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   Maintenance of Roadway Edge Drop-Off Utilizing Readily Available Materials

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13. Abstract

The Louisiana Department of Transportation and Development (DOTD) District 05, which is in the northeastern corner of the state, spent 55,000 hours and over $1 million in 2016 attempting to maintain roadway edges along non-paved shoulders.

Non-paved shoulders consist primarily of a soil and aggregate mixture, which is routinely disturbed and lost under normal traffic conditions primarily at the paved roadway edge. This problem is more prevalent on narrow winding roadways where the wheel path meanders closer to the edge of the roadway. Tires disturb this material leaving a drop-off (edge rut) that requires continuous maintenance and can be unsafe to the traveling public.

The means and methods used to maintain non-paved shoulders statewide varies with undocumented performance. Reclaimed asphalt pavement (RAP) is readily available and used in many areas of the state for shoulder repair. Some parish maintenance units use 100% RAP while others use a mixture of native soils blended to local proportions.

Although RAP is common among DOTD district offices, it needs a binder to help stabilize the often-rounded aggregate particles within. In so, additives (such as cement, fly ash, soil, and asphalt emulsion) can improve RAP strength and stability. Mix 1 (75% RAP and 25% lean clay) with an additive of 4% to 6% cement was successful in both feasibility (amount of material utilized by volume) and performance (strength and durability of test samples).

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Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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Maintenance of Roadway Edge Drop-Off Utilizing Readily Available Materials

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The means and methods used to maintain non-paved shoulders statewide varies with undocumented performance. Reclaimed asphalt pavement (RAP) is readily available and used in many areas of the state for shoulder repair. Some parish maintenance units use 100% RAP while others use a mixture of native soils blended to local proportions.

RAP is a common material found at DOTD district offices; however, due to its grain size distribution (poorly graded), it can roll like marbles under loads. RAP needs a binder to help stabilize the often-rounded aggregate particles within. In so, additives (such as cement, fly ash, soil, and asphalt emulsion) can improve RAP strength and stability. Mix 1 (75% RAP and 25% lean clay) with an additive of 4% to 6% cement was successful in both feasibility (amount of material utilized by volume) and performance (strength and durability of test samples).

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Implementation Statement

The information, insight, and techniques included and expanded in this report will provide district staff methods and strategies to combat the problem of edge drop-off maintenance. Edge drop-offs are not only a safety concern regarding vehicles and accidents, but require recurring efforts of labor and funds to maintain these shoulders.

The potential benefits for this study are enormous. Stable shoulders (without edge drop-offs) create a safer driving environment. Utilizing best practice with readily available materials, such as 100% RAP and/or other locally available, stable materials, and/or asphalt edge modifications, will reduce maintenance costs as well as will improve safety statewide.

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Introduction

Louisiana is a relatively rural state. Many roads in the state likely evolved from trails to dirt roads and then to gravel roads. These roads initially served narrow cars like the Model T. Over time, some roads were upgraded with asphalt or concrete paving while some were widened to handle two lanes of traffic, depending upon demand and limited budgets. Wider roads and shoulders require more land, material, and effort to construct, which often increases the burden and cost to local, rural areas.

Road shoulders, if they exist, should be contiguous with the traveled lane and provide an area along the highway for vehicles to stop, particularly during an emergency. Shoulders are also used to laterally support the pavement structure [1]. In both of these ways, the shoulder adds to the overall safety of a roadway. Edge drop-offs can create safety issues that district forces must frequently repair and maintain on these roads.

There are minimum standards for road shoulders, but these vary with the type of roadway (freeway, ramps, arterial, collector, or local) and by the location of the roadway (urban or rural). Some rural Louisiana roads have minimal shoulders (many about 2 ft. wide) due to the historical nature of the road. Furthermore, rural roads in these northern regions of the state often have the combination of rolling hills, winding roads, narrow shoulders, and steep slopes beyond the shoulder.

Shoulders can be composed of a variety of materials. Non-paved shoulders typically consist of a soil and aggregate mixture. Unfortunately, vehicles often encroach onto these shoulders (inattention, distraction, emergency, wide tires, etc.) and disturb these unpaved shoulders. This material is routinely disturbed, primarily at the edge of the paved roadway, and lost down the cross-slope through dynamic (moving and spinning) tires or erosion. Wheel ruts in the shoulder are more prevalent on narrow winding roadways where wheel paths meander near the roadway edge. These ruts compound the problem by deepening an edge drop-off and allowing water to collect (in the rut). This water can further soften the shoulders creating a hydraulic gradient leading to slope stability issues.

The Louisiana Department of Transportation and Development (DOTD) District 05, which is in the northeastern corner of the state, spent 55,000 hours and over $1 million in 2016 attempting to maintain roadway edges along non-paved shoulders.

Edge drop-offs can also be created by overlay operations. Figure 1 shows an extreme example of an edge drop-off created and/or exacerbated by an overlay. Depending upon the timing of any adjacent shoulder work to level the shoulder to the road edge, this drop-off can remain and create safety issues.

Figure 1. Extreme example of edge drop-off [2]


Sharp, steep pavement edge drop-offs can contribute to crashes.

The Federal Highway Administration (FHWA) has an Every Day Counts (EDC) program that "…identifies and rapidly deploys proven, yet underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce traffic congestion, and integrate automation." One innovation deployed through EDC-1 is the Safety Edge^{SM}. Safety Edge^{SM} is a process that creates a smoother road edge that is friendlier to cars that stray from the road. The DOTD has started utilizing the Safety Edge^{SM} to reduce the severity of new overlays.

The shoulder materials adjacent to overlays or existing road edges should be stable, durable, and graded to meet the road edge; see Figure 2. Vehicles, time, and erosions wear on the shoulders, resulting in the need for maintenance operations. Cost and space issues limit the availability of asphalt-paved shoulders on rural low-volume roads. The methods used to maintain non-paved shoulders vary statewide and performance has been undocumented.

Reclaimed asphalt pavement (RAP) is readily available and used in many areas of Louisiana for shoulder repair. Some parish maintenance units use 100% RAP, while others use a blended mixture of RAP and native soils.

Figure 2. SafeyEdge^{SM} and adjacent graded shoulder [3]

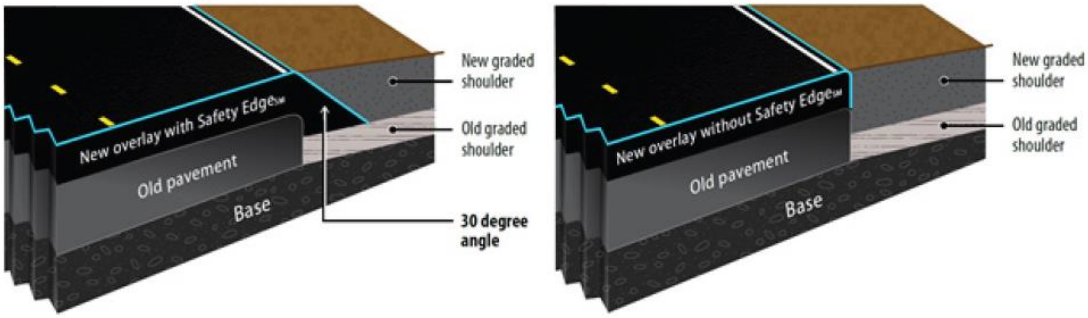

Figure 1. Graphic. SafetyEdge^{SM} versus conventional paved edge immediately after repaving.

(Left panel: SafetyEdge^{SM} immediately after paving with backfill material graded flush with paved surface. Right panel: Conventional pavement overlay without the SafetyEdge^{SM} with backfill material graded flush with the paved surface)

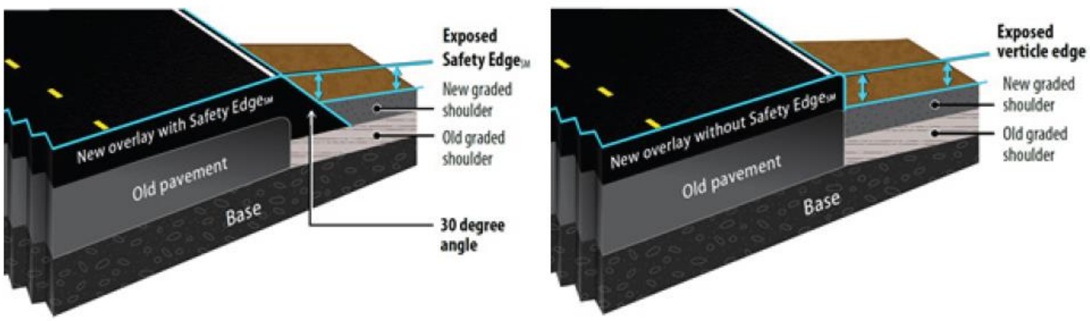

Figure 2. Graphic. SafetyEdge^{SM} versus conventional paved edge after backfill material settles or erodes.

(Left panel: SafetyEdge^{SM} is exposed to traffic after backfill material settles or erodes. Right panel: Conventional pavement overlay without the SafetyEdge^{SM} after backfill material settles or erodes)

Literature Review

Federal Highway Administration (FHWA)

FHWA provides the following insight on the function of a shoulder [4] :

> *Shoulders provide space for emergency storage of disabled vehicles. Particularly on high-speed, high-volume highways such as urban freeways, the ability to move a disabled vehicle off the travel lanes reduces the risk of rear-end crashes and can prevent a lane from being closed, which can cause severe congestion and safety problems on these facilities.*
>
> *Shoulders provide space for enforcement activities. This is particularly important for the outside (right) shoulder because law enforcement personnel prefer to conduct enforcement activities in this location. Shoulder widths of approximately 8 feet or greater are normally required for this function.*
>
> *Shoulders provide space for maintenance activities. If routine maintenance work can be conducted without closing a travel lane, both safety and operations will be improved. Shoulder widths of approximately 8 feet or greater are normally required for this function. In northern regions, shoulders also provide space for storing snow that has been cleared from the travel lanes.*
>
> *Shoulders provide an area for drivers to maneuver to avoid crashes. This is particularly important on high-speed, high-volume highways or at locations where there is limited stopping sight distance. Shoulder widths of approximately 8 feet or greater are normally required for this function.*
>
> *Shoulders improve bicycle accommodation. For most highways, cyclists are legally allowed to ride on the travel lanes. A paved or partially paved shoulder offers cyclists an alternative to ride with some separation from vehicular traffic. This type of shoulder can also reduce risky passing maneuvers by drivers.*
>
> *Shoulders increase safety by providing a stable, clear recovery area for drivers who have left the travel lane. If a driver inadvertently leaves the lane or is attempting to avoid a crash or an object in the lane ahead, a firm, stable shoulder greatly increases the chance of safe recovery. However, areas with pavement edge drop-offs can be a significant safety risk. Edge drop-offs occur where gravel or earth material is adjacent to the paved lane or shoulder. This material can settle or erode at the pavement edge, creating a drop-off that can make it difficult for a driver to safely recover after driving off the paved portion of the roadway. The drop-off can contribute to a loss of control as the driver tries to bring the vehicle back onto the roadway, especially if the driver does not reduce speed before attempting to recover.*

Shoulders improve stopping sight distance at horizontal curves by providing an offset to objects such as barrier and bridge piers.

On highways with curb and enclosed drainage systems, shoulders store and carry water during storms, preventing water from spreading onto the travel lanes.

On high-speed roadways, shoulders improve capacity by increasing driver comfort.

FHWA issued an Every Day Counts (EDC) brochure [2] regarding an asphalt innovation that enables an asphalt edge with a special edging device to reduce an abrupt vertical edge drop-off to a more subtle inclined edge. FHWA issued a Safety Edge^{SM} Design and Construction Guide [5].

Nebraska Department of Transportation

The Nebraska Department of Transportation (NDOT) conducted a study on this topic with a final report dated December 2015 [6]. Their study performed an excellent literature search on the topic, comparing:

- Federal
  - American Association of State Highway Transportation Officials (AASHTO) Roadside Design Guidance
  - Manual on Uniform Traffic Control Devices (MUTCD)
  - AASHTO Geometric Design of Highways and Streets
  - Federal Highway Administration (FHWA)
  - Transportation Research Board
- Iowa Research
  - Liquid Polymer
  - Foamed Asphalt
  - Soybean Oil
  - Portland Cement
  - Fly Ash, Recycled Concrete and Asphalt
  - Geo-grid
- Texas Initiatives
  - Raw Edging
  - Edge Seal / Strip Seal
  - Promoting the Growth of Desirable Vegetation
  - Edge Striping
  - Reshaping Shoulders with On-Site Material
  - Replenishing Pavement Edge with Select Borrow Material
  - Edge (Lane) Widening

    - Buffalo Grass

- Other Initiatives
    - Minnesota Department of Transportation (MnDOT) lets contracts to pave an additional 2 ft. of pavement beyond the road striping and rumble strips to allow drivers more time and space to regain control.
    - Washington State Department of Transportation installed experimental rumble strips and noted 40% and 35% reductions in off-road vehicle crashes at two sites.

Texas Department of Transportation

Texas Department of Transportation (TxDOT) published a report [7] on “Best Practices for Pavement Edge Maintenance.” The document provides a detailed explanation of the problem similar to this current research within Louisiana. The research identifies edge drop-off as a multi-faceted problem and a potential cause of accidents but focuses primarily on maintenance solutions.

Iowa Department of Transportation

Iowa and the Center for Transportation Research and Education (CTRE) studied edge drop-off in a report entitled “Effective Shoulder Design and Maintenance” [8].

> *This report included observations made during a field reconnaissance study, finding from an effort to stabilize the granular and subgrade layer at six shoulder test sections, and the results of a laboratory box study where a shoulder section overlying a soft foundation layer was simulated. Based on the research described in this report, the following changes are proposed to the construction and maintenance methods for granular shoulders:*

- *A minimum CBR value for the granular and subgrade layer should be selected to alleviate edge drop-off and rutting formation.*
- *For those constructing new shoulder sections, the design charts provided in this report can be used as a rapid guide based on an allowable rut depth. The charts can also be used to predict the behavior of existing shoulders.*
- *In the case of existing shoulder sections overlying soft foundations, the use of geogrid or fly ash stabilization proved to be an effective technique for mitigating shoulder rutting* [8].

Minnesota Department of Transportation (MnDOT)

MnDOT's research arm, MnRoads, provided a reference [9] outlining the cause of edge drop-off, several case studies, solutions, treatments, and benefits.

Thailand

Thailand conducted research on the stabilization of recycled asphalt pavement by fly ash as a sustainable pavement material [10].

Louisiana

In 1985, LTRC published report No. 177 [11] regarding the utilization of fly ash in aggregate shoulders. The study recommended the use of class C fly ash on sand-clay-gravel shoulders when upgrading, whether in maintenance or under contract on roads with a maximum of 10,000 average daily traffic (ADT). The recommendation was a minimum of 15% fly ash, by volume, for sand-clay-gravel with a maximum plasticity index (PI) of 10.

Another early DOTD document (1989) developed to assist DOTD and local forces is "Guide to Common Road and Equipment Maintenance Procedures" [12]. According to the document, which is connected to FHWA's Rural Technical Assistance Program (RTAP), "the videotapes/supplements cover a variety of road maintenance activities relative to asphalt pavement, earth and gravel roads, shoulders, drainage facilities and bridges." The document contains two brief, relevant chapters: (1) RTAP No.11, Reshaping Earth and Gravel Shoulders; and (2) RTAP No.12, Replenishing Earth and Gravel Shoulders. The material for replenishing is described as approved granular material, which has the correct proportion of well-mixed coarse and fine particles. The reference cites that water aids in good compaction, but there are no shoulder compaction requirements.

In 2011, Rupnow et al. [13] evaluated cement- and fly ash-treated RAP and aggregates for base construction. The research evaluated a variety of mixtures and determined 150 and 300 psi are capable of being produced with 4 to 8 percent Portland cement and 10 to 20 percent class C fly ash.

Another more recent DOTD document is the DOTD Maintenance Manual [14] dated 2019. The online guide's purpose is "to present general practice and procedures that when followed will provide for a uniform approach to maintaining the state highway system." Chapter 7 (attached as an appendix) of the manual briefly explains turf shoulders, aggregate shoulders, and paved shoulders but is limited in scope.

DOTD District 58

District 58 presented [15] a solution for shoulder maintenance at the 2018 Louisiana Transportation Conference (LTC). At that LTC, District 58 won an award for their innovative idea and action.

The District 58 shoulder restoration equipment consists of four main components, shown in Figure 3.

- Tractor – a heavy-duty vehicle used for towing or pulling attachments that are extremely hard to move.
- Disc attachment – a device used to break, turn, and raise existing materials.
- Blade attachment – a piece of heavy equipment designed specifically for leveling purposes.
- Broom attachment – optional attachment used to clean the travel lane of excess dirt, loose aggregate, etc. after restoring operation.

Figure 3. DOTD District 58 repair equipment

(a) Tractor

(b) Disc Attachment

(c) Blade Attachment

(d) Broom Attachment

Their LTC presentation showed the value of the edge disc, blade, and broom attachments. District 58 realized labor cost savings (See Table 1) and material costs by utilizing readily available RAP at $10/cubic yard (cy.). Other benefits they documented are summarized below:

- Creates ease of mobilizing the equipment
- Contains flexible connections – common three-point tractor hitch
- Reduced mowing due to disc-cutting/blending of material
- Extends/increases road life by removing high points, allowing for drainage
- Increases road safety by reducing the road crew and equipment for repair
- Increases road safety by repairing/leveling shoulder
- Reduces disruption to the traveling public
- Enhances road appearance

Table 1. DOTD District 58 equipment-savings in operating cost

Normal Set-Up	New Set-Up
Equipment	
Grader @ $70/hr. Tractor with Broom @ $106/hr. Lowboy Trailer @ $160/hr.	Tractor with Disc, Blade, & Broom Attachment @ $106/hr. 12 yd. Dump Truck @ $60/hr.
Total Equipment Cost: $356/hr.	**Total Equipment Cost: $166/hr.**
Manpower	
3 Operators @ $20/hr./each	2 Operators @ $20/hr./each
Total Savings per Hour = $210.hr.; $2,100.00 Savings/Day (10-hr. Work Day)	

Objective

This research evaluated the effectiveness of different strategies like RAP, hydrated fly ash (HFA), and other possible alternatives as possible shoulder material solutions to reduce and hopefully eliminate the edge drop-off safety issues within the state.

The research goal was to determine how effective roadway shoulder material can be at staying in place during typical traffic with different mixtures and additives. Some mixtures may require higher percentages (by volume) of additives, thus costing more.

This research evaluated the application and performance of different alternatives and developed a logical method(s) to address problematic shoulder locations. District offices have the ever-pressing need to do more with less; this research searched for cost-effective solutions for district personnel to utilize in their different areas.

Scope

The project investigated several materials that are readily available and commonly utilized for shoulder repair by DOTD district forces. This research conducted basic property and strength tests on a range of materials including and ranging from soil only, through soil/RAP proportional combinations, to 100% RAP. The research included studying several combinations of RAP with additives like fly ash and cement to achieve shoulder strength targets from 100 to 125 psi.

Methodology

The research team first investigated previous and ongoing work nationwide regarding edge drop-off issues. Researchers prepared and distributed a statewide survey to DOTD districts to determine current practices and remediation methods.

The research team then developed a test matrix to evaluate options, including laboratory testing and possible field test sections. The researchers evaluated the various options for performance and cost-effectiveness. The research tasks are listed below, describing how the team conducted the research.

Tasks

Task 1: Research existing state and federal efforts on managing edge drop-offs

LTRC conducted a thorough literature review to investigate other previous and ongoing research regarding edge drop-off. LTRC performed a statewide survey to DOTD districts to determine existing practices and current remediation methods.

Task 2: Determine testing matrix of implementation and mitigation methods for Louisiana

Utilizing the findings from task 1, a Louisiana-specific matrix was developed to evaluate the possible options. This included laboratory testing and the possibility of field test sections. LTRC will attempt to demonstrate the Safety Edge^{SM} recommended by FHWA in a demonstration project.

Task 3: Analyze and evaluate methods based on performance

The analysis evaluated options, best practices, and new concepts including the utilization of 100% RAP with and without rejuvenating agents as shoulder options. Other techniques like a beveled shoulder edge (SafetyEdge^{SM} and Carlson Edge) were examined; see Appendix B. LTRC investigated these methods, including the Nebraska recommendations, for appropriate implementation within DOTD.

