DATA STRUCTURING FOR STATISTICAL ANALYSIS OF EFFECTIVENESS OF RUMBLE STRIPES ON HIGHWAY SAFETY

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Abstract: The United States (U.S.) heavily relies on the roadway infrastructure and a considerable number of highway vehicle miles are driven every year. Unfortunately, the number of fatalities is staggering with accidents becoming more frequent. Every year on U.S highways, there are over 700 fatalities, 40,000 injuries, and 52,000 property-damage-only accidents. Most of the 700 fatalities are due to roadway departures. On average, one roadway departure fatality occurs every 23 minutes, and a roadway departure injury occurs every 43 seconds. It is estimated that the annual cost of roadway departure is $100 billion. The Federal Highway Administration (FHWA) indicates that improvements in infrastructure have helped keep the fatalities number from increasing. However, higher traffic volumes have counteracted any real reductions in the number of fatalities due to roadway departure [Public Roads 2005].

Therefore, countermeasures to prevent or lessen the occurrence of roadway departures are important steps towards improving the safety of U.S. roadways. Roadway departure countermeasures must be designed to keep the motorists in lanes and on the roads, enable the drivers to recover and safely return errant vehicles to the roadway, and keep vehicle occupants from greater harm if a vehicle does leave the roadway.

This paper will focus on a project funded by the Mississippi Department of Transportation to determine the safety effectiveness of one roadway departure countermeasure, rumble stripes, in Mississippi. More specifically, this paper presents a focuses on the process implemented to restructure and consolidate the data obtained from multiple divisions and districts to be able to measure the impact of rumble stripes on highway' safety.

The content of this paper was later used as the foundation for statistical analysis. The results presented in this paper reveal the importance of inter division and district collaboration, the need to establish a common data structure to facilitate the exchange of information among divisions and districts and the importance of using real life applied research experiences for making the connections that facilitate engineering education.

Keywords: Rumble Stripes, Rumble Strips, Safety, Data, Structuring

INTRODUCTION TO ROADWAY FATALITIES

The United States (U.S.) heavily relies on the roadway infrastructure. As shown in Table 1 a considerable number of highway vehicle miles are driven every year. Unfortunately, the number of fatalities is staggering with accidents becoming more frequent, resulting in situations as the one depicted in Figure 1.

Every year on U.S highways, there are over 700 fatalities, 40,000 injuries, and 52,000 property-damage-only accidents [Mohan & Gautam, 2002]. Most of the 700 fatalities are due to roadway departures. On average, one roadway departure fatality occurs every 23 minutes, and a roadway departure injury occurs

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every 43 seconds. It is estimated that the annual cost of roadway departure is $100 billion [FHWA Resource Center 2006]

Figure 1. Crash Sample Picture [Public Roads 2004]

The Federal Highway Administration (FHWA) indicates that improvements in infrastructure have helped keep the fatalities number from increasing. However, higher traffic volumes have counteracted any real reductions in the number of fatalities due to roadway departure [Public Roads 2005].

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This paper will focus on a project funded by the Mississippi Department of Transportation to determine the safety effectiveness of one roadway departure countermeasure, rumble stripes, in Mississippi. More specifically, this paper presents a focuses on the process implemented to restructure and consolidate the data obtained from multiple divisions and districts to be able to measure the impact of rumble stripes on highway' safety.

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OVERVIEW OF THE MDOT DIVISIONS AND DISTRICT OFFICES AND THEIR COLLECTED DATA

Collecting, processing, archiving and retrieving data/information is a costly, demanding and necessary MDOT divisions and district offices. Each division and district office manages data/information in a different way for a variety of purposes to fulfill their primary responsibility/mission.

The first step in consolidating the data was to identify the divisions and district offices with needed data, and their responsibility/roles in collecting data. Figure 2 shows the information needed for this project and the particular MDOT division and/or district responsible for the data.

