filled shall be free of jagged edges and other irregularities, free from objectionable or foreign materials and have smooth and level surfaces and smooth and level edges at the time the holes are to be filled. Each hole shall be filled to the proper depth prior to filling the hole.

**MILLED CENTERLINE CORRUGATIONS**

**Description**
This work shall consist of placing milled corrugations along the centerline of the roadway in accordance with 105.03.

**Construction Requirements**
Milled centerline corrugations shall be constructed by cutting a series of smooth and uniform strips in consistent alignment in the pavement without damaging the surrounding pavement. Corrugations shall not be placed within the limits of PFC bridge approach or on bridge decks. All waste materials from operations shall be disposed of in accordance with 104.07.

**Method of Measurement**
Milled centerline corrugations will be measured by the linear foot, measured parallel to the centerline of the roadway.

**Basis of Payment**
Milled centerline corrugations will be paid for at the contract unit price per linear foot. Payment will be made under:

- **Pay Item Pay Unit Symbol**
  - Milled Centerline Corrugations: LFT
US-231

Detail for Recurring Special Provision

Only Gapped at:
• Public Road Approaches
• Commercial Drives
PAINTED RUMBLE RESEARCH AND US-231 INSTALLATION

Tom Brennan, Purdue
EXAMPLE SAFETY BENEFITS
Tactile and Audible Reponses to Vehicle Leaving Lane
EXAMPLE SAFETY BENEFITS
Night Time and Wet Weather Visibility
EXAMPLE SAFETY BENEFITS (INSTALL 2010)
Night Time and Wet Weather Visibility (Video)
CONSTRUCTION SEQUENCE
Approximate Sequence of Retro Fit: Picture from FHWA

*~11’ 4”*

Picture from FHWA
INSTALLATION / EQUIPMENT
Pavement Marking Removal

Pavement Marking Grinding Machine
Grinding Head
EQUIPMENT
Rumble Milling Machine

Milling Machine
Grinding Teeth
INSTALLATION / EQUIPMENT
Pavement Marking Removal (Night Work)

Front of Milling Operation Convoy

Direction of Travel
INSTALLATION / EQUIPMENT
Example Milling Machine (SR 38)
INSTALLATION / EQUIPMENT

Example Milling Machine (SR 38)

Grinding Teeth
Sweeping the Rumble Strips

1st of 2 Sweeping Trucks to Pass
INSTALLATION / EQUIPMENT
Sealing Centerline Joint after Rumbles Installed
INSTALLATION / EQUIPMENT
Fog Sealant Installed on SR 38
INSTALLATION / EQUIPMENT
Fog Sealant Installed on SR 38 (VIDEO)
INSTALLATION / EQUIPMENT

Painting CLRS

Painting CLRS

Temporary Marking
PAINTED RUMBLES
Installed

- Crack sealant placed prior to Fog Seal
- Completed Paint on CLRS
- Min 8-Day Cured Fog Seal

(Lafayette)
LESSONS LEARNED ACROSS INDIANA
2010 to Present

Completed Paint on CLRS

Fog Seal

Crack sealant placed prior to Fog Seal

- Contract Letting: 8/8/12
- Completion: 10/31/12
FIELD STUDIES IN INDIANA
Paint, Thermoplastic, and Epoxy Paint

• **SR 28** Test Installation (Initial Test): West of Frankfort, East of I-65. 4-lane divided highway. Only painted edge line rumble strips were installed on existing eastbound rumbles for both yellow and white paint. Site was also use to test standard INDOT bead mix and 3M wet-dry bead mix.

• **SR 38** New Installation: East of Antioch, West of Kirkland. 2 Lane Rural Route. Complete installation on new asphalt including centerline joint adhesive, fog seal, and painted centerline rumble stripes.

• **US 120** New Installation: East of US13. Complete installation on new asphalt including centerline joint adhesive, fog seal, and painted centerline rumble stripes. Centerline joint and fog seal were used.

• **US 231** Retrofit: South of Lafayette, north of I-74. Installation on existing asphalt leaving existing RPMs in place. Edge line as well as Centerline painted rumbles were installed. Milling was performed on existing asphalt, and both the center and edge lines were joint sealed as necessary and fog sealed.

• **SR 26** New Installation: Between SR29 and US31, west of Kokomo. 2 Lane Rural Route. Installation on new mill and paved asphalt. **Epoxy paint** on center and edge line with one **thermoplastic** test strip.
FIELD STUDIES IN INDIANA
Paint, Thermoplastic, and Epoxy Paint

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  Retrofit: South of Lafayette, north of I-74. Installation on existing asphalt leaving existing RPMs in place. Edge line as well as Centerline painted rumbles were installed. Milling was performed on existing asphalt, and both the center and edge lines were joint sealed as necessary and fog sealed.

- **SR26**
  New Installation: Between SR29 and US31, west of Kokomo. 2 Lane Rural Route. Thermoplastic was used instead of paint at the centerline.

#1: SR28 EB (Edge Lines)

#2: SR38 (Center Lines)

#3: SR120 (Center Lines)

#4: US231 (Edge/Center Lines)

#5: SR26 (Edge/Center Lines)
PAINTED CENTERLINE

Installation Observations

Paint Appears to have de-bonded on fogseal

RPM Lens Removed
PAINTED EDGELINE
Installation Observations

Old Edgeline Removed

Fog Sealant Used on Edgeline

New Edgeline in Rumbles
MATERIAL SELECTION FOR MARKINGS
Paint, Thermoplastic, and Epoxy Trials

- Use design manual guidance for material selection defined in Indiana Design Manual Chapter 76
MATERIAL SELECTION FOR MARKINGS
Thermoplastic on SR 26

• Consider quality control in pre-phase planning
  – Speed and methods of application
  – Material temperature/application

Higher Speed Lower Pressure Application

Pitting in Rumble

Move Even Application

Lower Speed Higher Pressure Application
MAINTENANCE OF TRAFFIC
Grinding/Milling/Sealing/Marking/Lens Removal:

• Create traffic control plan based on site specific conditions.
• Use IMUTCD, Standard Specifications and Standard Drawings for guidance to maintain moving traffic.
• Include language regarding flagging of traffic and for equipment protection in each step of the installation and operation process.
• Understand that each process varies in speed (exceeding walking speed) and restricts lane usage.
• Understand that rumbles move traffic towards operations.
CLOSING

Bill Smith/Alan Plunkett
QUESTIONS
Alan Plunkett, Bill Smith, & Tom Brennan:

INDOT 2013 Goals

1. Let an estimated 213 INDOT construction contracts valued at approximately $981MM in FY2013. Projects to be let include 44 Major New Projects valued at approximately $620MM and 169 Preservation Projects valued at approximately $361MM.

2. Implement employee training and organizational changes to improve INDOT’s project management core competency. Create, communicate and deploy a consistent method to successfully manage projects agency-wide.

3. Improve INDOT’s work zone safety program and results. Increase employee involvement, responsibility, and accountability to provide a safe work environment and reduce employee injuries and crashes.

4. Reduce the number of severe crashes on INDOT roadways. Install proven safety treatments (i.e., rumble stripes, safety edge) to reduce vehicle lane departures, especially in rural areas.

5. Develop and implement new business practices to improve agency productivity and financial accountability. Engage INDOT’s management staff to modernize service delivery while fostering INDOT’s cultural values of respect, teamwork, accountability and excellence.

SAFETY BENEFITS
Tactile and Audible Responses to Vehicle Leaving Lane