Task 4: Analyze and evaluate methods based on cost effectiveness

The analysis evaluated options, best practices, and new concepts including the utilization of 100% RAP with and without rejuvenating agents as shoulder options. LTRC investigated these methods, including the Nebraska recommendations, for appropriate implementation within DOTD.

Task 5: Recommend and implement strategies for Louisiana

Based on the analysis of the previous tasks, the research provided specific strategies based on performance and cost effectiveness. This will allow best practices to be provided for within design and as a rehabilitation measure. This approach will allow the districts to get the best bang for their state dollars, whether in design or in maintenance.

Task 6: Document the research effort

The research team prepared a final report to document the entire research effort. The final report includes data, discussion of results, and recommendations generated by the study.

Laboratory Test Methods

The following test methods were utilized to determine the physical properties of common materials utilized throughout the state as readily available shoulder repair material, including some other additives and blends that may prove effective. The following American Society for Test Method (ASTM) [16], the American Association of State Highway Transportation Officials (AASHTO) [17], and DOTD Technical Reference (TR) standards will be utilized to evaluate the materials' properties.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- DOTD TR407 Mechanical Analysis of Soils [18]
- ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes [Unified Soil Classification System (USCS)]
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft.-lbf/ft^3)

- DOTD TR432 Determining the Minimum Cement Content for Soil Cement Stabilization
    - Method A: Naturally Occurring Soils or Soil-Aggregate
    - Method B: Soils with less than 5% Aggregate
    - Method C: Soils with 5% or more Aggregate
    - Method D: Durability of Cement Treated or Stabilized Materials
- AASHTO T 135-22: Wetting and Drying Test of Compacted Soil Cement Mixtures
- ASTM D1883 Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

The testing program is designed to evaluate readily available materials and rank them based on their strength and performance. The materials will vary from raw materials ranging from lean clay to RAP and combinations of the two, including additives in those combinations to see how performance varies. RAP contains capable gravel and sand, but they can roll like marbles under loads. In contrast, lean clay is less likely to roll but can soften and weaken when wet. As a way to bind the RAP together and provide additional strength, cohesion, and durability to the RAP, lean clay was added to create clay-RAP mixtures. Table 2 includes the test matrix for sample properties of each mix, while Table 3 includes different values of additives (concrete and fly ash) and their compressive strengths, CBR, and durability attributes.

Table 2. Initial sample properties test matrix

Edge Drop Off 19-1GT	Grain Size				Proctor Test		Atterberg Limits			Standard Proctor Compaction Unconfined Compressive Strength: Same Day Break (psi)				
Standard Proctor - 6" Mold	% Gravel	% Sand	% Silt	% Clay	Optimum Moisture (OM) %	Maximum Dry Density (MDD) pcf	Liquid Limit (LL) %	Plastic Limit(PL)%	Plastisity Index(PI)%	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density
100% Lean Clay (CL)														
Mix 3: 25% RAP / 75% CL														
Mix 2: 50% RAP / 50% CL														
Mix 1: 75% RAP / 25% CL														
100% Recycled Asphalt Pavement (RAP)							NP	NP	NP	Non-Plastic (NP)				

Table 3. Sample properties with additives test matrix

Edge Drop Off 19-1GT	Standard Proctor Compaction Unconfined Compressive Strength, psi										CBR				Durability	
	7 Day Break					28 day break					No Soak		Soak		% Loss	
Standard Proctor - 6" Mold	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density	0.1" Penetration	0.2" Penetration	0.1" Penetration	0.2" Penetration	Sample 1	Sample 2
100% Lean Clay + 5% FlyAsh																
100% Lean Clay + 10% FlyAsh																
100% Lean Clay + 15% FlyAsh																
100% Lean Clay + 20% FlyAsh																
100% Lean Clay + 2% Cement																
100% Lean Clay + 4% Cement																
100% Lean Clay + 6% Cement																
100% Lean Clay + 8% Cement																
Mix 3: 25% RAP / 75% CL + 5% FlyAsh																
Mix 3: 25% RAP / 75% CL + 10% FlyAsh																
Mix 3: 25% RAP / 75% CL + 15% FlyAsh																
Mix 3: 25% RAP / 75% CL + 20% FlyAsh																
Mix 3: 25% RAP / 75% CL + 2% Cement																
Mix 3: 25% RAP / 75% CL + 4% Cement																
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100% RAP + 20% Cement																

Discussion of Results

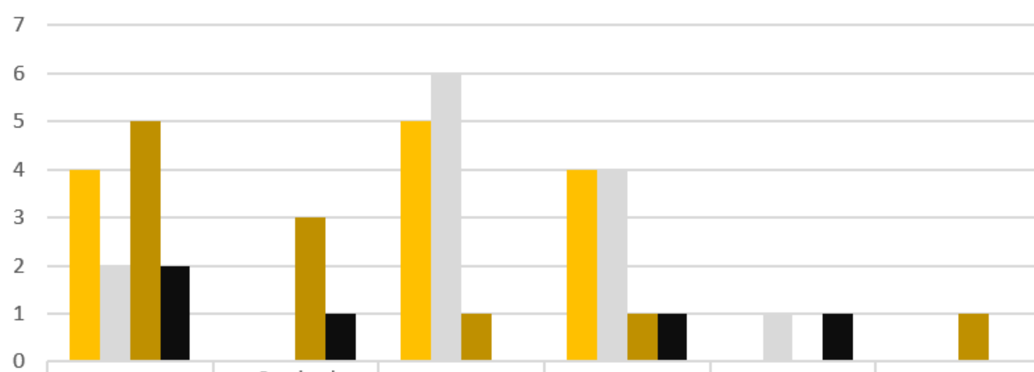
DOTD District Survey

Researchers developed and sent a survey to the different DOTD districts. A copy of the survey is included as an Appendix. The survey asked a variety of questions to get the pulse of district shoulder repair activities. The survey included questions about existing shoulders (width, materials, etc.), repairs to shoulders (materials, equipment, etc.), and the expected life of shoulder repairs. Responses were received from each DOTD district.

Existing Materials

One survey question asked about existing shoulders and the most common materials existing in these shoulders. Figure 4 shows the rankings of common materials composing district road shoulders. The gold bars in the following charts represent the number of 1st place votes (ranking most common); the silver bars the second most common votes, and so forth. Asphalt and RAP are the most common shoulder materials, but soil shoulders are also common. Asphalt received the second most 1st place votes, but it received the most total votes indicating that the material is common in the districts.

Figure 4. Road shoulder material's ranking (how common) by district

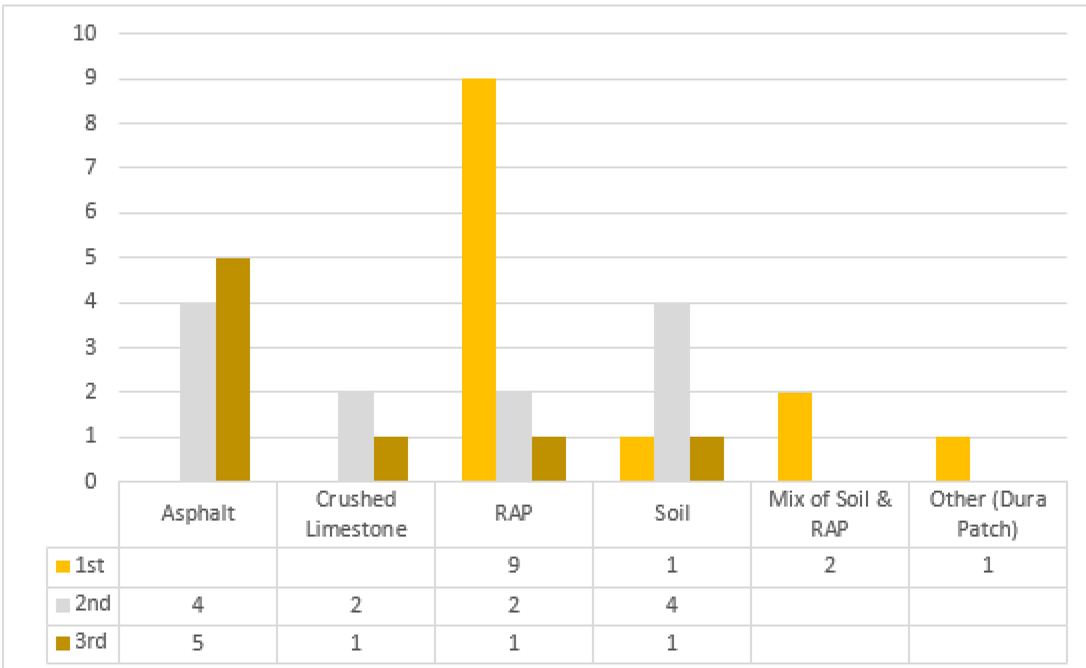


	Asphalt	Crushed Limestone	RAP	Soil	Mix of __	Other
1st	4		5	4		
2nd	2		6	4	1	
3rd	5	3	1	1		1
4th	2	1		1	1	

Repair Materials

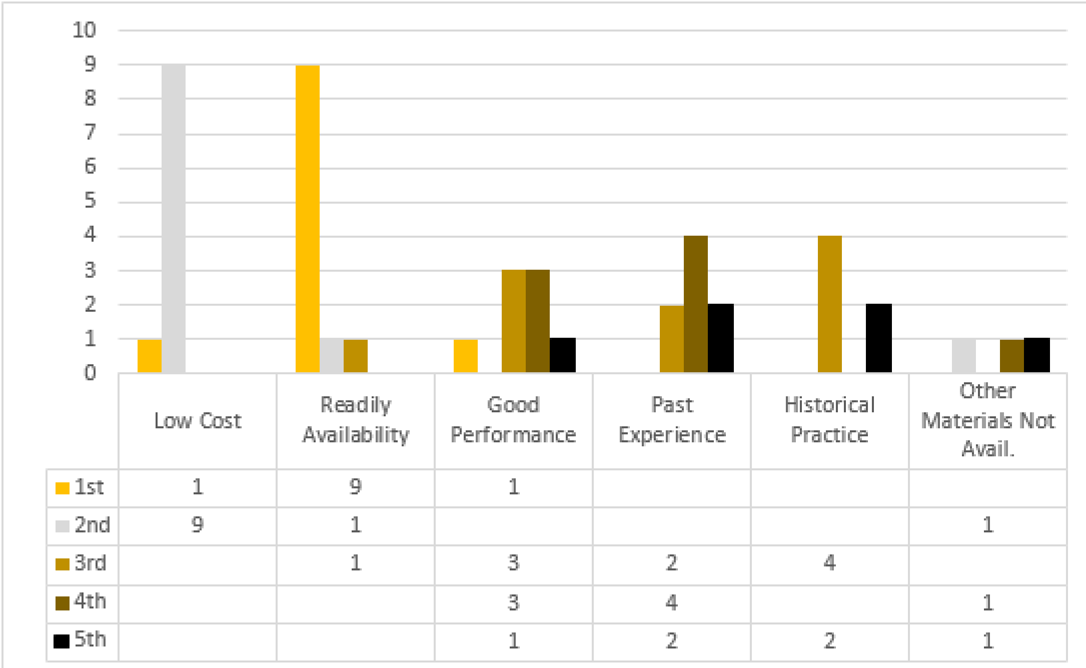
The survey indicated that DOTD districts utilize different materials to repair existing shoulders. Figure 5 shows the votes for their choices of shoulder repair material. RAP received the most 1st place votes indicating it is a very common repair material. Other repair materials included soil, a mix of soil and RAP, and a DuraPatch (cold patch mix).

Figure 5. Materials utilized by the DOTD districts for shoulder repair



The next survey question asked districts why they gave their 1st place votes to the material listed in Figure 5. Figure 6 shows survey responses, which indicate the preferred repair material (most commonly RAP) was selected primarily for its availability and for its low cost. The majority of district engineers mentioned that RAP is utilized over asphalt due to its low cost.

Figure 6. Reasons why districts utilize the materials for shoulder repair



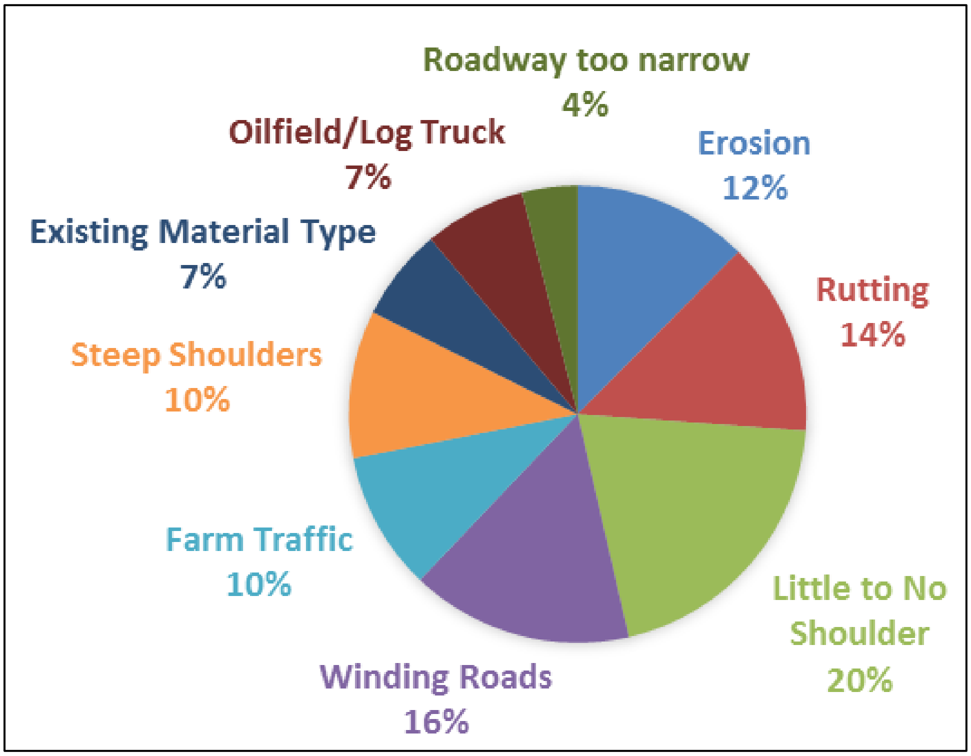
Edge Drop-Off Information from the Districts

The survey collected district information on average shoulder width. Table 4 presents the reported average shoulder widths, which ranged from 8 ft. to 2 ft. Average values and comments from the districts indicate that there are some zero width shoulders (i.e., no shoulders in parts of the state). Figure 7 shows survey results indicating that district personnel believe that *little to no shoulder* is most often the cause of edge drop-offs (20%). These areas with *little to no shoulder* are likely exacerbated by narrow *winding roads* (16%) when *farm trucks* (10%) *rutting* (14%), and *erosion* (12%) occurs and moves the materials off the *steep shoulders* (10%). This comports with the age of these roads and the lack of right-of-way in many areas. Combining these factors, it is easy to see the potential for edge drop-off problems.

Table 4. What is an average shoulder width in your district?

District 02	8 ft.	**District 07**	3 ft.
District 03	3-4 ft.	**District 08**	3 ft.
District 04	4, 6 ft. (*2 responses*)	**District 58**	3 ft.
District 05	2 ft., 2 ft., 2-3 ft., 2 ft., 0-6 ft. (*4 responses*)	**District 61**	2 ft.
		District 62	6 ft.

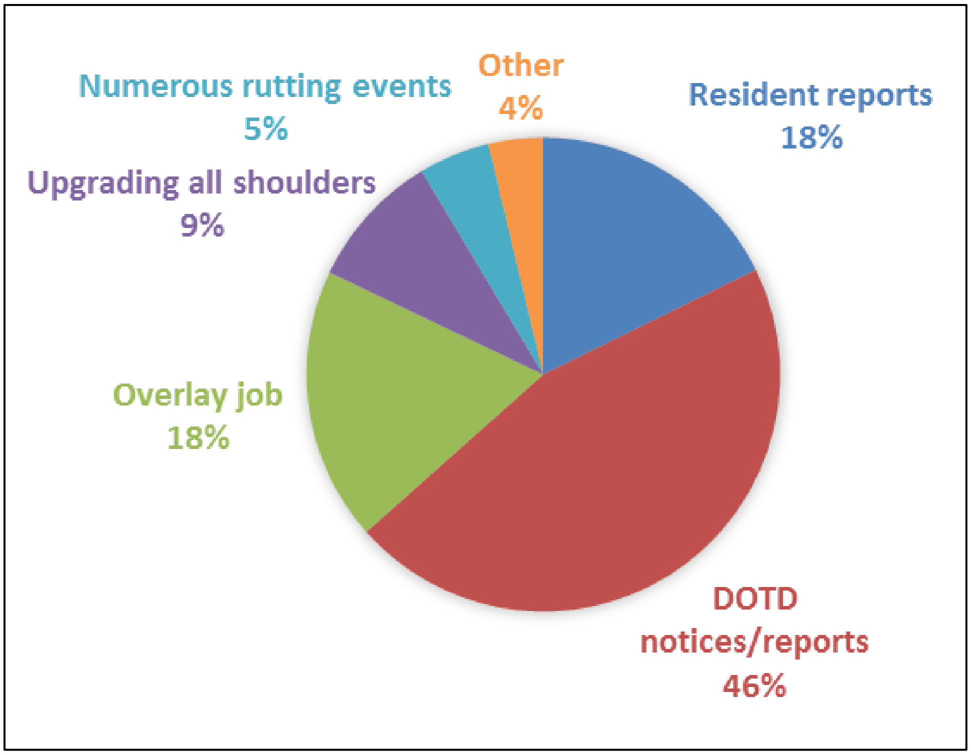
Figure 7. Causes of edge drop-off



Repair Decisions

The survey asked districts how they selected shoulders for repair. Figure 8 shows the different factors and indicates DOTD most often finds and reports. This likely occurs through DOTD visual, routine inspections, or through their own commutes to work through the area. The responses did not indicate that the edge drop-offs were located via the pavement management section (PMS) scans. These scans will be addressed in another section of this report.

Figure 8. Edge drop-off notification decision factors



Service Life

The longevity of a repair is dependent upon many things. Even if a "great" material is utilized for repairs, the placement and compaction of the material is also important.

The survey collected district information regarding what methods and equipment they utilized for their shoulder repairs. Table 5 presents a summary of these responses. Small excavators along with motor graders were the most commonly utilized. District 58 responded with a shoulder widener, which refers to the equipment outlined in Figure 3 (tractor, discs, a blade, and broom attachments for the tractor). The District 58 attachments are shorter in width than normal equipment and is ideal for narrow shoulders.

Table 5. How is the repair material most often placed, shaped, and compacted?

Method/Equipment	*Placed*	*Shaped*	*Compacted*
Reshaped by hand/shovel	02,03,05,08	02,03,04,05,08	02,03,05,08
Bobcat or small excavator	02,03,04,05,61,62	02,03,04,05,08,61	02,03,04,05,08,61
Dozer Blade	05	05	05
Tractor Disc	-	-	-
Motor Grader	02,03,04,05,07, 61,62	02,03,04,05,07, 08,58,61,62	02,03,04,05,08,61
Box Grader	05,62	05,62	
Dump truck/Tire	05,08		03,04,05
Side Spreader	05		
Shoulder Widener	58		
Roller			05,07,61

Note: Numbers represent the corresponding District # of DOTD and their responses.

Another survey question asked districts to estimate the life expectancy of their shoulder repairs. Table 6 shows a list of district responses. The responses varied from just a few months to years. There were some qualifications on these estimates like rain, new/recurrent divergents from the roadway onto the shoulder, and the material. RAP shoulders were said to last only two months, vs. another that said, “For extreme cases, asphalt is placed and last(s) much longer.”

Table 6. Expected service life responses

District	
02	Most drop offs are reoccurring, so any aggregates ruts again as traffic wears away. For extreme cases, asphalt is placed and last much longer.
03	Varies. 1-3 months in curves to 6m-1year in tangent sections.
04	1 year
04	1 year
05	2 years
05	6 months – depends on weather conditions
05	1-2 years
05	Depends on amount of rainfall
07	1 year
08	3 years
58	"years"
61	1 year
62	2 months – RAP shoulders

Cost

Most districts selected asphalt as the best repair material; however, asphalt at roughly $80 to $120/ton is more expensive than RAP. Louisiana, without natural bedrock stone, places a high value on RAP as is relatively free (recycled) within the Department. Old paving projects are roto-milled to harvest the RAP. Some states reincorporate their RAP, while in contrast, Louisiana stockpiles RAP for future use. The charge to do more with less is common within DOTD districts, and they therefore choose to utilize RAP because of its accessibility, availability, and negligible cost. This is a more cost-effective solution, but it does not have the appearance, performance, or longevity of a paved hot mix asphalt (HMA) shoulder.