Then, the MDOT leader of this project contacted the divisions and district offices and provided a brief description of the project and the research team. The research team followed-up this initial contact by requesting a meeting with the representatives of the divisions and district offices to provide an overview of the project and initiate the turn-over of the data that had been collected by the divisions and district offices.

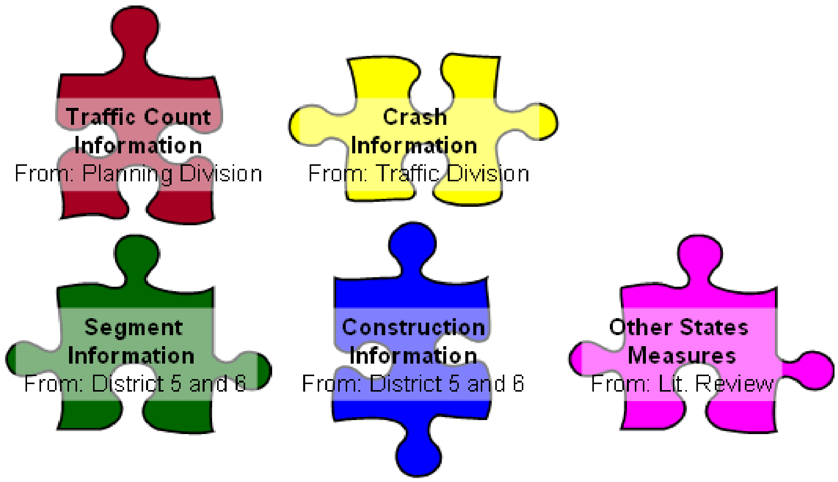

Figure 2. Data Needed for the Study and Sources

During, this initial meeting an informal interview was conducted with the divisions and district offices representative to explicitly identify the data that the divisions and district offices had already collected, the structure, and the media in which the data was stored as well as the retrieval means of the agency. Upon agreeing with the divisions and district offices concerning the data to be retrieved, a mechanism to transfer the data was established. As expected and evidenced below, each divisions and district offices used a different structure to archive the data. The following is a brief description of the data collected by different divisions and district offices involved in Rumble Strip/Stripes on Mississippi roads:

Districts 5 and 6 Data - Mississippi Department of Transportation (MDOT)

The MDOT District 5 and6 Office had all the construction documents developed by engineering prior to the construction as well as all the construction documents generated during the construction process. Given the diversity of the information handled by this office, there was no common structure in the data archived. This office handled descriptive, pictorial and numerical information. Information ranged from specific in nature (either by location or day) to very broad. One of the most valuable pieces of information provided by the District offices to the research team was the segments that could be used for this project as shown Table 1.

Table 1. Road Segments Included in the Study

ID	Project Name /District	Route	Starting Point (Mile Marker)	Ending Point (Mile marker)
1	US 98 in George County from the Greene County line to SR 63/Dist 6	US 98	Greene County line	SR 63
2	US 98 in Greene County from east of SR 198 in McLain to the George County line/Dist 6	US 98	Greene County from east of SR 198 in McLain	George County line
3	US 98 in Perry County from the Forrest County line east 7.5 miles/Dist 6	US 98	Forrest County line	East 7.5 miles into Perry County
4	US 98 in Forrest County from Interstate 59 to the Perry County line/Dist 6	US 98	Forrest County from Interstate 59	Perry County line
5	SR 589 in Lamar County from Haden Road north to US 98/Dist 6	SR 589	in Lamar County from US 98 north	to US 98
6	SR 589 in Lamar County from US 98 north to the Covington County line/Dist 6	SR 589	in Lamar County from US 98 north	to the Covington County line
7	SR 43 in Hancock County from SR 603 to Dummyline Road/Dist 6	SR 43	in Hancock County from SR 603	to Dummyline Road
8	SR 43 in Hancock County from Dummyline Road to Salem Road/Dist 6	SR 43	in Hancock County from Dummyline Road	to Salem Road