The Department utilizes DOTD activity codes to identify internal activities for accounting purposes. Table 7 presents a summary of those shoulder maintenance codes, and Appendix C contains the chapter "Shoulders" from the DOTD Maintenance Activity Guide [19].

Table 7. DOTD shoulder maintenance activity codes

430-00 Repair of Non-Paved Shoulders (SQ YD) *NON-ACTIVE 7/15/19*
430-01 Pre-Mix Patching - Non-Paved Shoulders (SQ YD) *NON-ACTIVE 7/15/19*
430-02 Pre-Mix Patching - Paved Shoulders (SQ YD)
430-03 Reshaping Non-Paved Shoulders with Motor Grader (MILE) *NON-ACTIVE 7/15/19*
430-04 Reshaping\Restoring Non-Paved Shoulders (LN FT)
430-05 Cutting Non-Paved Shoulders (LN FT)
430-06 Chip Seal Shoulders (LN FT) NON-ACTIVE 7/10/14
430-07 Shoulder Widening Asphalt (LN FT) *NON-ACTIVE 7/15/19*
430-08 Shoulder Widening Concrete (LN FT) *NON-ACTIVE 7/15/19*
430-09 Widening Non-Paved Shoulders (LN FT)
430-99 Other Shoulder Maintenance (Hours)

Researchers contacted DOTD Operations Engineer/DOTD Assistant Secretary, Vince Latino (now retired) for information regarding cost expenses due to edge drop-off repair. For fiscal year 2017-2018, information was received and is summarized below. The repair costs for fiscal year 2017-2018 ranged from approximately $229,000 to $814,000 across the districts and totaled over $4 million. The costs are summarized by district in Table 8, and the full data with all columns is included in Appendix D.

Table 8. Summary of DOTD FY 2017-2018 shoulder repair costs

Activity	Amount	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	9493.497	$148,275.80
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	23059.004	$142,518.80
	DISTRICT 02 TOTAL	**$290,794.60**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	8547.447	$297,151.04
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	66.66	$5,732.34
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	152164.993	$204,353.90
	DISTRICT 03 TOTAL	**$507,237.28**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	10521.505	$68,666.49
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	8	$1,215.95
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	182279.067	$368,034.87
	DISTRICT 04 TOTAL	**$437,917.31**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	9950.606	$100,520.40
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	4529	$111,693.03
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	203.33	$7,025.71
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	944803.49	$548,048.68
	DISTRICT 05 TOTAL	**$767,287.82**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	5352.5	$19,979.36
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	119.3	$14,683.00
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	10.69	$892.47
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	52703.7	$197,355.98
	DISTRICT 07 TOTAL	**$232,910.81**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	3265.792	$339,514.47
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	1098.001	$35,854.11
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	327839.999	$438,376.72
	DISTRICT 08 TOTAL	**$813,745.30**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	4012.599	$70,499.72
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	68.999	$3,225.85
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	4135.65	$45,626.91
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	3666947.86	$496,046.26
	DISTRICT 58 TOTAL	**$615,398.74**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	969.873	$104,484.70
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	354.002	$23,694.15
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	33.48	$4,760.85
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	89366.002	$148,260.37
	DISTRICT 61 TOTAL	**$281,200.07**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	838.126	$107,654.16
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	552.501	$10,828.26
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	3	$1,658.71
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	23726	$108,793.91
	DISTRICT 62 TOTAL	**$228,935.04**
	GRAND TOTAL: ALL DISTRICTS	**$4,175,426.97**

Table 9 presents the cost of items for each district and grand totals from 2016 through 2019. The table references item numbers 430-00 through 430-04 in the aforementioned Table 7. The overall annual total for DOTD has decreased year to year; however, this could change if another high amount of hours to repair roadway ages is necessary, such as the District 05 workload in fiscal year (FY) 2016-2017.

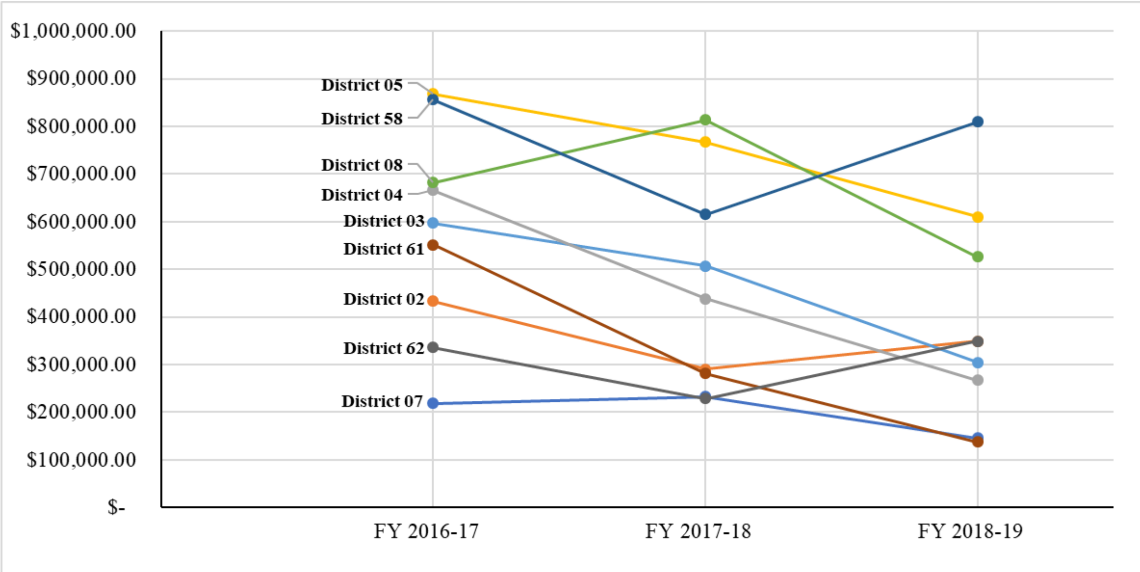
Table 9. 2016-2019 annual costs by district

FY 16-17	District 02 Grand Total	District 03 Grand Total	District 04 Grand Total	District 05 Grand Total	District 07 Grand Total	District 08 Grand Total	District 58 Grand Total	District 61 Grand Total	District 62 Grand Total
430-00	$155,961.78	$182,805.91	$139,243.18	$176,699.82	$37,502.83	$326,870.56	$44,822.76	$151,988.22	$87,477.44
430-01	$13,785.76	$0.00	$46,221.73	$72,459.42	$40,733.92	$7,692.53	$8,558.47	$62,065.10	$33,165.29
430-02	$0.00	$0.00	$9,928.68	$0.00	$957.60	$2,825.02	$15,052.13	$8,112.44	$1,178.58
430-04	$262,995.00	$413,802.32	$470,348.78	$619,354.66	$139,332.31	$344,866.43	$787,299.42	$329,688.29	$213,950.45
Total	$432,742.54	$596,608.23	$665,742.37	$868,513.90	$218,526.66	$682,254.54	$855,732.78	$551,854.05	$335,771.76
Annual Total for DOTD							**$5,207,746.83**		
FY 17-18	District 02 Grand Total	District 03 Grand Total	District 04 Grand Total	District 05 Grand Total	District 07 Grand Total	District 08 Grand Total	District 58 Grand Total	District 61 Grand Total	District 62 Grand Total
430-00	$148,275.80	$297,151.02	$68,666.48	$100,520.38	$19,979.36	$339,514.47	$70,499.72	$104,484.69	$107,654.16
430-01	$0.00	$5,732.34	$0.00	$111,693.03	$14,683.00	$35,854.11	$3,225.85	$23,694.15	$10,828.26
430-02	$0.00	$0.00	$1,215.95	$7,025.71	$892.47	$0.00	$45,626.91	$4,760.85	$1,658.71
430-04	$142,518.79	$204,353.89	$368,034.87	$548,048.67	$197,355.98	$438,376.72	$496,046.25	$148,260.36	$108,793.91
Total	$290,794.59	$507,237.25	$437,917.30	$767,287.79	$232,910.81	$813,745.30	$615,398.73	$281,200.05	$228,935.04
Annual Total for DOTD							**$4,175,426.86**		
FY 18-19	District 02 Grand Total	District 03 Grand Total	District 04 Grand Total	District 05 Grand Total	District 07 Grand Total	District 08 Grand Total	District 58 Grand Total	District 61 Grand Total	District 62 Grand Total
430-00	$119,580.61	$210,767.03	$55,755.98	$109,283.81	$25,304.87	$279,337.27	$26,185.72	$58,764.97	$139,104.39
430-01	$0.00	$0.00	$2,828.35	$31,274.27	$21,898.38	$6,770.20	$43,432.78	$6,124.12	$12,105.98
430-02	$0.00	$0.00	$401.03	$9,945.41	$1,050.96	$3,365.90	$21,271.59	$1,693.03	$5,271.74
430-04	$229,443.69	$94,088.68	$208,198.67	$459,997.41	$97,759.63	$237,194.48	$719,126.19	$71,401.92	$192,743.51
Total	$349,024.30	$304,855.71	$267,184.03	$610,500.90	$146,013.84	$526,667.85	$810,016.28	$137,984.04	$349,225.62
Annual Total for DOTD							**$3,501,472.57**		

Districts 05, 08, and 58 spent the most on edge repairs over these three fiscal years. District 04 spent above $665,000 in FY16-17 before seeing a decline in FY18-19 and another in FY18-19. Note that these four districts (04, 05, 08, and 58) make up the north part of Louisiana, where the terrain has rolling hills and more elevation changes.

Figure 9 shows the district trends from year to year. Six of the nine districts saw a decrease in expenditures from FY 2017-2018 to 2018-2019 including two of the northern districts (05 and 08). There were increases in the Districts 02, 58, and 62. District 58 spent over $800,000 in repairs in 2019. Though most districts saw a downward trend in costs, keeping this trend likely requires finding the most economical solutions, including utilizing readily available material, which requires fewer man-hours for shoulder repairs and fewer recurring visits.

Figure 9. District shoulder repair FY cost totals



Pavement Management Section

Data Collection

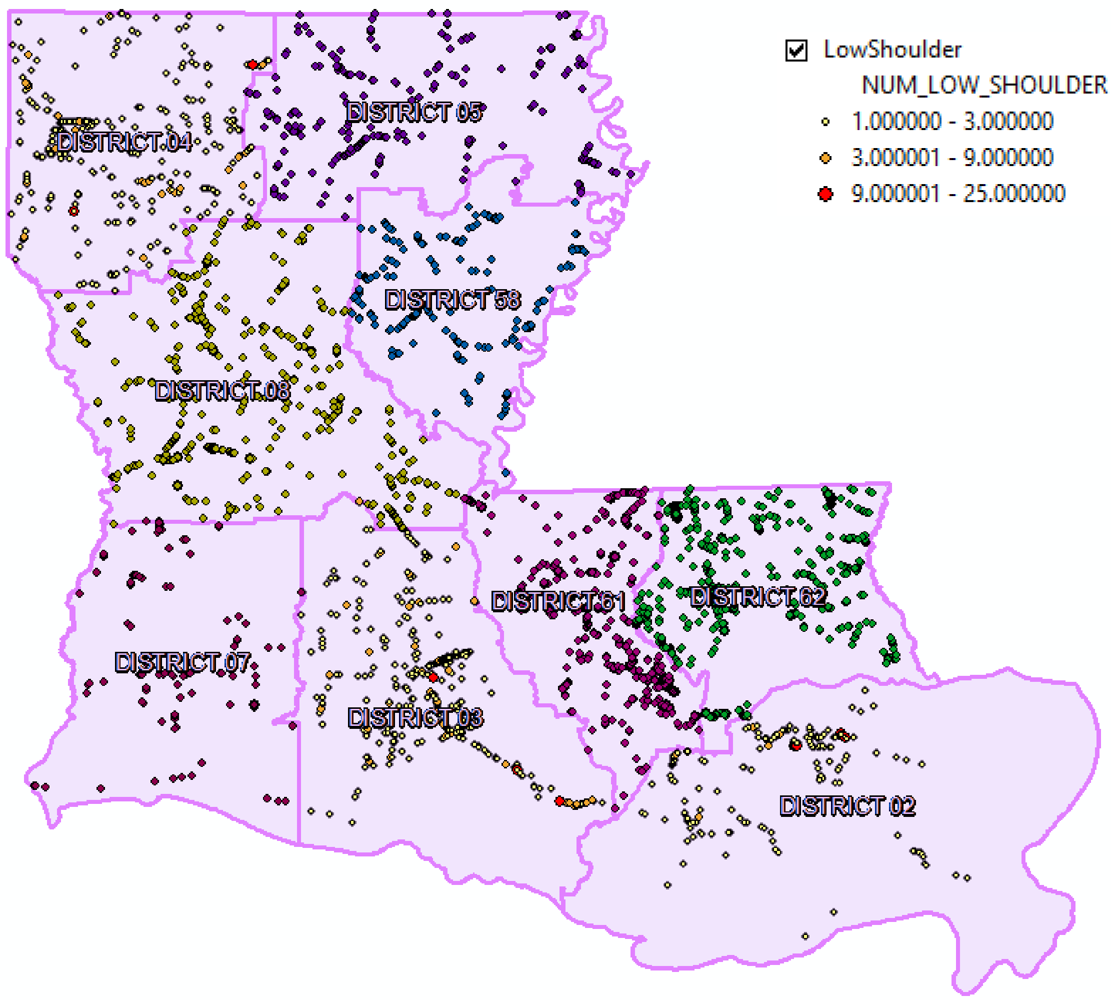
The Pavement Management Section (PMS) within DOTD collects data across the state through a variety of consultant contracts. The data includes a variety of measurements like International Roughness Index (IRI), video imagery, Global Positioning System (GPS) location and elevation information, laser profiles, etc. Two specific measurements that are calculated relevant to edge drop-off research are (1) the number of low shoulders and the number of high shoulders, which are collected as part of the Automatic Road Analyzer (ARAN) vehicle biennial measurements. From DOTD PMS staff:

> *Shoulders are reported from a combination of event rating and rut processor edge output. Presence of shoulder is rated as a span event and the average of drop off or curb height per tenth of a mile within this span from the rut processor output is reported as Shoulder height in the Summary table with a threshold between 2 in. and 6 in.*
>
> *Any edge less than 2 in. is not reported and any edge above 6 in. is reported as 6 in. Drop offs are reported as Low shoulders and Curbs are reported as High shoulders and Numbers indicated the number of stations of low or high shoulders per tenth of a mile.*

GIS Application. The data obtained from the DOTD PMS was incorporated into a Geographic Information System (GIS) platform to see if the edge drop-offs were associated with a particular area and/or highway configuration. A separate study through LTRC will examine edge drop-off data and crash data to search for a predictive model based on configuration for the likelihood of a potential crash.

Some of the data was difficult to interpret, and the data points may be in question. See Figure 10.

Figure 10. Example of edge drop-off data



Laboratory Testing

Utilizing the test matrix from aforementioned Table 2, the LTRC Geotechnical Research team determined the soil properties of five different sample types. The three mixes consist of Recycled Asphalt Pavement (RAP) and lean clay together in ratios of 25-75%, 50-50%, and 75-25%, respectively. The soil properties determined include grain size, Atteberg limits, and Proctor moisture-density results. Table 10 shows each of the five different sample mold materials properties and soil classification. This includes the percentage of gravel, sand, silt, and clay in each of the test molds.

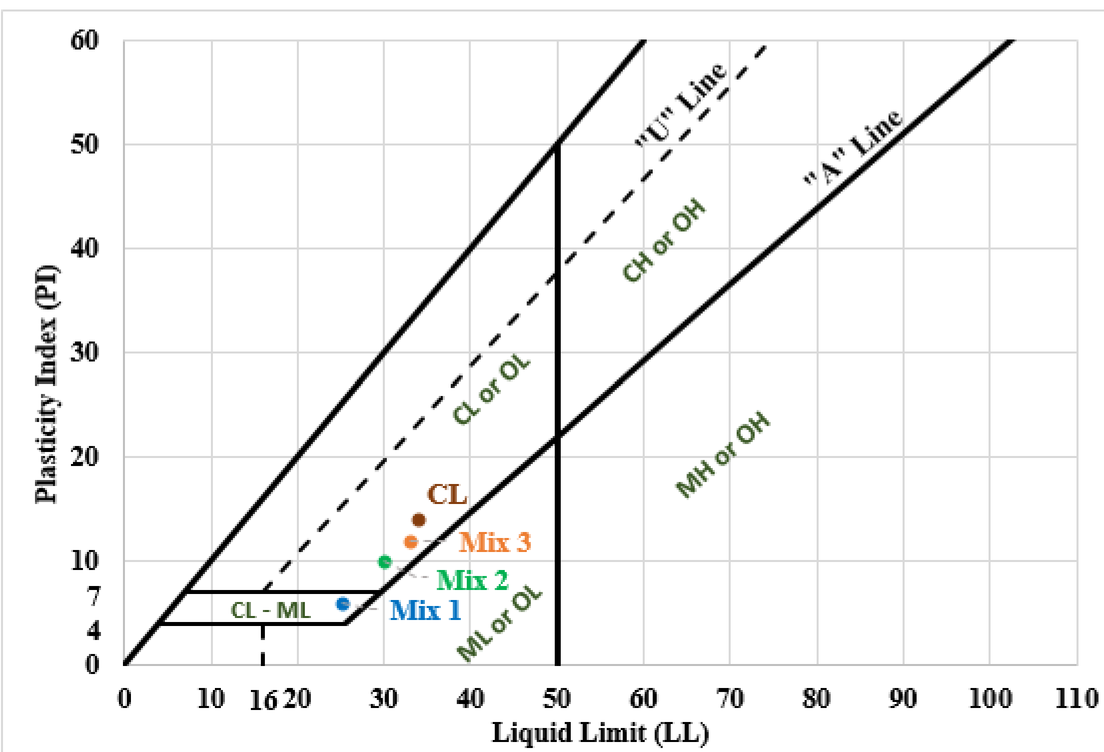
Table 10. Sample mold material properties and classification

		Lean Clay (CL)	Mix 3: 25% RAP 75% CL	Mix 2: 50% RAP 50% CL	Mix 1: 75% RAP 25% CL	100% RAP
Grain Size Distribution	% Gravel	0	21	34	29	93
	% Sand	22	32	22	47	7
	% Silt	56	11	9	17	0
	% Clay	22	36	35	7	0
Atterberg Limits	LL (%)	34	33	30	25	NP
	PL (%)	20	21	20	19	NP
	PI (%)	14	12	10	6	NP
USCS Classification		**(CL)** Lean clay w/sand	**(SC)** Clayey sand w/ gravel	**(GC)** Clayey gravel w/ sand	**(SM-SC)** Silty Sand w/ gravel	**(GP)** Gravel, Poorly graded
AASHTO Classification		**A-6**	**A-6**	**A-4**	**A-1-b**	**A-1-a**
Proctor Values	OMC (%)	11.9	10.4	7.9	3.9	16.6
	MDD (pcf)	107.7	106.9	120.9	123.5	107.2
Same Day Breaks Unconfined Compressive Strengths (UCS)	Sample 1 (psi)	28.5	29.7	16.4	11.4	NP
	Sample 2 (psi)	32.3	30.6	16.1	10.0	NP
	Sample 3 (psi)	30.7	28.2	12.1	10.3	NP
	Average Moisture (%)	16.9	12.0	10.2	7.9	NP
	Average Density (pcf)	107.3	114.1	119.9	125.4	NP

The Proctor maximum dry density (MDD) and optimum moisture content (OMC) are reported in units of pound per cubic foot (pcf) and percent moisture, respectively. The lowest optimum moisture content was in the 100% RAP sample, due to its granular nature. Table 10 shows the liquid limit (LL) and plastic limit (PL) for each material as percent moisture content. The plasticity index (PI) shown represents the calculated difference between the LL and PL.

Classifications according to the Unified Soil Classification System (USCS) are shown in Table 10. The original clay material is classified as lean clay with sand (CL) according to the USCS classification; and the RAP is classified as poorly graded gravel (GP). As the CL was blended into the RAP at various percentages to create other mixtures, the USCS classification changed. Mix 1 is classified as silty, clayey sand with gravel (SC-SM); Mix 2 is classified as clayey gravel with sand (GC); and Mix 3 is classified as clayey sand with gravel (SC). Figure 11 is the USCS plasticity chart, and it shows the Atterberg limits of each sample's fine grains. From Mix 1 to Mix 3, there is an increase in clay content, thus the LL and PI additionally increase. RAP is not included in the graph because it is "non-plastic."