Continue.. Table 1. Road Segments Included in the Study

ID	Project Name /District	Route	Starting Point (Mile Marker)	Ending Point (Mile marker)
9	SR 43 in Pearl River County from Pinetucky Road to SR 26/Dist 6	SR 43	in Pearl River County from Pinetucky Road	to SR 26
10	US 11 in Pearl River County from Minkler Road to Charwood Drive/Dist 6	US 11	in Pearl River County from Minkler Road	to Charwood Drive
11	11 in Pearl River County from Charwood Drive to the north corporate limits of Poplarville/Dist 6	US 11	in Pearl River County from Charwood Drive	to the north corporate limits of Poplarville
12	Scooba-Noxubee County Line (7 ½ Miles of 4 lane) in Kemper County /Dist 5	US45	Scooba 0.644 North of	Noxubee County Line
13	Porterville-Scooba (9 ¾ Miles of 4 lane)/Dist 5	US45	Porterville	Scooba
14	Lauderdale to Porterville (10 Miles of 4 lane)/Dist 5	US45	Lauderdale	Porterville

Planning Division Data - Mississippi Department of Transportation (MDOT)

The MDOT Planning Division had placed a number of traffic recording devices around the state. The data/information collected from these devices was mainly handled/presented in pictorial and numerical form. One of the most valuable pieces of information provided by the Planning Division to the research team was traffic volume in the studied area. Figure 3 to Figure 6 shows a sample of type of traffic volume data obtained from the Planning Division.

	A	B	C	D	E	F	G	H
3	ID	Location	Date1	Date2	Time	Westbound	Eastbound	Total
4	1	1	Monday 1/30/06	Wednesday 2/1/06	0	44	30	74
5	1	1	Monday 1/30/06	Wednesday 2/1/06	100	41	25	66
6	1	1	Monday 1/30/06	Wednesday 2/1/06	200	33	23	56
7	1	1	Monday 1/30/06	Wednesday 2/1/06	300	53	24	77
8	1	1	Monday 1/30/06	Wednesday 2/1/06	400	84	68	152
9	1	1	Monday 1/30/06	Wednesday 2/1/06	500	123	83	206
10	1	1	Monday 1/30/06	Wednesday 2/1/06	600	138	142	279
11	1	1	Monday 1/30/06	Wednesday 2/1/06	700	177	212	388
12	1	1	Monday 1/30/06	Wednesday 2/1/06	800	195	232	427
13	1	1	Monday 1/30/06	Wednesday 2/1/06	900	207	263	470
14	1	1	Monday 1/30/06	Wednesday 2/1/06	1000	229	235	463
15	1	1	Monday 1/30/06	Wednesday 2/1/06	AM Peak 1100	245	233	478
16	1	1	Monday 1/30/06	Wednesday 2/1/06	1200	240	244	484
17	1	1	Monday 1/30/06	Wednesday 2/1/06	1300	258	273	531
18	1	1	Monday 1/30/06	Wednesday 2/1/06	1400	281	278	558
19	1	1	Monday 1/30/06	Wednesday 2/1/06	1500	278	272	550
20	1	1	Monday 1/30/06	Wednesday 2/1/06	PM Peak 1600	283	287	570
21	1	1	Monday 1/30/06	Wednesday 2/1/06	1700	252	271	523
22	1	1	Monday 1/30/06	Wednesday 2/1/06	1800	195	228	423
23	1	1	Monday 1/30/06	Wednesday 2/1/06	1900	153	153	306
24	1	1	Monday 1/30/06	Wednesday 2/1/06	2000	120	120	240
25	1	1	Monday 1/30/06	Wednesday 2/1/06	2100	105	95	200
26	1	1	Monday 1/30/06	Wednesday 2/1/06	2200	80	85	164
27	1	1	Monday 1/30/06	Wednesday 2/1/06	2300	62	50	112
28	1	2	Tuesday 2/11/03	Thursday 2/13/03	0	34	39	73
29	1	2	Tuesday 2/11/03	Thursday 2/13/03	100	39	57	95
30	1	2	Tuesday 2/11/03	Thursday 2/13/03	200	91	91	182
31	1	2	Tuesday 2/11/03	Thursday 2/13/03	300	149	109	258
32	1	2	Tuesday 2/11/03	Thursday 2/13/03	400	144	161	305
33	1	2	Tuesday 2/11/03	Thursday 2/13/03	500	167	195	362