Figure 11. Sample mixes on the USCS plasticity chart



Proctor densities in the table increase as RAP with aggregate particles is added to the lean clay; however, the RAP alone has a low density due to void spaces between the aggregate. In the mixtures, the smaller clay particles fill void spaces of the RAP, creating denser mixes when combining the clay and RAP materials. The RAP was non-plastic (NP), meaning the material has little to no cohesion (silt or clay) in the sample. By adding CL to the RAP, we create more dense material that has cohesion to hold loose RAP particles in place on the road shoulder.

Table 10 shows the unconfined compressive strengths (UCS) of each material molded with standard Proctor compaction at the optimum moisture content. The laboratory-molded samples were compacted with an automatic Proctor hammer, extruded, and compressed to determine their strength on the same day, thus same-day breaks. The UCS results in pounds per square inch (psi) and decrease as more RAP is added to the lean clay, likely due to increasing the percentage of cohesionless RAP in the sample. Researchers conducted California Bearing Ratio (CBR) tests on the all samples to account for the cohesionless RAP. CBR mold confinement will help represent in-place strength of all material for comparison since RAP is non-plastic (NP). Table 10 shows the average moisture and average density of the tested samples. The values are similar to the original Proctor values of OMC and MDD.

The moisture content affects the density and strength of the molded material. The following figures show the proctor curves and the UCS break strength of those molded samples for each mixture. Figure 12 shows Mix 3 (25% RAP and 75% Clay) test samples. Figure 13 shows Mix 2 (50% RAP and 50% Clay) test samples, while Figure 14 shows Mix 1 (75% RAP and 25% Clay) sample results. The circular points represent proctor results, while the triangular symbols represent the UCS for the sample at that moisture. Figure 15 is a collection of all three mixes, and it shows that the density increases as the sample includes more RAP. However, the relationship is reversed when talking about the UCS break strength decreases as the sample incorporates more RAP material.

Figure 12. Density and UCS of Mix 3: 25% RAP and 75% Clay

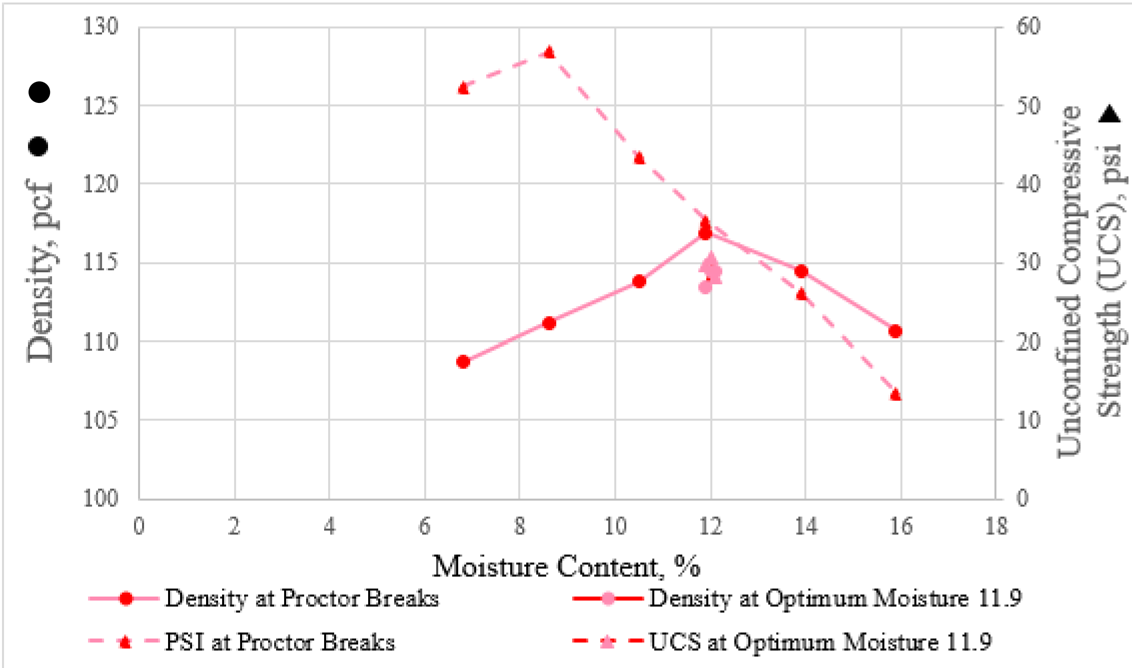


Figure 13. Density and UCS of Mix 2: 50% RAP and 50% Clay

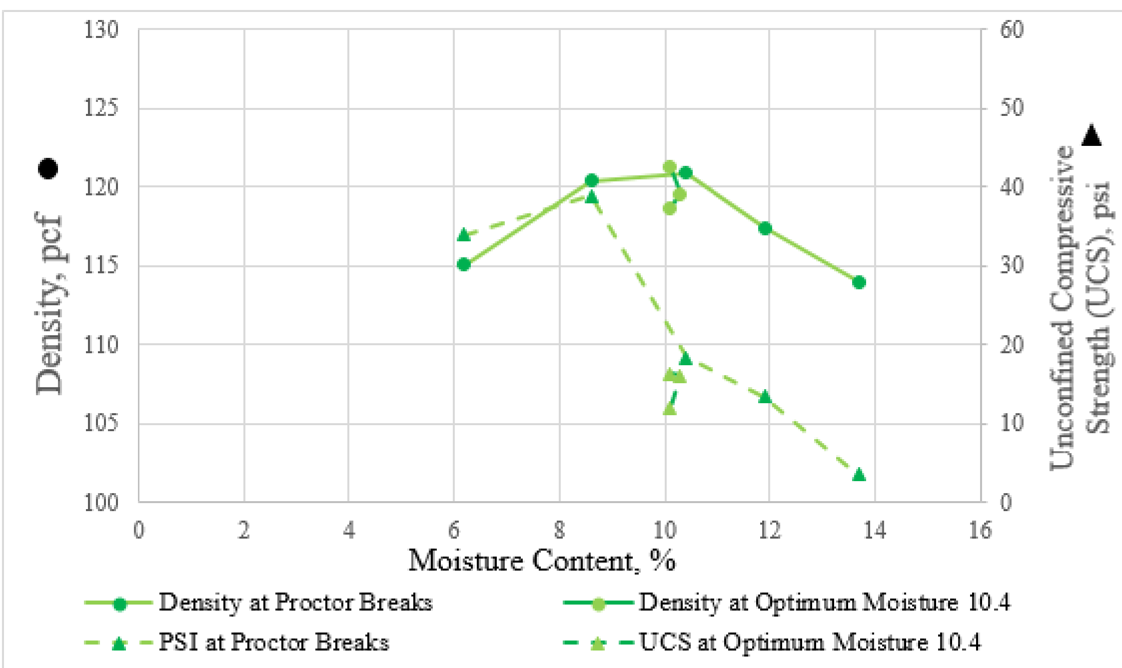


Figure 14. Density and UCS of Mix 1: 75% RAP and 25% Clay

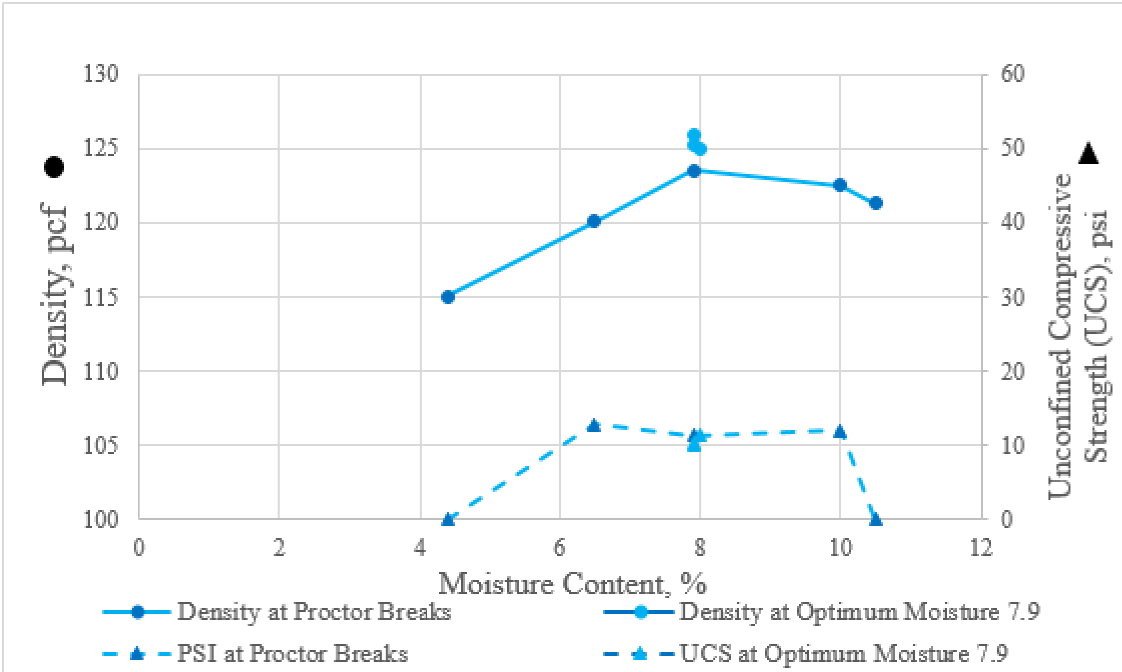
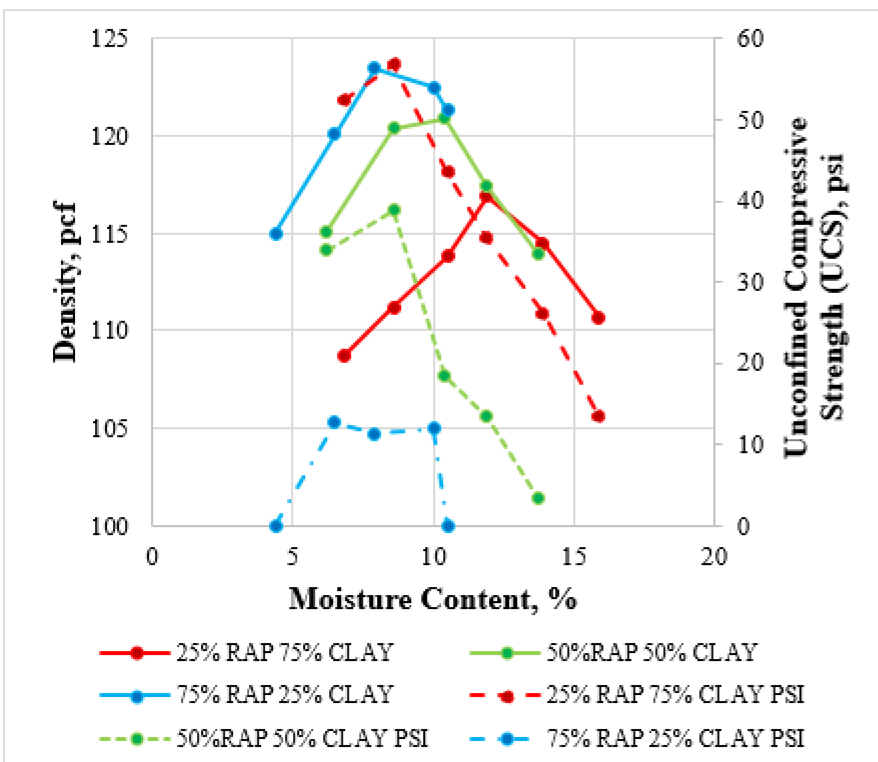


Figure 15. Density and UCS of all mixes



Since the 100% RAP was non-plastic, it could not maintain cylindrical form once extruded from the Proctor mold, and the unconfined compression test was impractical/impossible. Researchers therefore compared the five different materials utilizing a confined test method, the California Bearing Ratio (CBR) test. Table 11 shows the CBR results for each material at 0.1-in. and 0.2-in. penetrations on soaked and non-soaked samples. CBR results for soaked samples were less than non-soaked values, except in Mix 1 and the 100% RAP. This is likely due to the samples with more clay taking on moisture and losing strength. In contrast, the samples with more RAP had more inter-granular friction. These CBR values are relatively low compared to more common base course materials (well-graded crushed stone).

Table 11. CBR results for compressive strength

CBR Testing	Soaked	100% Lean Clay (CL)	Mix 3: 25% RAP 75% CL	Mix 2: 50% RAP 50% CL	Mix 1: 75% RAP 25% CL	100% RAP
0.1" Penetration	No	9.4	16.0	13.3	10.3	4.2
0.2" Penetration	No	10.0	16.6	14.5	14.7	5.6
0.1" Penetration	Yes	2.4	7.2	5.3	19.0	9.6
0.2" Penetration	Yes	9.6	3.4	7.5	7.3	13.0

Additives for Test Samples

Clay and RAP have value and can perform but have limitations. Another potential solution for cost effective shoulder repair includes the use of additives like cement to bond particles together. RAP is a common material found at DOTD district offices due to its grain size distribution (poorly graded). It can roll like marbles under loads. RAP coated with asphalt remnants may also reduce inter-granular friction vs. other raw aggregates. Additionally the slick asphalt (on the RAP) is not enough to bind the material like hot mix asphalt (HMA). Researchers investigated applying different additives such as cement, fly ash, and asphalt emulsion to the project materials. Improving these materials with additives may provide additional alternatives to strengthen and provide a more suitable material for edge drop-offs — at a slightly higher cost than untreated material.

Cement. Cement is a common construction product and soil additive. Table 12 and Table 13 show the research test matrix of soil samples combined with cement added in 2%, 4%, 6%, and 8% increments. Six samples were formed for each design mixture. Three were tested for their compressive strength in psi after 7 days of curing and three other samples were tested after 28 days. Table 12 and Table 13 show the unconfined compressive strength (UCS) results for all of the cement and fly ash samples. A target strength of 100 to 125 psi is desired for these shoulder materials.

The strengths' of mixtures with 2% cement were all less than 100 psi, except Mix 1. At 4% cement: Mix 1, Mix 2, and the 100% RAP strengths were above 100 psi. At 6% and 8% cement, nearly all samples exceeded strengths of 100psi some 28-day strengths (Mix 1 and 100% RAP were above 300 psi with 8% cement.

These higher cement percentages produced higher strengths, but they also incur more material costs. If a cement spreader and mixer are utilized, the mobilization costs are the same, regardless of the cement percentage. Even mixing by hand varies little by the amount mixed; however, by hand efforts are obviously more laborious than mechanical methods.

Fly ash. Fly ash is another common additive, but it contains less reactive material than cement, thus more is required to attempt to reach cement strengths. For this research, fly ash was added to the mixtures in amounts of 5%, 10%, 15%, and 20%. The fly ash blends struggled to reach 100 psi. Only Mix 1 and the 100% RAP samples were able to reach 100 psi at 15% and 20% fly ash by weight. The 100% RAP with 20% fly ash yielded the highest compressive strength exceeding 150 psi. The fly ash results are shown in Table 12 and Table 13. According to a 2011 report produced by the Transportation Development Foundation (TDF), fly ash cost $40 per ton as opposed to cement, which is more than double in cost at $92 per ton [20].

The data shows that strengths generally increased with more additive and time; however, fly ash percentages are relatively high and did not prove to have the compressive strength needed to provide an adequate roadway edge for the effort. Regarding cost, fly ash is less expensive than cement, yet fly ash requires a higher quantity of material to produce the strengths that of cement. Figure 16 shows the comparison of average compressive strengths of both cement and fly ash additives. A huge increase of strength is indicated when cement additive cures longer from 7 days to 28 days; however, this is not the case for the fly ash results.

Table 12. UCS test matrix with additives part 1

Standard Proctor Compaction Unconfined Compressive Strength, psi	7-Day Break					28-Day Break				
	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density
100% Lean Clay + 5% Fly ash	26	42	41	18.9	NA[1]	38	42	41	20.9	NA[1]
100% Lean Clay + 10% Fly ash	38	35	48	19.9	104.4	41	32	38	19.9	104.5
100% Lean Clay + 15% Fly ash	NA[1]	NA[1]	NA[1]	19.4	105.4	31	59	33	19.2	105.7
100% Lean Clay + 20% Fly ash	42	33	48	19.7	104.6	60	55	54	20.3	103.9
100% Lean Clay + 2% Cement	80	51	72	18.3	105.1	64	80	79	18.4	104.1
100% Lean Clay + 4% Cement	104	101	82	19.8	102.8	105	112	127	19.3	102.9
100% Lean Clay + 6% Cement	144	152	153	19.1	102.5	186[2]	147[2]	144[2]	19.2	101.4
100% Lean Clay + 8% Cement	170	147	171	18.5	103.4	199	208	197	19.0	103.0
Mix 3: 25% RAP / 75% CL + 5% Fly ash	32	32	38	15.5	111.0	37	37	37	14.0	112.0
Mix 3: 25% RAP / 75% CL + 10% Fly ash	17	14	17	19.1	104.6	28	33	30	18.6	105.6
Mix 3: 25% RAP / 75% CL + 15% Fly ash	51	52	43	19.4	105.2	24	26	26	18.7	106.0
Mix 3: 25% RAP / 75% CL + 20% Fly ash	28	33	30	18.3	106.8	30	25	16	18.2	106.0
Mix 3: 25% RAP / 75% CL + 2% Cement	NA[1]	40	46	18.4	105.4	47	38	51	18.3	106.1
Mix 3: 25% RAP / 75% CL + 4% Cement	65	75	75	19.2	106.0	NA[1]	93	85	19.4	105.0
Mix 3: 25% RAP / 75% CL + 6% Cement	65	98	88	18.5	106.2	112	85	89	16.7	107.0
Mix 3: 25% RAP / 75% CL + 8% Cement	107	122	102	17.9	106.3	124	143	121	19.5	104.9
Mix 2: 50% RAP / 50% CL + 5% Fly ash	17	17	13	17.0	107.7	7	7	8	19.2	105.2
Mix 2: 50% RAP / 50% CL + 10% Fly ash	16	13	18	20.3	104.4	12	16	17	20.4	105.0
Mix 2: 50% RAP / 50% CL + 15% Fly ash	38	35	40	13.8	114.2	38	40	46	12.9	116.3
Mix 2: 50% RAP / 50% CL + 20% Fly ash	54	56	49	14.0	114.7	59	45	43	11..9	116.9

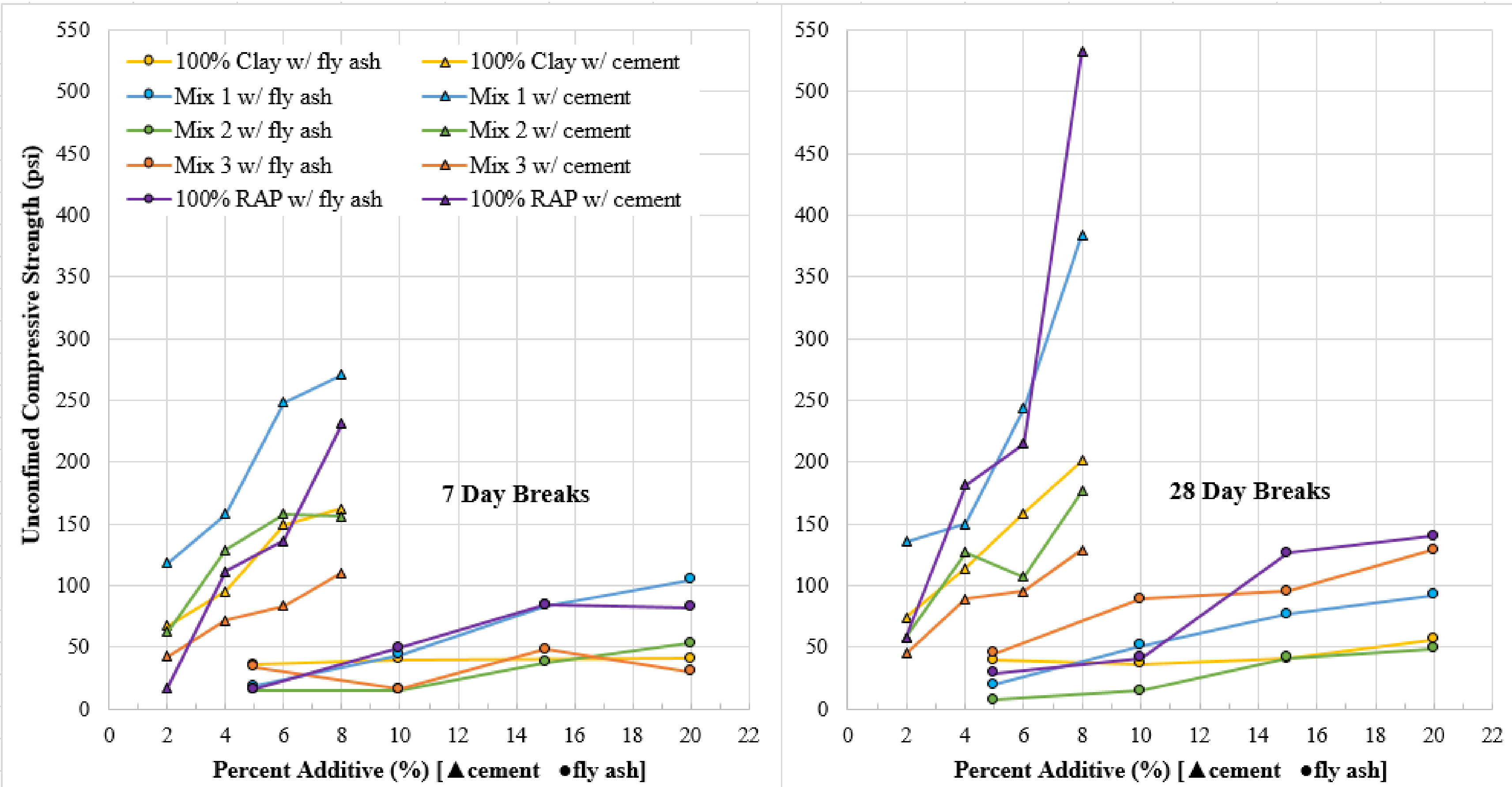
Note: 1. NA= Not available; this is due to either sample or device errors.
2. Pink shaded boxes indicate that the samples were broken at 50 days (rather than 28) due to office closure from the Covid-19 pandemic.