Figure 3. A Sample of the Hourly Traffic Volume Data Received from Planning

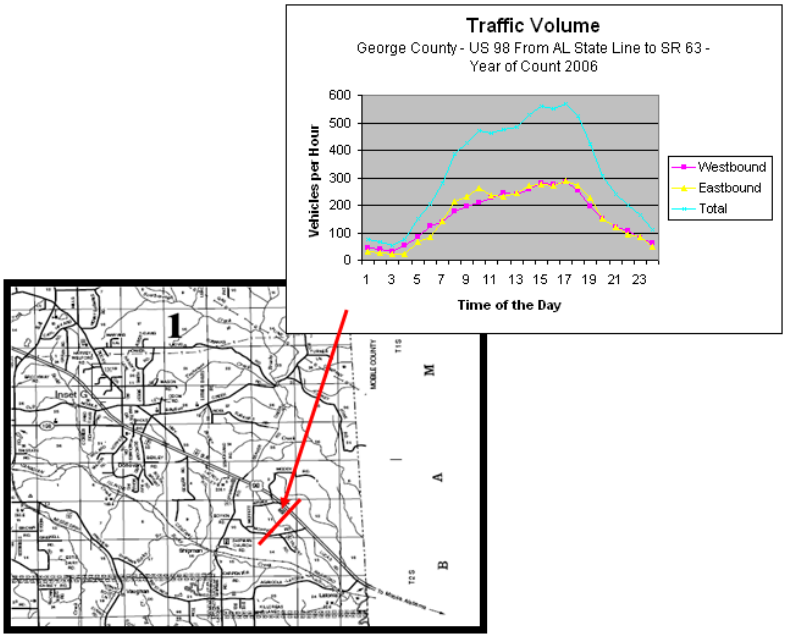

Figure 4. A Sample of the Hourly Traffic Volume Data Received from Planning

ID	Location #	Location Description	Route	County	AADT 1 Year	AADT 1 Volume	AADT 2 Year	AADT 2 Volume
1	1	From SR 63 to Greene CL	US 98	George	2002	6500	2005	7200
2	1	From Perry CL to Old Hwy 24	US 98	Greene	2001	8500	2004	8900
2	2	From Perry CL to Old Hwy 24	US 98	Greene	2003	10000	2006	8000
2	3	From SR 57 to Vernal River Rd	US 98	Greene	2003	7300	2006	6500
2	4	From Vernal River Rd to George CL	US 98	Greene	2003	7700	2006	7500
3	1	From Mahned Rd to SR 29	US 98	Perry	2003	10000	2006	9700
3	2	From SR 29 to SR 198	US 98	Perry	2001	8700	2004	10000
3	3	From SR 198 (W) to Eight Mile Rd	US 98	Perry	2003	8400	2006	8700
4	1	From I-59 to US 49	US 98	Forrest	2003	13000	2006	23000
5	1	From WPA to Old Hwy 24	SR 589	Lamar	2001	2000	2004	2000
6	1	From US 98 to Epley Rd	SR 589	Lamar	2000	4300	2004	5000
6	2	From Epley Rd to SR 42	SR 589	Lamar	2000	4200	2004	4300
6	3	From SR 42 to Covington CL	SR 589	Lamar	2000	1800	2004	2200
8	1	From Dummyline Rd to Pearl River CL	SR 43	Hancock	2003	4000	2006	6400
8	2	From Pearl River CL to Salem Rd	SR 43	Pearl River	2003	4000	2006	6400
9	1	From Pinetucky Rd to SR 26	SR 43	Pearl River	2003	1600	2006	1900
10	1	From Derby Whitesand Rd to SR 26	US 11	Pearl River	2004	1900	2006	3300
11	1	From Derby Whitesand Rd to SR 26	US 11	Pearl River	2003	1900	2006	3300
11	2	From SR 26 to North St	US 11	Pearl River	2003	6200	2006	6300
11	3	From North St to Lamar St	US 11	Pearl River	2003	4800	2006	5200
11	4	From Lamar St to Springhill Rd	US 11	Pearl River	2003	1500	2006	1700
14	1	From Old Lauderdale Rd to Kemper CL	US 45	Lauderdale	2003	3600	2006	3700
14	2	From Lauderdale CL to Dekalb-Porterville Rd	US 45	Kemper	2003	3600	2006	3700

Figure 5. Annual Average Daily Traffic over Time Received from Planning

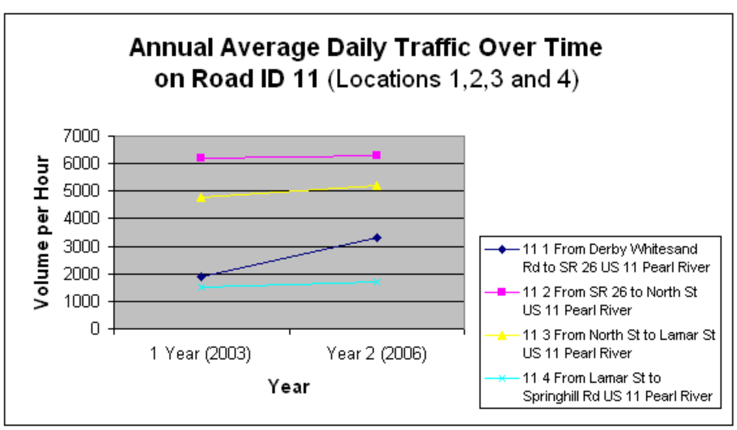

Figure 6. A Sample of the Annual Average Daily Traffic Over Time

Traffic Engineering Division Data – Mississippi Department of Transportation (MDOT)

The MDOT Traffic Engineering Division continuously collects safety related information. All information provided by this office to the research team was in electronic files. Several files were provided to the research team to analyze the safety conditions of the studied area. Although, all the data was electronically stored, given the diversity of the data, few (if any) of the fields were common to all the data stored. The most valuable pieces of information provided by the Traffic Engineering Division to the research team were the crash data. Figure 7 to 9 show a sample of crash data obtained from the Traffic Engineering Division.

	B	C	D	E	F	G	H	I
1	ROUTE I	SAMS ROUTE NAM	STREET NAME	INTERSECTING ROUTE	INTERSECTING STREET NAME	SAMS INT ROUTE N	COUNTYNAM	SAMS CITYNA
4	198	MS 198	LONDON ST	198	RATLIFF ST	MS 198	George [20]	LUCEDALE
5	063		SOUTH				George [20]	
6			WEST CAMELLIA ROAD		TWIN CREEK ROAD		George [20]	
7	26	MS 26	WINTER ST.	63	COWART STREET	MS 63	George [20]	LUCEDALE
8			026 WEST		HENERY COCHRAN		George [20]	
9			063		VENTURA DR.		George [20]	
10			063 SOUTH		WALMART PL.		George [20]	
11			063 WALMART		063	MS 63	George [20]	
12			063 WINTER ST.		AUTO ZONE		George [20]	
13			08 SUNSET DR		FAIRGROUNDS		George [20]	
14			098		HWY 63		George [20]	
15			1205 MILL ST EAST		FOUNTAIN LAKE RD		George [20]	
16			13185 HWY 613		HWY 613	MS 613	George [20]	
17			132 NATHANS LANE		TUT RD		George [20]	
18			13TH ST		GRAND AVE		George [20]	
19	163		163	163	WALMART PARKING LOT		George [20]	LUCEDALE
20			163 SOUTH		WALMART PARKING LOT		George [20]	LUCEDALE
21	163		163 SOUTH	26	WINTER ST	MS 26	George [20]	LUCEDALE