Table 13. UCS test matrix with additives part 2

Standard Proctor Compaction Unconfined Compressive Strength, psi	7-Day Break					28-Day Break				
	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density	Sample 1	Sample 2	Sample 3	Average Moisture	Average Density
Mix 2: 50% RAP / 50% CL + 2% Cement	65	60	60	17.0	108.7	61	51	63	15.8	109.7
Mix 2: 50% RAP / 50% CL + 4% Cement	135	140	113	12.9	114.9	129	125	127	12.9	114.5
Mix 2: 50% RAP / 50% CL + 6% Cement	142	139	194	12.5	194.0	195	172	181	13.2	114.3
Mix 2: 50% RAP / 50% CL + 8% Cement	152	147	170	14.0	112.8	173	201	156	14.8	112.8
Mix 1: 75% RAP / 25% CL + 5% Fly ash	18	16	21	8.0	123.9	19	NA	21	8.0	122.0
Mix 1: 75% RAP / 25% CL + 10% Fly ash	55	46	31	8.0	125.7	61	26	67	8.0	125.6
Mix 1: 75% RAP / 25% CL + 15% Fly ash	84	83	84	9.0	117.5	54	81	97	9.0	118.1
Mix 1: 75% RAP / 25% CL + 20% Fly ash	105	89	122	10.2	117.9	92	93	93	10.0	117.9
Mix 1: 75% RAP / 25% CL + 2% Cement	99	133	124	9.7	119.7	116	159	134	9.8	120.9
Mix 1: 75% RAP / 25% CL + 4% Cement	153	192	129	9.9	120.0	167	133	NA	9.2	120.8
Mix 1: 75% RAP / 25% CL + 6% Cement	300	198	NA	9.2	119.9	228	269	234	9.2	120.6
Mix 1: 75% RAP / 25% CL + 8% Cement	252	267	293	10.2	121.5	320	456	377	7.5	123.6
100% RAP + 5% Fly ash	19	17	13	9.0	119.5	29	29	NA	7.2	123.8
100% RAP + 10% Fly ash	72	37	39	9.0	119.2	43	40	42	7.1	119.8
100% RAP + 15% Fly ash	143	65	45	11.6	116.9	91	143	144	6.8	124.9
100% RAP + 20% Fly ash	139	75	34	13.6	118.5	143	116	162	8.7	119.6
100% RAP + 2% Cement	11	7.6	33	7.8	113.0	47	70	NA	7.8	112.3
100% RAP + 4% Cement	131	92	NA	7.0	117.8	188	190	167	5.2	120.2
100% RAP + 6% Cement	121	149	139	5.4	122.9	201	182	262	5.4	118.4
100% RAP + 8% Cement	161	304	229	6.2	114.0	696	490	413	6.0	127.2

Note: Gray shaded boxes for Mix 1 and 100% fly ash incorporated a different fly ash from New Roads, LA.

Figure 16. Average compressive strengths



Durability. This is an important characteristic when dealing with paved and unpaved road surfaces. Some states utilized a freeze-thaw test, but in Louisiana, wet-dry cycles are more important. For this research, rather than test the 40 different mixture/additive combinations for durability, researchers selected samples for durability based on results shown in Table 14. For the very time-consuming durability tests (DOTD TR432 Method D: Durability of Cement Treated or Stabilized Materials and AASHTO T 135-22: Wetting and Drying Test of Compacted Soil Cement Mixtures), the samples underwent 12 cycles of soaking and oven drying for one sample and 12 cycles of brushing for a second sample. Therefore, the selection of these six mixture/additive types reduced overall laboratory time and effort.

Table 14. Durability results

Material Type & Additive		100% Lean Clay (CL) + 6% cement	Mix 2: 50% RAP/ 50% CL + 6% cement	Mix 1: 75% RAP/ 25% CL + 4% cement	Mix 1: 75% RAP/ 25% CL + 6% cement	100% RAP + 20% fly ash	100% RAP + 4% cement
Molded moisture contents	Sample 1	13.1%	10.8%	7.9%	8.7%	5.8%	4.3%
	Sample 2	13.0%	11.0%	8.7%	8.4%	5.6%	4.1%
Dry density (pcf)	Sample 1	102.2	117.1	122.3	122.2	126.4	119.8
	Sample 2	102.3	116.8	122.2	122.8	125.4	111.5
Soil cement loss of sample No. 2		8.6%	3.6%	9.4%	1.9%	15.5%[1]	8.8%
Unconfined compressive strength (psi)	Sample 1	NA[2]	650.6	412.5	720.7	255.4	314.3
	Sample 2	NA[2]	363.0	350.1	642.2	124.8	87.3
Sample cure time[3]		NA[2]	54 days	53 days	54 days	52 days	88 days

Notes: 1. The *100% RAP + 20% fly ash* sample fails durability testing due to its total mass loss exceeding TR 432-02 criteria (Table 15).
2. NA= Not available; the *100% lean clay + 6% cement* sample did not stay intact for the full 12 cycles.
3. This cure time is longer than normal and includes both the 7-day cure time in the moisture room and the span of the 12-cycle durability testing.

There are two types of failures for durability testing: (1) the sample not surpassing the 12 cycles of oven dry, slaking, and brushing; and (2) mass change of the sample surpasses the maximum loss according to TR 432, as seen in Table 15. Table 15 highlights the durability requirements of typical mixture/additive scenarios. The 100% RAP with 20% fly ash additive sample failed to stay within 14% loss of mass.

Table 15. TR 432-02 durability sample loss limits [18]

AASHTO Classifications	Maximum Loss, % by Dry Mass	19-1GT Samples	
A-1-a, A-1-b, A-2-4	14	100% RAP	Mix 1
Sand clay gravel, recycled material, etc.	14	100% Recycled Asphalt Pavement (RAP)	
A-2-6, A-4	10	Mix 2	
A-6	7	Mix 3	100% Lean Clay

The 100% RAP and Mix 1 additive combinations performed the best for sample breaks in Table 13. Mix 1 and Mix 2 samples performed the best in the durability trials (lasting through the 12 cycles and passing the durability limit criteria). Additionally, if the samples were still intact after durability, then the researchers conducted unconfined compression tests. UCS test results on the surviving durability samples are indicated in the last three rows of Table 14. These samples had longer than normal cure time due to the additional durability cycles. These higher cure times showed improved strengths with the exception of the 100% RAP that had more sample loss during the trials (most likely due to the granular material). Post durability-tested Mix 1 samples produced the highest average compressive strengths; Mix 2 samples also resulted in high strengths. Mix 1 (75% RAP and 25% CL) with an additive of 6% cement performed the best during durability testing and post-durability UCS tests.

Asphalt Emulsion – Other additives in consideration were emulsions, which are commonly used as tack coat. Tack coat is a liquid asphalt additive that is applied between newly hot mix asphalt overlays and lower surface layers to improve bonding between the lifts. Adding emulsion to test samples was performed and tested by the asphalt research group at LTRC. The group molded a series of samples consisting of various percentages of emulsion by weight. They also varied the application of the emulsion (before or after mixing), to relate to how field personnel might apply the emulsion, such as directly on top the sample mold to provide an easier task for roadway personnel.

During laboratory testing, the emulsion only penetrated a test sample by about 2-3 in. from the top. Therefore, it was considered that emulsion could be sprayed between smaller layers of RAP, including prior to the placement of RAP on the roadway shoulder to help adhere layers. This proposed method could allow additional RAP to be added or embedded atop the tack coat to provide surface friction. For deeper patches, multiple layers of tack coat and RAP should be added to tighten the mix.

Two types of emulsions were tested due to the accessibility of its resources across the district laboratories in Louisiana. The first emulsion tested was cationic and has a positive chemical charge, which is compatible with siliceous (negatively charged) aggregates. Since most of the aggregates utilized in road construction are negatively charged particles, cationic emulsions have an advantage in creating a more structured and adhesive relationship with the aggregates [21]. Technicians stirred and heated the emulsion to 70°C and blended with RAP material minus a ¾-in. sieve. Emulsions was added at 4% and 6% (by weight). Samples were prepared with a total weight of around 5,270 grams, a height of around 155-160 mm, and a 6-in. diameter after 13 gyratory compactions. Samples were removed from molds within the first hour after compaction and left for curing for 6 days.

The second type of emulsion tested was SS1-HH, which is a slow setting anionic (negatively charged) emulsion. The speed an emulsion takes to set is important when mixing with fine aggregates. With finer aggregates, a slower setting of emulsion is needed. When spraying water on the roadway with emulsion, the anionic emulsions are susceptible to temperature and humidity in terms of the breaking process [21]. The LTRC asphalt lab prepared samples with the SS1-HH emulsions in the same manner as with the cationic emulsions.

The results showed that the cationic emulsion performed better than the SS1-HH anionic emulsion when the cure time was 6 days, as seen in Table 16. For shoulder strengths researchers were looking for an average compressive strength range around 100-150 psi. In a 6-day cure window, only the 6% cationic emulison succeded in the target range for compressive strength.

Table 16. Emulsion with RAP sample mold data

% Emulsion	Sample ID	Cure Time	Compressive Strength (psi)	Average Compressive Strength (psi)	Standard Deviation
6% Cationic	1	6 Days	148.3	146.7	8.5
	2		135.5		
	3		156.2		
4% Cationic	1	6 Days	54.6	53.3	1.4
	2		51.3		
	3		53.9		
6% SS1-HH (A)*	1	2.5 Months	167.2	187.2	14.2
	2		197.8		
	3		196.6		
6% SS1-HH (B)	1	6 Days	38.5	47.9	9.9
	2		61.6		
	3		43.5		

Note: * Cure time for 6% SS1-HH (A) was 2.5 months due to the coronavirus pandemic and shutdown. 6% SS1-HH (B) was molded to achieve the 6-day cure time.

The LTRC asphalt group started molding samples with 6% emulsion. One batch of 6% SS1-HH (A) molds were left unattened and cured for 2.5 months due office closures during the novel coronavirus pandemic of 2020. After the shutdown and return to office, the asphalt group tested these samples, which produced high average compressive strengths. However, compressive strengths of samples with the same emulsion percentage, cured for only 6 days and produced significantly lower strengths. Based on the 6% SS1-HH not achieving near the compressive strength threshold, samples at 4% SS1-HH were not created or tested. More cure time improves compressive strength; however, when applied in the field, this extra cure time may not be realized since shoulders do not receive normal/daily traffic loads.

Conclusions

- Researchers conducted a survey that indicated reclaimed asphalt pavement (RAP) was indeed the material most-often utilized for edge drop-off repairs with availability being its best attribute.
- RAP is commonly found at DOTD district offices; however, due to aging, the material has limited asphalt content and behaves as non-plastic material (gravel).
- This research created multiple sample variations in which clay was added to RAP to fill voids, add cohesion, and improve strength and durability.
- RAP was modified with additives, such as cement, fly ash, and asphalt emulsion to improve density, strength, and durability.
- Mix 1 (75% RAP and 25% CL) with an additive of 4% to 6% cement performed well in both feasibility (minimal additives utilized) and performance (strength and durability of test samples).
- The 6% cationic asphalt emulsion mixed with 100% RAP samples performed well; however, there would likely need to be several 2-in. lifts (sprayed on) for field applications to perform adequately.
- DOTD District 58 successfully deployed equipment to blend, compact, and finish the shoulder material. They were acknowledged at a Louisiana Transportation Conference for their innovative implementation.
- The Safety Edge^{SM} has been implemented by the department and has reduced the severity of edge drop-offs, and the ability of vehicles to more easily return to the travel lanes.
- The addition of rumble strips can help reduce lane divergence.
- Pavement Management's iVision can be utilized to locate problematic edge drop-off locations for repair.

Recommendations

There are methods to reduce edge drop-off and improve shoulder strength and durability. These recommendations will help improve safety on and the longevity of highway shoulders.

LTRC recommends the following:

- Rumble strips – to alert drivers of the highway lane edge with sound and vibrations
- Safety Edge^{SM} technology – to help drivers return to the travel lanes should they have a departure
- Recommended mixtures, equipment, etc.:
  - Mixture for edge drop-off solution
    - Mix 1 (75% RAP and 25% CL) with an additive of 4% to 6% cement for a long-term edge drop-off shoulder repair
  - District 58 style equipment
    - Spreader boxes and small discs
      - For spreading and blending components on medium sized projects
      - Smaller projects may be resolved with hand mixing and compaction equipment
    - Rubber tire roller compactors can help produce a relatively smooth surface to help control drainage and erosion.
- Pavement Management's iVision – to identify problematic drop offs and help schedule asset repairs
- Proactively improving shoulders – to reduce the potential and or severity for/of lane departure incidents

Repairs should be based on several factors, including severity, safety history, recurrence, available funds, etc.

Acronyms, Abbreviations, and Symbols

Term	Description
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
ARAN	Automatic Road Analyzer from Fugro
ASTM	American Society of Testing Materials
CBR	California Bearing Ratio
CL	lean clay (from USCS)
cm	centimeter(s)
CTRE	Centre for Transportation Research and Education (Iowa)
cy.	cubic yard(s)
DOTD	Louisiana Department of Transportation and Development
EDC	Every Day Counts
FHWA	Federal Highway Administration
ft.	foot (feet)
FY	fiscal year(s)
GIS	Geographic Information System
GC	clayey gravel (from USCS)
GP	poorly graded gravel (from USCS)
GPS	Global Positioning System
HFA	Hydrated fly ash
HMA	hot mix asphalt
hr.	hour(s)
in.	inch(es)
IRI	International Roughness Index
lb.	pound(s)
LL	Liquid Limit
LTC	Louisiana Transportation Conference
LTRC	Louisiana Transportation Research Center
m	meter(s)

Term	Description
MDD	Maximum dry density
MnDOT	Minnesota Department of Transportation
MUTCD	Manual Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NDOT	Nebraska Department of Transportation
NA	Not Applicable
NP	non-plastic
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
PMS	Pavement Management Section
psi	Pounds per square inch
RAP	Recycled Asphalt Pavement
RTAP	Rural Technical Assistance Program
SC	clayey sand with gravel (from USCS)
SC-SM	silty, clayey sand with gravel (from USCS)
SS1-HH	slow-setting anionic asphalt emulsion
TDF	Transportation Development Foundation
TR	Technical Reference
TxDOT	Texas Department of Transportation
UCS	unconfined compressive strength(s)
USCS	Unified Soil Classification System
w/	with
yd.	yard(s)

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Appendix A

District Survey Questionnaire

LTRC Project: Maintenance of Roadway Edge Drop-Off Utilizing Readily Available Materials

This research is intended to address shoulder drop-offs and repairs to shoulders. We understand this is a safety and maintenance issue. This part of the research will deal primarily with the maintenance side, with hopes to offer economical, long-lasting, repair solutions. We appreciate your insight.

- Which materials compose the road shoulder surfaces in your District?
  Please Rank/estimate the following based on frequency. Most common = #1 thru Not Applicable, NA.
  __ Asphalt
  __ Crushed Limestone
  __ RAP
  __ Soil
  __ Mix of ____
  __ Other(s) ____

- Based on your District's experience, which materials work best as shoulder repair material?
  Please Rank your Top 3 (Best = #1)
  __ Asphalt
  __ Crushed Limestone
  __ RAP
  __ Soil
  __ Mix of ____
  __ Other(s) ____

- When repairing shoulder ruts and drop-offs, which materials are utilized? (Check one)
  □ Existing material is reshaped, or
  □ New material is brought in: (Rank Top 3, Most often = #1)
    __ Asphalt
    __ Crushed Limestone
    __ RAP
    __ Soil
    __ Mix of ____
    __ Other(s) ____
  □ Other(s) ____

- Please explain why the material is utilized.
  Please Rank Top 5, Most often = #1 through not applicable)
  □ Low Cost
  □ Readily Availability
  □ Good Performance
  □ Past Experience
  □ Historical Practice (good or bad)
  □ Other Materials Not Available
  □ Other(s) ____
  ____

- How is the repair material most often placed, shaped, and compacted? Check all that apply.

Method/Equipment	Placed	Shaped	Compacted
Reshaped by hand/shovel			
Bobcat or Small Excavator			
Dozer Blade			
Tractor Disc			
Motor Grader			
Box Grader			
Other (please describe)			

- Is the most common shoulder material, the best performing material in your district?
  - ☐ If not, why? ____
- Service life of treatment: How long do you expect a shoulder repair to last?
  ______months, _____ years, or Other:____
- List / Describe any shoulder repair materials that have caused difficulties/problems?
  Check any and Explain problems
  __ Asphalt
  __ Soil
  __ Crushed Limestone
  __ RAP
  __ Other ____
- Which causes most of your shoulder edge drop-off problems? (Rank Top 5, Most common = #1)
  __ Erosion
  __ Rutting
  __ Little to No Shoulder
  __ Winding roads
  __ Farm traffic
  __ Steep shoulders
  __ Existing Material Type ___________________
  __ Other:_____________________________________
  - Any specific route examples in your District?
    ____
- What is an estimate of average shoulder width in your District? _____________
- What is a percentage estimate of shoulders less than 2feet wide? __________%
  - ☐ Does this affect your repair methods? If so, How? ________________________________
    ____
- How is a site selected for repair? (Rank Top 3, Most often = #1)
  __ Resident reports
  __ DOTD notices & reports
  __ Overlay job, therefore upgrade & level adjacent shoulder
  __ Upgrading all shoulders, working a list
  __ Numerous rutting events (how many?) __Other:___________________________
- Do you have any special tools for shoulder repair like District 58 presented at the Transportation Conference?
  http://www.ltrc.lsu.edu/ltc_18/pdf/presentations/Session_8-D58_-_tractor_disc_blade_attachment.pdf
  ____Yes or ___No. If yes, please explain:____
  ____
- Strength: an embankment has a strength of approx. 50psi, treated subgrade approx. 100psi. Do you believe that 100psi is an appropriate strength value for shoulder material? Why or Why not. _______________________
  ____
- FHWA Everyday Counts Recommends utilizing a Safety Edge when applying an overlay to reduce edge drop-offs. Are you familiar with this technology? Check one.
  __ If so, how do you address shoulder material on the edge wedge? ________________________________
  __ What material is utilized to level the shoulder after the overlay? ________________________________

Your Name:____ **District:**________________________

Thanks for your insight. Please send this document to me via snail mail, email, or fax, whichever is easier for you.

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LTRC Geotechnical
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Gavin.Gautreau@LA.GOV

Survey Question 1: Which materials compose the road shoulders in your District?

	Asphalt	Crushed Limestone	RAP	Soil	Mix of __	Other
District 02	1	3	2	4		
District 03	2	3	1	NA		
District 04	1		2	3		
District 04	1			2		
District 05	3	NA	2	1	NA	
District 05	3	NA	2	1	4 (Soil/RAP)	5 (CC)
District 05	3	4	1	2		
District 05	4	NA	1	2		3 (S-C Gravel)
District 07	3		1	2		
District 08	1	3	2	NA		
District 58	3	NA	2	1		
District 61	4	5	3	1	2 (Soil&Agg.)	
District 62	2	NA	1			

Survey Question 2: Based on your District's experience, which materials work best as shoulder repair material?

	Asphalt	Crushed Limestone	RAP	Soil	Mix of __
District 02	1		2		
District 03	1		3		2 (Cold Mix)
District 04	1		2		
District 04	1			2	
District 05	2	NA	1	3	
District 05	1	NA	4	2	3 (Rec. Concrete)
District 05	1	2	3	4	
District 05			3	2	1 (Soil & RAP)
District 07	1		2	3	
District 08	1	3	2		
District 58	1		2		
District 61	1	2	3		
District 62	1		3	2	

Survey Question 3: When repairing shoulder ruts and drop-offs, which materials are utilized?

	Asphalt	Crushed Limestone	RAP	Soil	Mix of __	Other
District 02	2		1			
District 03	2	3	1			
District 04			1	2		
District 04					1 (Soil & RAP)	
District 05			1	2		
District 05	3	NA	2	1	4 (Soil)	
District 05	3	2	1			
District 05			3	2	1 (Soil & RAP)	
District 07	2		1			
District 08	3		2			1 (Dura Patch)
District 58	2		1	3		
District 61	3	2	1			
District 62	3		1	2		

Survey Question 4: Please explain why this material is utilized.

	Low Cost	Readily Availability	Good Performance	Past Experience	Historical Practice	Other Materials Not Available
District 02	2	1				
District 03	2	1	3	4	5	
District 04	2	1	4	3		
District 04		1				2
District 05	2	1	4	3	5	
District 05	2	1	6	5	3	4
District 05	2	1	5	4	3	
District 05	x	x			x	
District 07	1	2	3			
District 08	2	3	1	4	5	
District 58	2	1	3*	4	3*	5 (expensive)
District 61	2	1	4	5	3	
District 62	x	x				x (limited budget)

Survey Question 5: How is the repair material most often placed, shaped, and compacted?

Method/Equipment	*Placed*	*Shaped*	*Compacted*
Reshaped by hand/shovel	02,03,05,08	02,03,04,05,08	02,03,05,08
Bobcat or small excavator	02,03,04,05,61,62	02,03,04,05,08,61	02,03,04,05,08,61
Dozer Blade	05	05	05
Tractor Disc	-	-	-
Motor Grader	02,03,04,05,07, 61,62	02,03,04,05,07, 08,58,61,62	02,03,04,05,08,61
Box Grader	05,62	05,62	
Dump truck/Tire	05,08		03,04,05
Side Spreader	05		
Shoulder Widener	58		
Roller			05,07,61

Note: Numbers represent the corresponding District # of DOTD and their responses.

Survey Question 6: Is the most common shoulder material the best performing material in your District?

District 02	Yes
District 03	RAP most common. Asphalt & Cold Mix better but more expensive.
District 04	No, Asphalt would be better but more costly
District 04	Cheapest and readily available
District 05	Yes
District 05	Soil and RAP more available, but asphalt and cold mix are better but more expensive.
District 05	No, material does not perform as well as hot mix.
District 05	No, because washes away. Hills and valleys
District 07	Asphalt is best and most expensive. RAP is cost effective and most common.
District 08	Yes
District 58	Yes
District 61	No, RAP doesn't tend to stay in place long.
District 62	N/A

Survey Question 7: Expected service life responses

District	
02	Most drop offs are reoccurring, so any aggregates ruts again as traffic wears away. For extreme cases, asphalt is placed and last much longer.
03	Varies. 1-3 months in curves to 6m-1year in tangent sections.
04	1 year
04	1 year
05	2 years
05	6 months – depends on weather conditions
05	1-2 years
05	Depends on amount of rainfall
07	1 year
08	3 years
58	"years"
61	1 year
62	2 months – RAP shoulders

Survey Question 8: List/describe and materials that have caused difficulties/problems.

	Asphalt	CL	RAP	Soil	Mix of _	Other
District 02	Left blank					
District 03	Left blank					
District 04			x			
District 04			x			
District 05	Left blank					
District 05	*	NA	x	x		*Asphalt, if steep slope
District 05				x		
District 05	Left blank					
District 07			x			Pushed out by traffic
District 08		x				Pushed out by traffic
District 58				x		
District 61	Left blank					
District 62	Left blank					

Survey Question 9: Which causes most of your shoulder edge drop-off problems?

Dist.	Erosion	Rutting	Little to no shoulder	Winding roads	Farm traffic	Steep shoulders	Existing Materials	Other (Explain)
02	1	2						
03		5	3	1	2		4	
04		x		x			x	x (Oilfield Truck)
04	3		1	2		5		4 (Log & Oilfield Truck)
05	4	2	3		1	5		
05	4	3	2	7	6	1	5	
05	5	4	1			2	3	
05	x		x	x				x (Roadway to narrow)
07				x				x (Log Trucks)
08								x (Tractor/Trailer traffic)
58	4		1	3	2		5	
61	5	2	3	4	6	1		
62								x (traffic run off pavement)

Survey Question 10: What is an average shoulder width in your District?

District 02	8 ft
District 03	3-4 ft
District 04	6 ft
District 04	4 ft
District 05	2-3 ft
District 05	0-6 ft
District 05	2 ft
District 05	2 ft
District 07	3 ft
District 08	3 ft
District 58	3 ft
District 61	2 ft
District 62	6 ft

Survey Question 11: Percentage of shoulders less than 2 ft. wide?

District 02	10%
District 03	< 5%
District 04	NA
District 04	90%
District 05	15%
District 05	65%
District 05	80%
District 05	NA
District 07	10%
District 08	10%
District 58	NA
District 61	10%
District 62	NA

Survey Question 12: How is a site selected for repair?

	Resident Reports	DOTD notices & reports	Overlay job	Upgrade to all shoulders	Numerous Rutting Issues	Other (Explain)
District 02	4	1	2		3	
District 03	2	1	3			
District 04	3	1			2	
District 04	3	1	2			
District 05		1	3	2		
District 05	1	2	6	5	3	4 (Political)
District 05	3	1	2			
District 05	x	x				
District 07		1	3	2		
District 08		1		3	2	
District 58		1				Safety Issue
District 61	3	2	1	4		
District 62		1				

Survey Question 13: Do you have special tools for shoulder repair like District 58 presented at the transportation conference?

District 02	No	
District 03	No	
District 04	No	
District 04	No	
District 05	No	
District 05	No	
District 05	No	
District 05	No	
District 07	No	
District 08	No	
District 58	Yes	Disc Blade attachment
District 61	Yes	Widening machine
District 62	Yes	New purchased attachment to function as motor grader

Survey Question 14: Strength requirement: Do you believe that 100 psi is an appropriate strength value for shoulder material?

Responses:

- "No. Too many large vehicles running off the roadway on the shoulders."
- "Yes. Shoulders are not designed for traffic. 100 PSI is sufficient."
- "It seems erosion and rutting from traffic will occur regardless of underlying strength of the material as rutting and erosion are a loss of the top of material and not base failures."
- "No. Cars/trucks go off the pavement regularly."
- "Yes, because shoulder is designed for emergency traffic – should have little traffic load."
- "No, most damage caused by farm trucks."
- "Yes."
- "Yes, should be as strong as the subgrade."
- "100 psi seems fine."

Survey Question 15: FHWA Everyday Counts Recommends utilizing a Safety Edge when applying an overlay to reduce edge drop-offs. Are you familiar with this technology? If so, how do you address shoulder material on the edge wedge? What material is utilized to level the shoulder after the overlay?

Responses:

- "Pull shoulder material over wedge."
- "Repair ruts and drop offs the same way as without safety edge." "Either aggregate or soil" [for material utilized]
- "Asphalt wedge" [for material utilized]
- "Yes. Built material against edge" " RAP or DuraPatch" [for material utilized]
- "This is being used on new construction overlays." " RAP" [for material utilized]
- "It's placed to the top of the wedge during construction, but it later erodes to the bottom of the wedge or below."
- "Yes. Overlay." "RAP." [for material utilized]
- "Yes. Shoulder wedges are required; most commonly RAP." [for material utilized]
- "Yes. Dress shoulder with dirt." "Dirt." [for material utilized]
- "Yes. Material is added or pulled up to the top of the asphalt wedge." "Stone, RAP." [for material utilized]

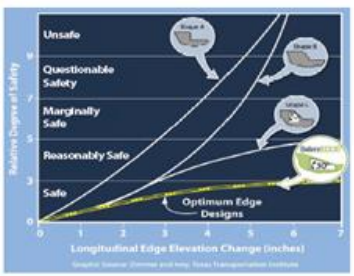
Appendix B

FHWA – EDC – Safety Edge^{SM} Brochure

FAQs

Why should I change my current process to include the Safety Edge?

The Safety Edge improves the short- and long-term safety of the roadway. Studies show that severe crashes may occur when a vehicle drops a tire over the edge of a nearly vertical pavement. The research shows that virtually all drivers can recover, even at high speeds, when the pavement edge is a 30-degree wedge. Using the Safety Edge also improves the durability of the pavement edge.

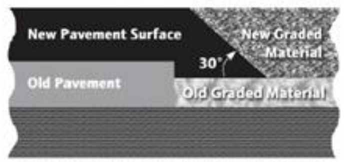


Do I need to modify my paving process to install the Safety Edge on asphalt?

Very few changes are needed. The key item is to add a specially designed shoe, per manufacturer's instructions, to the paver to create the Safety Edge. While paving, the shoe should be monitored and adjusted to keep the bottom edge of the device in contact with the road shoulder surface. Using the Safety Edge should not affect the rate of production.

How much will the addition of the Safety Edge cost per mile?

It will be almost negligible for hot-mix asphalt. It does depend somewhat on the specific design and construction parameters, but typically the process compacts asphalt that often otherwise would break off because it was loose. When measured, it has been calculated to be less than 1 percent additional asphaltic material.



This diagram shows how the Safety Edge is created during a repaving project. As the new graded material begins to settle or erode, the angled and more durable Safety Edge prevents a vertical edge from forming, making the pavement edge safer for drivers and cyclists.

Contact Information

For training or more information on this Every Day Counts Initiative, please contact your local FHWA Division Office.

To learn more about EDC, visit:
http://www.fhwa.dot.gov/everydaycounts

About Every Day Counts

Every Day Counts is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of our roadways, and protecting the environment.

innovation ingenuity Every Day Counts imagination invention

Publication Number: FHWA-SA-10-034

innovation ingenuity Every Day Counts imagination invention

The Safety Edge

A Pavement Edge Drop-Off Treatment

U.S. Department of Transportation
Federal Highway Administration

What is the Safety Edge?

The Safety Edge is a simple but effective solution that can help save lives by allowing drivers who drift off highways to return to the road safely. Instead of a vertical drop-off, the Safety Edge shapes the edge of the pavement to 30 degrees. Research has shown this is the optimal angle to allow drivers to re-enter the roadway safely. The asphalt Safety Edge provides a strong, durable transition for all vehicles. Even at higher speeds, vehicles can return to the paved road smoothly and easily. The FHWA's goal is to accelerate the use of the Safety Edge technology, working with States to develop specifications and adopt this pavement edge treatment as a standard practice on all new paving and resurfacing projects.

The Safety Edge is shown here in the main photo during construction. Upon project completion, the adjacent unpaved material should be graded flush with the top of the pavement (inset photo). The Safety Edge creates a more durable pavement edge and makes recovery from any future drop-off much easier and safer.

How Does It Work?

Drivers leave the paved road for many reasons. When steering the tires back onto the pavement, a vertical edge can make it difficult for a driver to safely re-enter the travel lane. Drivers may over-steer and lose control of the vehicle, leading to severe crashes. The challenge is that a drop-off is created during most paving projects. Even when the unpaved shoulder is regraded to eliminate the drop-off, the edge often becomes exposed within a few months. The edge also may deteriorate.

The Safety Edge is an effective solution to reduce pavement edge-related crashes, by shaping the edge of the pavement to 30 degrees using a commercially available device (called a shoe) that can be attached to the paver. The asphalt is extruded under the shoe, resulting in a durable edge that resists edge raveling. Research has shown this 30-degree shape allows drivers to re-enter the roadway safely.

After paving with the Safety Edge, the adjacent material should be regraded flush with the top of the pavement. This is considered the best practice, and provides the safest pavement edge. The difference is that when the edge becomes exposed, this shape can be more safely traversed than a vertical edge.

The shoe that creates the Safety Edge is a special edging device that asphalt paving contractors can install on new or existing resurfacing equipment.

Quick Facts

Sharp, steep pavement edge drop-offs can contribute to crashes.

- The Safety Edge can help decrease highway fatalities and serious injuries on our Nation's highways.
- Because the Safety Edge provides an additional level of consolidation on the edge, edge raveling is decreased. This contributes to longer pavement life.
- The Safety Edge involves minimal time and cost to implement. Typically, less than 1 percent additional asphalt is needed. The Safety Edge shoe, which creates the edge, can be installed on existing equipment.
- The Safety Edge also can be installed on Portland Cement concrete pavements. (Several differences should be considered. For more information, visit the Safety Edge Web site for details.)
- Best practice is to maintain a flush edge, so that no drop-off exists. The Safety Edge reduces the risk of drop-offs when maintenance forces cannot keep up with erosion or tire wear.
- Vertical and near vertical pavement edge drop-offs have been a factor in a substantial percentage of severe crashes in which vehicles leave the road, particularly on rural roads with unpaved shoulders. The Safety Edge reduces this problem, providing a safer transition back to the road.
- The Safety Edge is a safer design for motorcyclists and bicyclists, as well as motorists.

Case Study: Iowa Adopts Safety Edge Policy

Safety Edge treatment being applied during an asphalt overlay.

The Iowa FHWA Division and the Iowa Department of Transportation (IDOT) recently began working with counties to install the Safety Edge on projects with a history of roadway departure crashes. The Safety Edge was included at the county level on project plans or incorporated as change orders on already-let projects. During one of these county projects, the contractor's safety officer felt positive about the results because the Safety Edge potentially reduced the contractor's liability by providing immediate elimination of the vertical drop-off.

After seeing how easily even large vehicles could traverse the pavement edge without loss of control or damaging the edge, the county decided its typical practice of bringing in a gravel wedge before nightfall was not necessary when the Safety Edge was present. The results were so positive that IDOT decided to use the Safety Edge on one of its State paving projects on a narrow road. Since then, IDOT has decided to adopt the Safety Edge as standard practice across the entire State.

Pavement Edge Drop-Offs Can Contribute to Crashes

Roadway departures account for 53 percent of fatal crashes. State-level studies point to the life-saving potential of the Safety Edge. For example, researchers studying crashes in Missouri during 2002-2004 reported that pavement edges may have been a contributing factor in as many as 24 percent of rural run-off-road crashes on paved roadways with unpaved shoulders. This type of crash was twice as likely to include a fatality than rural crashes overall on similar roads.[1]

When a driver drifts off the roadway and tries to steer back onto the pavement, a vertical pavement edge can create a "tire scrubbing" condition that may result in over-steering. If drivers over-steer to return to the roadway without reducing speed, they are prone to lose control of the vehicle. The resulting crashes tend to be more severe than other crash types. The vehicle may veer into the adjacent lane, where it may collide with oncoming cars; overturn; or run off the opposite side of the roadway and strike a fixed object or overturn on a slope.

This is a typical diagram for a crash caused by tire scrubbing. The vehicle at left scrubbed the edge of the pavement, and when it returned, the driver overcorrected, lost control, crossed into the adjacent lane, and struck an oncoming vehicle. (Graphic source: AAA Foundation for Highway Safety)

Inexperienced drivers are not the only victims of tire scrubbing. Smaller, lighter vehicles have a harder time climbing a steep pavement edge. At high speeds, the climb is particularly dangerous. According to in-service evaluations, a vertical or near vertical drop-off of 2.5 inches or greater has been shown to pose a significant risk, while pavements built with the Safety Edge showed reductions of more than 5 percent of total crashes .

[1] Hallmark et. al: Safety Impacts of Pavement Edge Drop-Offs, AAA Foundation for Highway Safety, Washington, DC, September 2006.

Carlson Safety Edge^{SM} - brochure information [22]

Heat And Extrusion

Every Carlson Safety Edge comes standard with an electric heat element. These long lasting, state-of-the-art elements provide even and efficient heat to the attachment, enabling extrusion of material and sealing of the edge. Heating of the attachment also eliminates cold spots from forming, allowing for clean formed edges. Built with heavy duty components, including 450 Brinell rated steel, the Carlson Safety Edge outlasts similar attachments while ensuring consistent paving quality use after use.

Appendix C

DOTD Maintenance Activity Guide – Chapter "Shoulders"

ROAD MAINTENANCE

SHOULDERS

1) **Basis of Activity:**
   a) This is the repair of paved shoulders with hot and/or cold mix.
   b) To address the loss of surface material on paved shoulders.

2) **Threshold of Activity:**
   This activity is considered when:
   a) Loss of surface material approaching 3" but less than 5" in depth is considered routine; therefore, they are to be scheduled, during the normal planning cycle.
   b) Loss of surface material 5" or more in depth are to be addressed as soon as resources are available.

3) **Planning of Activity:**
   a) The following are recommended as needed to accomplish this activity:

Personnel:
6 to 12 Workers

Equipment:
1 to 2 Dump Trucks
1 Roller
1 Asphalt Distributor
1 Crew Cab Truck
1 Motor Patrol
1 Backhoe

Small Tools:
Rakes
Shovels
Picks
Brooms
Hand Tamps

Materials:
Asphaltic Tack
Bituminous Premix

4) Procedure for Activity:

a) Place traffic control devices as per "Maintenance Traffic Control Handbook".
b) Remove loose or broken material.
c) Tack area as required.
d) Place premix, level and compact.

5) Quality Assurance:

a) Finished area is to be approximately level with the surrounding surface.
b) The quality of work will be determined by visual inspection.
c) Foreman assures the quality of work.

6) Responsibility for Performing the Activity:
Parish Maintenance Admin Unit normally performs this activity.

7) Reporting of Accomplishment and Quality of Work Performed:
Foreman or other responsible person enters the work order into Agile Assets using the mobile device or computer.

a) This work order includes location, date, material (type & quantity), labor and equipment.

8) Accountability of Work Performed:
This is the responsibility of the Parish Highway Maintenance Superintendent.

1) Basis of Activity:

a) This is the displacement of shoulder material resulting in edge ruts, drop-offs, raveling and low shoulders.

b) Restoring shoulders to original grade and cross slope with or without material.

2) Threshold of Activity:
This activity is considered when:

a) Edge ruts or drop-offs approaching 3" but less than 5" in depth are considered routine; therefore, they are to be scheduled during the normal planning cycle.
b) Edge ruts or drop-offs 5" or more in depth, repair as soon as resources are available.

3) Planning of Activity:

a) The following are recommended as needed to accomplish this activity:

Personnel:
2 to 12 Workers

Equipment:
1 Pick-up Truck
1 Motor Grader
1 Shoulder Widener
1 to 10 Dump Trucks
1 Roller
1 Mechanical Broom
1 Widening Machine
1 Roller
1 Asphalt Distributor

Small Tools:
Level
Shovels
Rakes
Brooms

Materials:
Aggregate Type Materials
Recycled Asphaltic Concrete
Hot Mix
Cold Mix
Soil

4) **Procedure for Activity:**
   a) Place traffic control devices as per "Maintenance Traffic Control Handbook".
   With Material:
   b) Remove any undesirable material from the area.
   c) Clean area as needed.
   d) Apply tack coat as needed.
   e) Place new shoulder material to proper grade and slope.
   f) Compact new shoulder material.
   g) Sweep loose material off roadway as necessary.
   Without Material:
   b) Pulling existing material up against pavement surface or cut high shoulders.
   c) Blade excess material across shoulder.
   d) Compact material with motor grader/tractor wheels.
   e) Sweep loose material off roadway as necessary.

5) **Quality Assurance:**
   a) Finished area is to be approximately level with the surrounding surface.
   b) The quality of work will be determined by visual inspection.
   c) Foreman assures the quality of work.