Figure 7. Sample Crash Information with Components and their Elements

	H	I	J	K	L	M	N	O	P	Q
1	COUNTYNAM	SAMS CITYNA	INTERSECTION DIS	INTERSECTION DIST U	INTERSECTION DIST DI	REPORTED DA	REPORTED TI	SAMS CRASH	VEHICLE COU	SAMS INJURY
4	George [20]	LUCEDALE	0.15	F	W	02/21/2006	12:05	1876478	2	
5	George [20]		0			09/03/2002	12:31	3970484	3	
6	George [20]					09/08/2005	05:40	1812614	1	
7	George [20]	LUCEDALE	200	F	S	10/08/2006	15:10	3470592	2	
8	George [20]		0			11/16/2002	12:41	4011012	2	
9	George [20]		0			09/10/2002	17:32	4027514	2	
10	George [20]		0			12/30/2003	13:04	4108442	2	
11	George [20]		0			03/04/2003	13:25	4032498	2	
12	George [20]		0			10/21/2002	11:48	3998293	3	
13	George [20]		500	F		01/13/2003	08:49	4013364	1	
14	George [20]		0			12/26/2002	03:45	4058866	1	
15	George [20]		0.08	M	S	10/27/2002	18:05	4021189	2	
16	George [20]		0.5	F	W	05/06/2005	14:20	3446778	2	
17	George [20]		300	F	N	10/06/2005	16:07	1812613	2	
18	George [20]					06/27/2005	19:17	3444162	2	
19	George [20]	LUCEDALE				05/04/2004	14:57	1768515	2	
20	George [20]	LUCEDALE				11/15/2004	11:25	1819635	2	
21	George [20]	LUCEDALE				08/22/2005	17:15	1819487	2	

Figure 8. Sample Crash Information with Components and their Elements

	Q	R	S	T	U	V	W	X
1	SAMS INJURY C	SAMS FATAL C	SAMS STAT INJURY SEVER	SAMS STAT DUI I	LIGHT CONDITION DES	ROAD CONDITION DESC	SAMS CRASH TYPE DESC	SAMS INTR
4			5		Daylight	Dry	Parked vehicle	
5	0	0	5		Daylight	Dry	Angle	
6	1		4		Dark-Unlit	Dry	Fixed Object	
7			5	0	Daylight	Dry	Hit and Run	
8	0	0	5		Dawn	Dry	Rear end slow or stop	
9	0	0	5		Daylight	Dry	Rear end slow or stop	
10	0	0	5		Daylight	Dry	Angle	
11	0	0	5		Daylight	Dry	Parked vehicle	
12	0	0	5		Daylight	Dry	Rear end slow or stop	
13	0	0			Daylight	Dry	Parked vehicle	
14	0	0	5		Dark-Unlit	Dry	Run off Road - Straight	
15	1	0	4		Dark-Unlit	Dry	Parked vehicle	
16			5	0	Daylight	Dry	Parked vehicle	
17			5		Daylight	Dry	Parked vehicle	
18			5	0	Daylight	Dry	Angle	
19			5		Daylight	Dry	Left turn same roadway	
20			5		Daylight	Dry	Rear end slow or stop	
21			5		Daylight	Dry	Rear end slow or stop	

Figure 9. Sample Crash Information with Components and their Elements

THE RESTRUCTURING AND CONSOLIDATION OF THE AVAILABLE DATA FOR THE ANALYSIS

The restructuring and consolidation of the data was driven by the main objective of the project which was to evaluate the effectiveness of Rumble Strip/Stripes on highway safety. To achieve this main objective, eleven specific statistical analyses were established aiming to determine if there was any correlation between the studied variables. The eleven analyses were as follows:

Analysis 1 – Rumble Stripe on the Road Vs. Number of Overall Crash
Analysis 2 – Rumble Stripe on the Road Vs. Number of Roadway Departure
Analysis 3 – Rumble Stripe Overtime Vs. Number of Overall Crash
Analysis 4 – Rumble Stripe Overtime Vs. Number of Roadway Departure
Analysis 5 – Lighting Conditions (Day/Night) Vs. Number of Overall Crash.
Analysis 6 – Lighting Conditions (Day/Night) Vs. Number of Roadway Departure
Analysis 7 – Road Conditions (Wet/Dry) Vs. Number of Overall Crash.
Analysis 8 – Road Conditions (Wet/Dry) Vs. Number of Road Way Departures.
Analysis 9 – Rumble Stripe on Road Vs -Crash Severity of Overall Crashes
Analysis 10 – Rumble Stripe on Road Vs Crash Severity of Road Way Departure
Analysis 11 – Rutting Condition Vs. Number of Overall Crash.
Analysis 12 – Rutting Condition Vs. Number of Road Way Departures.

Based on the eleven analyses, the following data was required:

- Construction starting and ending data of each studied segment
- Crashes in each of the studied segments
- Crash types/descriptions (Roadway departures, Overturn, etc)
- Crash dates
- Lighting conditions (Dark / Lighten)
- Road condition (Dry / Wet / Snow)
- Crash Injury Severity (Property Damage Only, Complain of Pain, Moderate, Life Threatening, Fatal)
- Rutting Condition

Upon comparing the required statistical analysis and the data available from the MDOT division and/or district, it was recognized that there were four distinctive data sets (as shown in Figure 10): 1- Segments Information, 2- Crash Information 3- Traffic Volume Information, and 4- Pavement Analysis.

Segments Information Data Set
Segment ID
Project Name
Route
Starting Point
Ending Point
Intersecting Roads
Construction Start Date
Construction Ending Date

Crash Information Data Set
Segment ID
Date
Crash type/description
Lighting conditions
Road conditions
Crash Injury Severity

Traffic Volume Data Set
Segment ID
Date
Traffic Count

Pavement Analysis Data Set
Segment ID
Date
Rutting Conditions

Figure 10. Data Sets for Analyses

The following is a brief description of the restructuring of the data from the different a MDOT division and/or district involved:

Restructuring Districts 5 and 6 Data - Mississippi Department of Transportation (MDOT) Data

The segment information received from District 5 & 6 (shown in Table 1) was modified to include all the elements of the "Segment Information" data set. Figure 11 shows a portion of the enhanced segment information with all the needed elements

ID	Project Name /District	Route	Starting Point (Mile Marker)	Ending Point (Mile marker)	Desc	Map	Intersecting Roads	Project Dates (Start)	Project Dates (Ending)	BEFORE Data Traffic Flow and Incidents (Years)	AFTER Data Traffic Flow and Incidents (Years)
1	US 98 in George County from the Greene County line to SR 63/Dist 6	US 98	Greene County line	SR 63	has rumble stripe.		McInnis Ln - Billy Knight Rd Ben Eubanks Rd. Cutoff Rd. Merril Rd. Unknown Rd. Nicholson Ln N Bexley Rd. S Bexley Rd. Darlenes Ln Unknown Rd. Main St. – CF Eubanks Rd. Ernest Pipkins Rd.	04/08/2004	09/31/2004	From 01/01/2002 To 03/31/2004	From 10/01/2004 To 12/31/2006
2	US 98 in Greene County from east of SR 198 in McLain to the George County line/Dist 6	US 98	Greene County from east of SR 198 in McLain	George County line	has a rumble strip		Old MS 24 Unknown Rd. Hwy 57 Dewey McInnis Rd. – Jim Powell Rd. Midway Church Rd. Merritt Rd. Gatlin Creek Rd. Harry Eubanks Rd. Miller Loop Tom Miller Rd. Merritt Rd. Miller Loop Oscar Howard Rd. – Vernay Rd.	04/10/2003	11/28/2003	From 01/01/2001 To 03/31/2003	From 12/01/2003 To 12/31/2006

Figure 11. Enhanced Segment Information

The segment id, project name, district, route, starting and ending points were used as received without re-structuring. Intersecting roads were found and added to the information to facility the collection of the crash and traffic volume information. The project start and ending date were used to identify the before and after periods to collect and perform comparative analysis.