6) **Responsibility for Performing the Activity:**
   Parish Maintenance Admin Unit normally performs this activity.

7) **Reporting of Accomplishment and Quality of Work Performed:**
   Foreman or other responsible person enters the work order into Agile Assets using the mobile device or computer.
   a) This work order includes location, date, material (type & quantity), labor and equipment.

8) **Accountability of Work Performed:**
   This is the responsibility of the Parish Highway Maintenance Superintendent.

CUTTING NON-PAVED SHOULDERS **ACTIVITY 430-05**
Unit of Measure: Linear Feet

1) **Basis of Activity:**
   a) Cutting high shoulders and hauling off excess material.
   b) Heaved or high shoulders are a result of grass growth build-up, soil, swelling or accumulation of waste material above level of edge of roadway.

2) **Threshold of Activity:**
   This activity is considered when:
   a) Roadway surface water is not draining properly due to shoulder being higher than the edge of roadway.
   b) This activity should be performed during the spring and summer months in order for the growth of grass on the shoulders.

3) **Planning of Activity:**
   a) The following are recommended as needed to accomplish this activity:

Personnel:
1 to 6 Workers

Equipment:
1 Motor Grader
1 Front End Loader
1 Dump Truck
1 Gradall
1 Pick-up Truck
1 Mechanical Broom
1 Excavator
1 Back Hoe

Small Tools:
Brooms
Shovels
Rakes

Materials:
N/A

CUTTING NON-PAVED SHOULDERS **ACTIVITY 430-05**
Unit of Measure: Linear Feet

4) **Procedure for Activity:**
   a) Place traffic control devices as per "Maintenance Traffic Control Handbook".
   b) Cut shoulders with motor patrol or excavator to existing pavement grade.
   c) Load excess material into dump truck with front-end loader if cutting with motor patrol or load directly into dump trucks when cutting with excavator.
   d) Sweep loose material off roadway as necessary.

5) **Quality Assurance:**
   a) Finished area is to be approximately level with the surrounding surface.
   b) The quality of work will be determined by visual inspection.
   c) Foreman assures the quality of work.

6) **Responsibility for Performing the Activity:**
   Parish Maintenance Admin Unit normally performs this activity.

7) **Reporting of Accomplishment and Quality of Work Performed:**
   Foreman or other responsible person enters the work order into Agile Assets using the mobile device or computer.
   a) This work order includes location, date, labor and equipment.

8) **Accountability of Work Performed:**
   This is the responsibility of the Parish Highway Maintenance Superintendent.

WIDENING NON-PAVED SHOULDER **ACTIVITY 430-09**
Unit of Measure: Linear Feet

1) **Basis of Activity:**
   a) The widening of non-paved shoulders.

2) **Threshold of Activity:**
   This activity is considered when:
   a) Areas where vehicles (primarily trucks) stray off the existing edge of non-paved shoulder, wiping out shoulder material and causing edge ruts or raveling.

3) **Planning of Activity:**
   a) The following are recommended as needed to accomplish this activity:

<u>Personnel:</u>
2 to 15 Workers

<u>Equipment:</u>
1 Mechanical Broom
1 Motor Grader
3 to 10 Dump Trucks
1 Widening Machine
1 Roller
1 to 4 Crew Cab Pickup Truck
1 Asphalt Distributer
1 Front End Loader
1 Back Hoe
1 Vibrator

<u>Small Tools:</u>
Shovel
Hot Mix Rake
Hammer Drill 3/4"
Lumber
Hammer
Dowels in baskets
Concrete Rakes
Floats
Straight Edge
Tine rake

<u>Materials:</u>
Recycled Asphaltic Concrete Pavement
Hot Mix
Nails
Measuring Tape
Concrete curing compound
Steel Deformed Reinforcement Bars
Concrete epoxy resin

WIDENING NON-PAVED SHOULDER **ACTIVITY 430-09**
Unit of Measure: Linear Feet

4) **Procedure for Activity:**
   a) Place traffic control devices and flagging personnel as per "Maintenance Traffic Control Handbook".
   b) Motor grader to plow out the desired depth and width of shoulder.
   (Aggregate Steps)
   c) Motor grader spreads the recycle hot mix into the hole excavated earlier.
   d) Roller machine compacts the recycle. A mechanical broom is used to clean the edge of road of aggregate left by the operation.
   e) Soil excavated by the motor grader is spread on the shoulder foreslope or removed.
   (Asphalt Steps)
   c) Shoulder widening machine places the hot mix into the hole excavated by the motor grader.
   d) Roller machine compacts the hot mix behind the widening machine. Rakes and brooms are used as needed to clean the road edge during operation.
   e) Soil excavated by the motor grader is spread on the shoulder fore slope or removed.
   (Concrete Steps)
   b) Trackhoe and motor grader excavate a trench next to the roadway at the desired depth and a width that is two feet wider than required.
   c) Carpenter personnel construct the outside wood formwork for the concrete pour, driving support stakes for the formwork. If the adjacent lane is closed and where practical, form enough trenches to allow for a concrete pour lasting a full workday.
   d) Drill holes and set longitudinal bars; set transverse joint dowel baskets per the applicable standard plans and details.
   e) Smooth and moisten the ground surface prior to pouring concrete. Pour concrete at the desired slump; vibrate the concrete to consolidate; screed to the desired cross-slope against the existing concrete slab; tine the surface during the initial set; cover with plastic or curing compound when complete.

5) **Quality Assurance:**
   a) The quality of work will be determined by visual inspection.
   b) Foreman assures the quality of work.

6) **Responsibility for Performing the Activity:**
   Parish Maintenance Admin Units normally perform this activity.

7) **Reporting of Accomplishment and Quality of Work Performed:**
   Foreman or other responsible person enters the work order into Agile Assets using the mobile device or computer.
   a) This work order includes location, date, material (type & quantity), labor and equipment.

8) **Accountability of Work Performed:**
   This is the responsibility of the Parish Highway Maintenance Superintendent.

OTHER SHOULDER MAINTENANCE **ACTIVITY 430-99**
Unit of Measure: Hours

Any shoulder maintenance activities that cannot be distributed to other maintenance activity codes.

Appendix D

DOTD FY 2017-2018 Shoulder Repair Costs

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G510 - WEST BANK MAINT/MAINT	14	$1,894.12	$0.00	$1,494.00	$0.00	$0.00	$3,388.12
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G520 - WEST BANK MAINT/MAINT	9	$694.05	$0.00	$935.50	$244.49	$0.00	$1,874.04
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G530 - EAST BANK MAINT/MAINT	48	$907.72	$5.75	$1,843.86	$480.00	$0.00	$3,237.33
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G540 - BRIDGE MAINTENANCE/MAINT	8094.998	$39,521.58	$0.00	$33,584.46	$5,195.59	$0.00	$78,301.63
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G550 - BRIDGE MAINTENANCE/MAINT	1244.999	$28,400.61	$0.00	$21,566.06	$412.53	$0.00	$50,379.20
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D02/G711 - DRAINAGE HOUMA/MAINT	82.5	$6,694.58	$0.00	$4,305.90	$95.00	$0.00	$11,095.48
Total		**9493.497**	**$78,112.66**	**$5.75**	**$63,729.78**	**$6,427.61**	**$0.00**	**$148,275.80**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D02/G510 - WEST BANK MAINT/MAINT	2305.002	$51,445.41	$0.00	$31,048.45	$41.86	$0.00	$82,535.72
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D02/G520 - WEST BANK MAINT/MAINT	14885.002	$22,477.28	$0.00	$21,346.64	$2,959.01	$0.00	$46,782.93
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D02/G530 - EAST BANK MAINT/MAINT	72	$2,556.76	$0.00	$4,302.10	$240.00	$0.00	$7,098.86
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D02/G540 - BRIDGE MAINTENANCE/MAINT	3978	$1,958.05	$0.00	$2,282.60	$195.00	$0.00	$4,435.65
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D02/G570 - EAST BANK MAINT/MAINT	1819	$867.63	$0.00	$728.00	$70.00	$0.00	$1,665.63
Total	**DISTRICT 02**	**23059.004**	**$79,305.14**	**$0.00**	**$59,707.79**	**$3,505.87**	**$0.00**	**$142,518.80**
						DISTRICT 02 TOTAL		**$290,794.60**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G510 - MAINTENANCE/RD MAINT	1491.405	$39,105.85	$0.00	$43,859.66	$15,064.00	$0.00	$98,029.51
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G520 - MAINTENANCE/RD MAINT	1	$300.39	$0.00	$282.75	$10.00	$0.00	$593.14
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G530 - MAINTENANCE/RD MAINT	73	$1,382.46	$0.00	$1,618.15	$288.57	$0.00	$3,289.18
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G540 - MAINTENANCE/RD MAINT	34	$1,541.60	$0.00	$2,643.40	$0.00	$0.00	$4,185.00

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G550 - MAINTENANCE/RD MAINT	461.25	$34,247.96	$0.00	$30,179.38	$4,742.49	$0.00	$69,169.83
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G560 - MAINTENANCE/RD MAINT	6362.882	$41,723.52	$0.00	$45,835.53	$14,053.36	$0.00	$101,612.41
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G570 - MAINTENANCE/RD MAINT	0.25	$79.64	$0.00	$36.90	$0.00	$0.00	$116.54
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G580 - MAINTENANCE/RD MAINT	123.66	$6,775.64	$0.00	$12,103.17	$1,276.60	$0.00	$20,155.41
Total		**8547.447**	**$125,157.07**	**$0.00**	**$136,558.94**	**$35,435.03**	**$0.00**	**$297,151.04**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D03/G520 - MAINTENANCE/RD MAINT	66.66	$1,427.08	$0.00	$3,190.60	$1,114.66	$0.00	$5,732.34
Total		**66.66**	**$1,427.08**	**$0.00**	**$3,190.60**	**$1,114.66**	**$0.00**	**$5,732.34**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G510 - MAINTENANCE/RD MAINT	90180	$7,744.03	$0.00	$10,918.25	$5,030.00	$0.00	$23,692.28
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G520 - MAINTENANCE/RD MAINT	8828.995	$28,230.52	$35.38	$29,199.23	$4,777.23	$0.00	$62,242.36
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G530 - MAINTENANCE/RD MAINT	15180.999	$23,220.79	$0.00	$27,432.70	$8,030.00	$0.00	$58,683.49
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G540 - MAINTENANCE/RD MAINT	10933	$8,530.57	$0.00	$11,983.77	$5,050.00	$0.00	$25,564.34
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G560 - MAINTENANCE/RD MAINT	11513.999	$5,501.97	$0.00	$3,589.70	$2,442.70	$0.00	$11,534.37
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G570 - MAINTENANCE/RD MAINT	15238	$5,509.08	$0.00	$8,427.35	$2,755.00	$0.00	$16,691.43
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G580 - MAINTENANCE/RD MAINT	60	$255.02	$0.00	$183.60	$7.10	$0.00	$445.72
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D03/G710 - DIST MAINT/RD MAINT	230	$2,062.40	$0.00	$3,437.50	$0.00	$0.00	$5,499.90
Total	**DISTRICT 03**	**152164.993**	**$81,054.39**	**$35.38**	**$95,172.10**	**$28,092.03**	**$0.00**	**$204,353.90**
						DISTRICT 03 TOTAL		**$507,237.28**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G510 - ARCADIA/CASTOR UNITS	2.87	$334.81	$0.00	$199.65	$289.97	$0.00	$824.43
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G520 - HOMER UNIT/MAINT	3086.936	$6,948.58	$0.00	$5,717.07	$1,653.94	$0.00	$14,319.59
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G530 - MINDEN/LETON UNITS	2907.001	$7,050.79	$1,125.93	$8,313.94	$2,587.00	$0.00	$19,077.66
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G540 - BOSSIER/PLAIN DEALING	1	$121.74	$0.00	$35.30	$20.17	$0.00	$177.21
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G550 - SHREVEPORT/VIDRINE UNITS	2187	$677.65	$0.00	$546.00	$0.00	$0.00	$1,223.65

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G560 - MANSFIELD UNIT/MAINT	428.498	$11,844.84	$23.29	$10,019.88	$2,085.00	$0.00	$23,973.01
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G570 - COUSHATTA UNIT/MAINT	60.2	$2,342.61	$0.00	$3,210.80	$362.00	$0.00	$5,915.41
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G710 - DIST ROAD FLEET/MAINT	25	$1,010.96	$0.00	$338.00	$0.00	$0.00	$1,348.96
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D04/G711 - DIST ROAD FLEET/MAINT	1823	$725.56	$0.00	$1,081.00	$0.00	$0.00	$1,806.56
Total		**10521.505**	**$31,057.55**	**$1,149.22**	**$29,461.64**	**$6,998.08**	**$0.00**	**$68,666.49**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D04/G520 - HOMER UNIT/MAINT	4	$45.19	$0.00	$88.25	$90.28	$0.00	$223.72
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D04/G530 - MINDEN/LETON UNITS	4	$512.58	$0.00	$339.13	$140.52	$0.00	$992.23
Total		**8**	**$557.77**	**$0.00**	**$427.38**	**$230.80**	**$0.00**	**$1,215.95**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G510 - ARCADIA/CASTOR UNITS	55421.5	$32,089.10	$0.00	$34,054.71	$24,254.90	$0.00	$90,398.71
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G520 - HOMER UNIT/MAINT	10326	$8,510.61	$0.00	$9,953.73	$7,380.20	$0.00	$25,844.54
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G530 - MINDEN/LETON UNITS	6316.3	$12,301.29	$0.00	$14,592.63	$1,038.34	$0.00	$27,932.26
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G540 - BOSSIER/PLAIN DEALING	2815	$5,686.01	$48.57	$3,373.46	$2,939.52	$0.00	$12,047.56
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G550 - SHREVEPORT/VIDRINE UNITS	32663.66	$31,935.20	$40.52	$24,851.82	$1,630.00	$0.00	$58,457.54
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G560 - MANSFIELD UNIT/MAINT	19529.999	$15,456.89	$0.00	$13,733.31	$2,920.00	$0.00	$32,110.20
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G570 - COUSHATTA UNIT/MAINT	20122.5	$16,698.72	$0.00	$18,113.16	$4,143.60	$0.00	$38,955.48
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G710 - DIST ROAD FLEET/MAINT	11976.288	$23,283.00	$65.58	$20,452.50	$0.00	$0.00	$43,801.08
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D04/G711 - DIST ROAD FLEET/MAINT	23107.82	$13,630.60	$0.00	$24,856.90	$0.00	$0.00	$38,487.50
Total	**DISTRICT 04**	**182279.067**	**$159,591.42**	**$154.67**	**$163,982.22**	**$44,306.56**	**$0.00**	**$368,034.87**
						DISTRICT 04 TOTAL		**$437,917.31**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G520 - MAINTENANCE/MONROE	28	$1,191.79	$0.00	$1,112.50	$361.01	$0.00	$2,665.30
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G530 - MAINTENANCE/MONROE	3920.771	$21,506.68	$267.32	$27,532.43	$1,440.00	$0.00	$50,746.43
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G540 - MAINTENANCE/MONROE	2267.498	$8,308.04	$0.00	$8,397.21	$2,051.60	$0.00	$18,756.85

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G550 - MAINTENANCE/MONROE	3	$131.53	$0.00	$188.50	$0.00	$0.00	$320.03
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G560 - MAINTENANCE/MONROE	1392.334	$2,681.20	$0.00	$3,070.30	$1,230.00	$0.00	$6,981.50
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G590 - MAINTENANCE/MONROE	2339.003	$11,951.01	$0.00	$8,782.16	$317.10	$0.00	$21,050.27
Total		**9950.606**	**$45,770.26**	**$267.32**	**$49,083.11**	**$5,399.71**	**$0.00**	**$100,520.40**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G540 - MAINTENANCE/MONROE	176	$603.04	$0.00	$532.40	$175.58	$0.00	$1,311.02
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D05/G550 - MAINTENANCE/MONROE	4353	$34,438.59	$0.00	$34,472.90	$41,470.52	$0.00	$110,382.01
Total		**4529**	**$35,041.63**	**$0.00**	**$35,005.30**	**$41,646.10**	**$0.00**	**$111,693.03**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D05/G540 - MAINTENANCE/MONROE	203.33	$1,990.36	$0.00	$2,993.76	$2,041.59	$0.00	$7,025.71
Total		**203.33**	**$1,990.36**	**$0.00**	**$2,993.76**	**$2,041.59**	**$0.00**	**$7,025.71**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G510 - MAINTENANCE/MONROE	41512	$20,757.45	$0.00	$27,312.61	$1,732.48	$0.00	$49,802.54
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G520 - MAINTENANCE/MONROE	31729.996	$30,126.87	$47.16	$27,033.76	$6,355.24	$0.00	$63,563.03
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G530 - MAINTENANCE/MONROE	5228.5	$18,180.57	$0.00	$20,974.19	$1,229.82	$0.00	$40,384.58
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G540 - MAINTENANCE/MONROE	14258.001	$11,142.43	$14.57	$13,922.22	$8,041.58	$0.00	$33,120.80
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G550 - MAINTENANCE/MONROE	305376	$61,944.04	$112.06	$53,946.91	$5,221.21	$0.00	$121,224.22
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G560 - MAINTENANCE/MONROE	1100	$2,960.54	$0.00	$2,544.00	$408.00	$0.00	$5,912.54
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G570 - MAINTENANCE/MONROE	6350	$6,292.65	$61.23	$8,151.55	$0.00	$0.00	$14,505.43
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G580 - MAINTENANCE/MONROE	377779.995	$51,948.10	$0.00	$25,766.55	$2,980.00	$0.00	$80,694.65
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G590 - MAINTENANCE/MONROE	17852.998	$15,769.69	$0.00	$16,168.26	$3,745.41	$0.00	$35,683.36
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D05/G710 - MAINTENANCE/M0NROE	143616	$27,746.35	$34.36	$75,376.81	$0.00	$0.00	$103,157.52
Total	**DISTRICT 05**	**944803.49**	**$246,868.70**	**$269.38**	**$271,196.86**	**$29,713.74**	**$0.00**	**$548,048.68**
						DISTRICT 05 TOTAL		**$767,287.82**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G510 - ROADWAY MAINT	9	$379.80	$0.00	$726.00	$90.00	$0.00	$1,195.80
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G520 - DERIDDER/MAINT	208	$3,344.62	$0.00	$2,995.10	$643.72	$0.00	$6,983.44

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G540 - JENNINGS/MAINT	30	$2,406.95	$0.00	$2,739.56	$280.00	$0.00	$5,426.51
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G580 - OBERLIN/MAINT	5105.5	$2,700.05	$0.00	$3,503.56	$170.00	$0.00	$6,373.61
Total		**5352.5**	**$8,831.42**	**$0.00**	**$9,964.22**	**$1,183.72**	**$0.00**	**$19,979.36**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G510 - ROADWAY MAINT	110.3	$3,876.88	$0.00	$3,705.99	$1,815.47	$0.00	$9,398.34
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D07/G520 - DERIDDER/MAINT	9	$1,966.25	$0.00	$2,489.98	$828.43	$0.00	$5,284.66
Total		**119.3**	**$5,843.13**	**$0.00**	**$6,195.97**	**$2,643.90**	**$0.00**	**$14,683.00**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D07/G510 - ROADWAY MAINT	6.69	$206.40	$0.00	$52.00	$53.71	$0.00	$312.11
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D07/G520 - DERIDDER/MAINT	2	$121.90	$0.00	$173.50	$64.45	$0.00	$359.85
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D07/G580 - OBERLIN/MAINT	2	$110.30	$0.00	$88.50	$21.71	$0.00	$220.51
Total		**10.69**	**$438.60**	**$0.00**	**$314.00**	**$139.87**	**$0.00**	**$892.47**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D07/G510 - ROADWAY MAINT	7115.7	$28,073.34	$122.53	$19,502.85	$3,516.95	$0.00	$51,215.67
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D07/G520 - DERIDDER/MAINT	23577	$10,862.11	$0.00	$14,786.17	$4,260.00	$0.00	$29,908.28
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D07/G540 - JENNINGS/MAINT	9295	$24,087.08	$0.00	$51,244.05	$14,092.39	$0.00	$89,423.52
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D07/G570 - CREOLE/MAINT	9049.001	$9,754.66	$0.00	$7,824.81	$3,746.14	$0.00	$21,325.61
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D07/G580 - OBERLIN/MAINT	3666.999	$3,283.44	$0.00	$2,089.46	$110.00	$0.00	$5,482.90
Total	**DISTRICT 07**	**52703.7**	**$76,060.63**	**$122.53**	**$95,447.34**	**$25,725.48**	**$0.00**	**$197,355.98**
						DISTRICT 07 TOTAL		**$232,910.81**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G510 - MAINTENANCE/ALEX	1234.78	$18,889.75	$0.00	$78,586.44	$12,355.72	$0.00	$109,831.91
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G520 - MAINTENANCE/MARKSVILLE	57	$7,343.66	$0.00	$3,905.47	$560.00	$0.00	$11,809.13
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G560 - MAINTENANCE/WINNFIELD	471	$23,033.87	$0.00	$34,025.80	$5,117.00	$0.00	$62,176.67
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G570 - MAINTENANCE/DRY PRONG	1503.012	$66,414.14	$0.00	$65,991.21	$23,291.41	$0.00	$155,696.76
Total		**3265.792**	**$115,681.42**	**$0.00**	**$182,508.92**	**$41,324.13**	**$0.00**	**$339,514.47**

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G520 - MAINTENANCE/MARKSVILLE	298	$8,588.96	$0.00	$4,174.08	$330.00	$0.00	$13,093.04
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D08/G530 - MAINTENANCE/MANY	800.001	$6,131.46	$0.00	$6,924.23	$9,705.38	$0.00	$22,761.07
Total		**1098.001**	**$14,720.42**	**$0.00**	**$11,098.31**	**$10,035.38**	**$0.00**	**$35,854.11**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G510 - MAINTENANCE/ALEX	63440	$6,466.05	$11.44	$19,898.76	$6,360.00	$0.00	$32,736.25
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G520 - MAINTENANCE/MARKSVILLE	26994	$11,055.10	$1,023.49	$16,832.77	$7,215.00	$0.00	$36,126.36
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G530 - MAINTENANCE/MANY	47800	$19,021.96	$0.00	$13,461.28	$16,318.32	$0.00	$48,801.56
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G540 - MAINTENANCE/LEESVILLE	17500.001	$20,299.50	$0.00	$21,475.28	$3,372.54	$0.00	$45,147.32
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G550 - MAINTENANCE/NATCHITOCHES	170342.998	$65,569.87	$1,268.10	$136,991.40	$49,750.00	$0.00	$253,579.37
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G560 - MAINTENANCE/WINNFIELD	1560	$2,095.69	$0.00	$3,178.80	$400.00	$0.00	$5,674.49
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G570 - MAINTENANCE/DRY PRONG	200	$968.12	$0.00	$1,553.00	$600.00	$0.00	$3,121.12
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D08/G710 - DISTRICTWIDE ROAD MAINTENANCE	3	$4,733.14	$507.11	$7,950.00	$0.00	$0.00	$13,190.25
Total	**DISTRICT 08**	**327839.999**	**$130,209.43**	**$2,810.14**	**$221,341.29**	**$84,015.86**	**$0.00**	**$438,376.72**
						DISTRICT 08 TOTAL		**$813,745.30**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D58/G530 - TENSAS PRH/MAINT	2215	$7,784.77	$0.00	$9,723.25	$1,077.50	$0.00	$18,585.52
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D58/G540 - CATAHOULA PRH/MAINT	1362.599	$4,753.00	$0.00	$2,447.71	$1,104.85	$0.00	$8,305.56
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D58/G580 - LASALLE PRH/MAINT	435	$15,637.18	$0.00	$23,621.46	$4,350.00	$0.00	$43,608.64
Total		**4012.599**	**$28,174.95**	**$0.00**	**$35,792.42**	**$6,532.35**	**$0.00**	**$70,499.72**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D58/G540 - CATAHOULA PRH/MAINT	68.999	$1,865.54	$0.00	$913.75	$446.56	$0.00	$3,225.85
Total		**68.999**	**$1,865.54**	**$0.00**	**$913.75**	**$446.56**	**$0.00**	**$3,225.85**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D58/G540 - CATAHOULA PRH/MAINT	78.65	$2,333.30	$0.00	$944.20	$675.19	$0.00	$3,952.69
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D58/G711 - ASPHALT	4057	$4,001.20	$1,268.59	$11,052.76	$25,351.67	$0.00	$41,674.22
Total		**4135.65**	**$6,334.50**	**$1,268.59**	**$11,996.96**	**$26,026.86**	**$0.00**	**$45,626.91**

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G510 - CALDWELL PRH/MAINT	18005	$11,892.61	$0.00	$22,849.50	$351.69	$0.00	$35,093.80
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G520 - FRANKLIN PRH/MAINT	85863	$17,981.65	$113.21	$27,885.95	$7,059.20	$0.00	$53,040.01
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G530 - TENSAS PRH/MAINT	3273628.999	$15,942.81	$0.00	$22,370.40	$2,580.01	$0.00	$40,893.22
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G540 - CATAHOULA PRH/MAINT	140021.864	$42,940.64	$0.00	$62,319.49	$25,275.00	$0.00	$130,535.13
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G550 - CONCORDIA PR/MAINT	117399.998	$62,638.29	$0.00	$82,175.25	$22,977.80	$0.00	$167,791.34
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D58/G580 - LASALLE PRH/MAINT	32029	$23,675.31	$0.00	$38,260.49	$6,756.95	$0.00	$68,692.75
Total	**DISTRICT 58**	**3666947.86**	**$175,071.32**	**$113.21**	**$255,861.08**	**$65,000.65**	**$0.00**	**$496,046.26**
						DISTRICT 58 TOTAL		**$615,398.74**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G510 - PRH MAINT CREW/UNIT 2	35	$1,819.84	$0.00	$1,653.54	$240.00	$0.00	$3,713.38
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G530 - PRH MAINT CREW/BR	320	$1,718.21	$0.00	$865.15	$1,015.22	$0.00	$3,598.58
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G540 - PRH MAINT CREW/BR	18	$1,065.55	$0.00	$1,030.20	$0.00	$0.00	$2,095.75
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G550 - PRH MAINT CREW/BR	5	$2,090.56	$0.00	$3,577.45	$260.00	$0.00	$5,928.01
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G560 - PRH MAINT CREW/UNIT 2	95	$2,808.24	$0.00	$2,745.00	$2,081.08	$0.00	$7,634.32
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G580 - PRH MAINT CREW/UNIT 2	317.543	$39,084.35	$0.00	$28,400.35	$9,698.66	$0.00	$77,183.36
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G590 - PRH MAINT CREW/BR	179.33	$1,340.68	$0.00	$2,521.79	$468.82	$0.00	$4,331.29
Total		**969.873**	**$49,927.44**	**$0.00**	**$40,793.48**	**$13,763.78**	**$0.00**	**$104,484.70**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G510 - PRH MAINT CREW/UNIT 2	1.002	$900.14	$0.00	$978.00	$783.87	$0.00	$2,662.01
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G540 - PRH MAINT CREW/BR	6	$769.30	$0.00	$682.50	$686.59	$0.00	$2,138.39
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G560 - PRH MAINT CREW/UNIT 2	345	$9,864.84	$0.00	$5,445.81	$2,887.83	$0.00	$18,198.48
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D61/G580 - PRH MAINT CREW/UNIT 2	2	$353.87	$0.00	$341.40	$0.00	$0.00	$695.27
Total		**354.002**	**$11,888.15**	**$0.00**	**$7,447.71**	**$4,358.29**	**$0.00**	**$23,694.15**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D61/G520 - PRH MAINT CREW/UNIT 2	29.48	$1,183.80	$0.00	$2,601.00	$262.08	$0.00	$4,046.88

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D61/G560 - PRH MAINT CREW/UNIT 2	4	$155.46	$41.10	$212.26	$305.15	$0.00	$713.97
Total		**33.48**	**$1,339.26**	**$41.10**	**$2,813.26**	**$567.23**	**$0.00**	**$4,760.85**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G510 - PRH MAINT CREW/UNIT 2	409.001	$8,130.03	$89.51	$7,959.80	$900.00	$0.00	$17,079.34
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G520 - PRH MAINT CREW/UNIT 2	17126.001	$3,971.50	$0.00	$4,232.60	$1,106.65	$0.00	$9,310.75
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G530 - PRH MAINT CREW/BR	1910	$7,360.39	$0.00	$6,079.30	$2,513.79	$0.00	$15,953.48
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G540 - PRH MAINT CREW/BR	11693	$4,532.35	$0.00	$5,202.44	$1,590.00	$0.00	$11,324.79
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G550 - PRH MAINT CREW/BR	101	$4,480.15	$0.00	$4,913.06	$790.00	$0.00	$10,183.21
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G590 - PRH MAINT CREW/BR	53697	$30,980.19	$94.50	$26,883.10	$2,867.44	$0.00	$60,825.23
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G710 - PRH MAINT CREW/BR	4025	$7,861.95	$0.00	$10,714.00	$0.00	$0.00	$18,575.95
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D61/G711 - PRH MAINT CREW/BR	405	$4,044.86	$0.00	$962.75	$0.00	$0.00	$5,007.61
Total	**DISTRICT 61**	**89366.002**	**$71,361.42**	**$184.01**	**$66,947.06**	**$9,767.88**	**$0.00**	**$148,260.37**
						DISTRICT 61 TOTAL		**$281,200.07**
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G530 - MAINTENANCE/MAINT	295.126	$27,131.53	$0.00	$19,133.96	$2,971.16	$0.00	$49,236.65
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G540 - MAINTENANCE/MAINT	53	$4,343.30	$0.00	$3,508.21	$1,643.86	$0.00	$9,495.37
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G570 - MAINTENANCE/MAINT	426	$19,344.74	$0.00	$15,867.75	$660.00	$0.00	$35,872.49
430-00 REPAIR OF NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G580 - MAINTENANCE/MAINT	64	$5,596.60	$0.00	$6,793.05	$660.00	$0.00	$13,049.65
Total		**838.126**	**$56,416.17**	**$0.00**	**$45,302.97**	**$5,935.02**	**$0.00**	**$107,654.16**
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G530 - MAINTENANCE/MAINT	533.95	$2,354.65	$0.00	$1,226.85	$2,022.89	$0.00	$5,604.39
430-01 PRE-MIX PATCHING - NON-PAVED SHOULDERS (YD2 - Square Yard)	D62/G580 - MAINTENANCE/MAINT	18.551	$3,109.41	$0.00	$1,433.88	$680.58	$0.00	$5,223.87
Total		**552.501**	**$5,464.06**	**$0.00**	**$2,660.73**	**$2,703.47**	**$0.00**	**$10,828.26**
430-02 PRE-MIX PATCHING - PAVED SHOULDERS (YD2 - Square Yard)	D62/G580 - MAINTENANCE/MAINT	3	$926.32	$0.00	$535.70	$196.69	$0.00	$1,658.71
Total		**3**	**$926.32**	**$0.00**	**$535.70**	**$196.69**	**$0.00**	**$1,658.71**
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D62/G530 - MAINTENANCE/MAINT	500	$1,235.04	$0.00	$1,593.00	$0.00	$0.00	$2,828.04

Activity	Admin Unit	Amount	Labor Cost ($)	K-Time Cost ($)	Equipment Cost ($)	Material Cost ($)	Other Cost ($)	Total Cost ($)
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D62/G540 - MAINTENANCE/MAINT	6195.002	$11,636.04	$0.00	$8,258.46	$0.00	$0.00	$19,894.50
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D62/G550 - MAINTENANCE/MAINT	2769.999	$6,187.19	$0.00	$7,766.44	$3,670.93	$0.00	$17,624.56
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D62/G555 - MAINTENANCE/MAINT	3400	$4,469.32	$0.00	$1,890.05	$1,080.00	$0.00	$7,439.37
430-04 RESTORING NON-PAVED SHOULDERS (LF - Linear Foot)	D62/G570 - MAINTENANCE/MAINT	10860.999	$30,183.76	$0.00	$24,822.93	$6,000.75	$0.00	$61,007.44
Total	**DISTRICT 62**	**23726**	**$53,711.35**	**$0.00**	**$44,330.88**	**$10,751.68**	**$0.00**	**$108,793.91**
						DISTRICT 62 TOTAL		**$228,935.04**
					GRAND TOTAL – ALL DISTRICTS			**$4,175,426.97**

Appendix E

DOTD Maintenance Manual, Chapter 7 [14]

Maintenance of Shoulders, Ditches and Small Drainage Structures

7.01 SHOULDERS GENERAL

Shoulders are defined as “That portion of the roadbed between the surfacing and the top of the side slopes of the roadbed.”

Shoulders are of three general types of construction:

- Turf: Earth or sod.
- Aggregate: Stone, Sand-Clay-Gravel, Recycled Portland Cement Concrete, Reclaimed Asphaltic Pavement, Crushed Slag, Shell or Gravel.
- Paved: Stabilized base and surfaced with surface treatment or bituminous hot mix.

All types of shoulders should be maintained reasonably smooth and flush with the edge of the surfacing. They shall be sloped away from the pavement to assure proper drainage of the roadbed.

Sections of shoulders that are used repeatedly as a turnout, such as at mailboxes and public roads, should be given special attention. Additional aggregate maybe placed in high use areas; however, a “patch work” effect should be minimized or avoided.

Reference should be made to the ACTIVITY CODE BOOK for standards of quality and quantity, work methods, production standards, equipment and personnel standards, etc.

7.02 TURF SHOULDERS

Turf shoulders should contain a sufficient amount of granular material for stability. Shoulders of this type tend to build up from vegetation, material for filling ruts, etc., and it will be necessary to blade the excess material off with the motor grader. If done at regular intervals, the quality of material bladed off will be insignificant and will present no problem if wasted on the slope.

If this dressing down has been postponed and a reasonably large quantity of earth and sod must be cut off, the material should be windrowed on the shoulder, picked up, and disposed of.

Blading is sometimes necessary to restore normal cross slope. Reseeding, fertilizing, and rolling are sometimes desirable to finish the surface and to restore compaction. This will assist and promote the growth of the grass to provide stability.

Reworking of shoulders of this type should, when possible, be done in the spring to allow ample time for natural resodding prior to the winter months. Turf shoulders are less expensive to maintain than aggregate shoulders because less blading and material is required.

7.03 AGGREGATE SHOULDERS

Shoulders constructed with stone, sand-clay-gravel, recycled Portland cement concrete, reclaimed asphaltic pavement, crushed slag, shell, or gravel provide better ride ability than those of sod. This type, however, tends to be worn down by traffic and the elements, and a rut will form at the edge of the pavement unless it is maintained regularly and properly. Maintaining the proper elevation and slope of a soil-aggregate shoulder is one important phase of maintenance.

Blading is required periodically. It reshapes or levels off the shoulder surfacing material to the proper grade and slope to provide good drainage; blading also removes excess materials and, at the same time, it brings material flush with the edge of the pavement. A good blading procedure is to pull the material to the edge of the slab on the first pass and, with the blade resting on the pavement edge and the motor grader or tractor tire at the edge of the pavement, to brush it out over the shoulder on the second pass. Such a procedure will cut off the high spots, fill in depressions, and leave the compacted shoulder flush with the pavement.

As material is lost from this type of shoulder, it should be replaced with additional material compacted and shaped to proper grade by a motor grader. Hand spreading and shaping is permissible for small isolated areas; however, a motor grader should be used when the area is extensive. Aggregate shoulders cost significantly more to maintain than turf shoulders because of the additional blading and material replacement requirements.

7.04 PAVED SHOULDERS

Problems encountered will be practically the same as those found in maintaining similar road surfaces. Paved shoulders should receive the same maintenance as prescribed for rigid or flexible pavements.

Whenever bituminous materials are applied on shoulders, special precautions must be taken to prevent the asphalt from being sprayed on the travel way, culvert headwalls, bridge ends, curbs, signposts, etc.

Patching bituminous-treated shoulders should be done in the same manner as patching roads with similar surfaces. Always bear in mind that surfaces should be patched with like materials. However, there is no objection to patching potholes in a surface-treated shoulder with a bituminous hot or cold mix.

7.05 SHOULDERS ADJACENT TO PRIVATE DRIVEWAYS

Maintenance in these areas should be in accordance with EDSM IV.1.1.2.

7.06 DITCHES – GENERAL

Reference should be made to the ACTIVITY CODE BOOK for standards of quality and quantity, work methods, production standards, equipment and personnel standards, etc.

Section 223 of the Highway Act reads as follows:

A. The department may construct canals, ditches, or drains sufficient in its judgment to properly drain any highway embraced in the system of state highways constructed or to be constructed through any lands of private person. The rights of way for these canals may be acquired in the same manner and on the same basis of compensation as provided for acquiring rights of way for highways.

B. No highways shall be occupied by drainage canals or ditches except those drainage canals and ditches excavated, operated, and maintained by the department for the purpose of draining the highway. The department may prohibit and prevent the connection of any drainage canal or ditch or any other system of drainage canals or ditches with the canals or ditches on a highway.

C. The agents and employees of the department under the direction of the Chief Engineer may enter and clean or improve by widening and deepening, if necessary in the opinion of the Chief Engineer, such natural and public drainage channels, ditches or canals that are adjacent to and form part of the drainage system of any state highway.

D. The blocking or impeding of any drainage ditch on, along, across a highway, or the blocking or impeding of any natural drainage crossed, by any means is prohibited.

E. When any drainage area discharges naturally across a highway through a bridge, culvert, or other device, the department may prohibit and prevent any action which, by discharging into such a drainage area additional water not naturally falling within that area, or which, by increasing the run-off in the channel or channels across the highway, will jeopardize the safety and integrity of the structures across the highway.

In view of the above and as per EDSM IV.1.1.1, the Department has absolute control of all ditches that are considered essential to the maintenance of the highway. Something you should be especially careful of is to **NEVER** allow anyone to block a ditch.

In accordance with Louisiana statute RS 48:385, no industrial wastes, sewage, effluent from septic tanks, nor any noxious or harmful matter, solid, liquid, or gaseous, shall be discharged upon the rights-of-way of State highways without having obtained prior approval of the Department of Health and Hospitals, and securing a permit from DOTD. (EDSM I.1.1.6)

7.07 ROADWAY DITCHES

As explained under Paragraph 4.06, Chapter IV, maintaining a satisfactory and efficient roadside ditch is an extremely important item of maintenance. All ditches and slopes should be maintained as nearly as possible to their original cross section. All side ditches, especially those in cut sections, should be kept clean and deep enough to keep standing water below the subgrade.

7.08 OUTFALL OR LATERAL DITCHES

Where the Department has secured easements and constructed lateral ditches, they should be kept clean and in a well maintained condition.

Where natural lateral ditches existed at the time the highway was built or improved and the Department has secured no easement, our policy is to deny any liability for keeping such ditches clean.

7.09 DISPOSITION OF MATERIAL FROM DITCHES

When ditches are cleaned, the material taken out of them should, where feasible, be used within our right-of-way. Material of this type can be used on low unsurfaced shoulders to build out narrow shoulders, or to fill washed out places on the slopes.

7.10 DRAINAGE STRUCTURES – GENERAL

Drainage structures covered in this chapter are of the smaller types designed to collect and remove water from the highway include:

- Small box culverts up to approximately 25 square feet opening.
- B. Pipe culverts both cross and side drains.
- Drop inlets, catch basins, and junction boxes.

7.11 ROUTINE INSPECTION

Drainage structures should be inspected by personnel responsible for maintenance of the sections of road involved. Inspection should be made during and immediately after heavy rains as this will be the time any defects in the system will show up. Removing dirt and debris from drainage structures should be done as needed; however, it becomes particularly important in the fall and early spring as heavy rains following these periods will require that they function to their full capacity.

Particular attention should be paid to the inlet and outlet ends of drainage structures and any scour or erosion noted should be corrected.

7.12 STORM SEWERS & CATCH BASINS

Proper maintenance of storm sewers, catch basins, and like facilities should include the following:

- Check open grates frequently to see if they are handling water directed to them. Remove all trash or debris from the grate to prevent clogging.
- Check for any structural defects or failures and make repairs. Any needed repairs of a major nature should be reported to higher authority.

7.13 PUMPING STATIONS

Particular attention shall be given to pumping facilities at underpasses as these installations are rather critical and any failure will cause inconvenience and possibly damage to motor vehicles.

Pumps should be kept in a good state of repair at all times. They should be tested and serviced periodically to ensure uninterrupted operation when needed. Close attention shall be given to check valves to eliminate failures at critical times. Sump pits, connecting lines, and catch basins shall be kept clean. Such facilities should be closely checked during heavy rains to observe if the facility is functioning as required.