The date field in the received data was defined as "Ordinal" because it represented an intrinsic order. Additionally, the year and month were extracted from the date and defined as "Ordinal" with values between 1 and 12 representing each month of the year as shown in Figure 12 The month information was extracted allow further analysis based on the month.

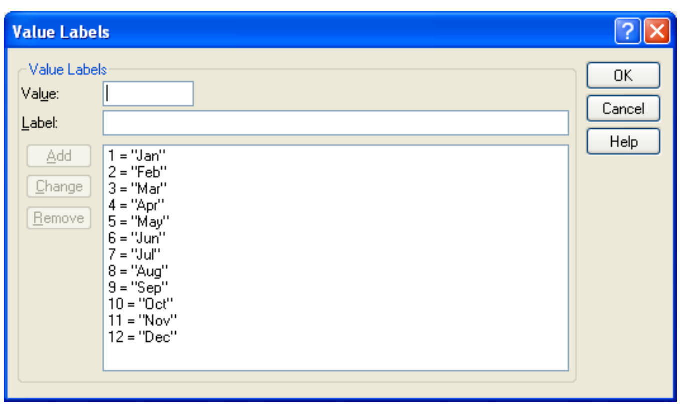

Figure 12. Month Values for Statistical Analysis

Restructuring Planning Division Data - Mississippi Department of Transportation (MDOT)

The traffic volume information received from the MDOT Planning Division (shown in Figure 4-4) was re-structured to two variables: Time of the Day and Volume. The variable Time of the Day was defined as "Ordinal" and since the "Volume" variable represented magnitude it was defined as "Scale".

The Time of the Day variable was assigned a number between 0 and 23 representing a 24 hours clock which begins at midnight (which is 0000 hours). The Volume variable was organized by direction (bound) of the traffic and contained the number of vehicles per hour that passed each studied segment each hour. Figure 4-13 shows a sample a 24 hour count.

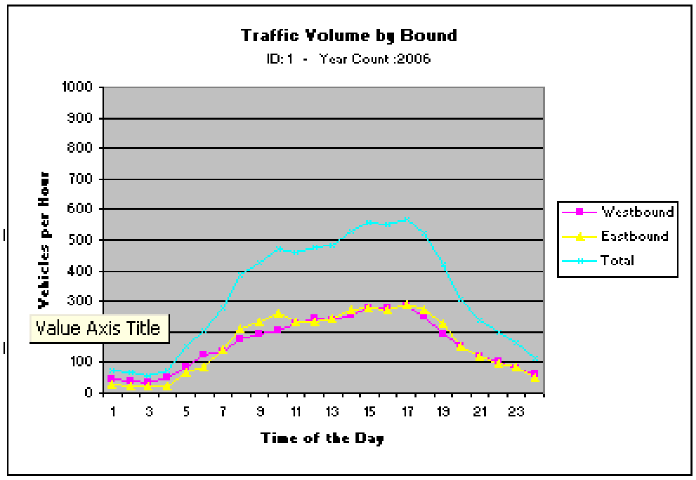

Figure 13. Sample 24 hour Traffic Count

Restructuring Traffic Engineering Division Data - Mississippi Department of Transportation (MDOT)

The crash information received from the Traffic Engineering Division (shown in Figure 9 to 11) was restructured to six variables: Segment ID, Date, Crash type/description
Lighting conditions, Road conditions and Crash Injury Severity.

The variables Date was defined as "Ordinal" as previously described based on the variable data new variable named Construction Status was created and received a value between 0 and 2, where 0 was assigned to "During" (Construction), 1 was assigned to the "Before" (construction), and 2 was assigned to the "After" (Construction) as shown in Figure 14.

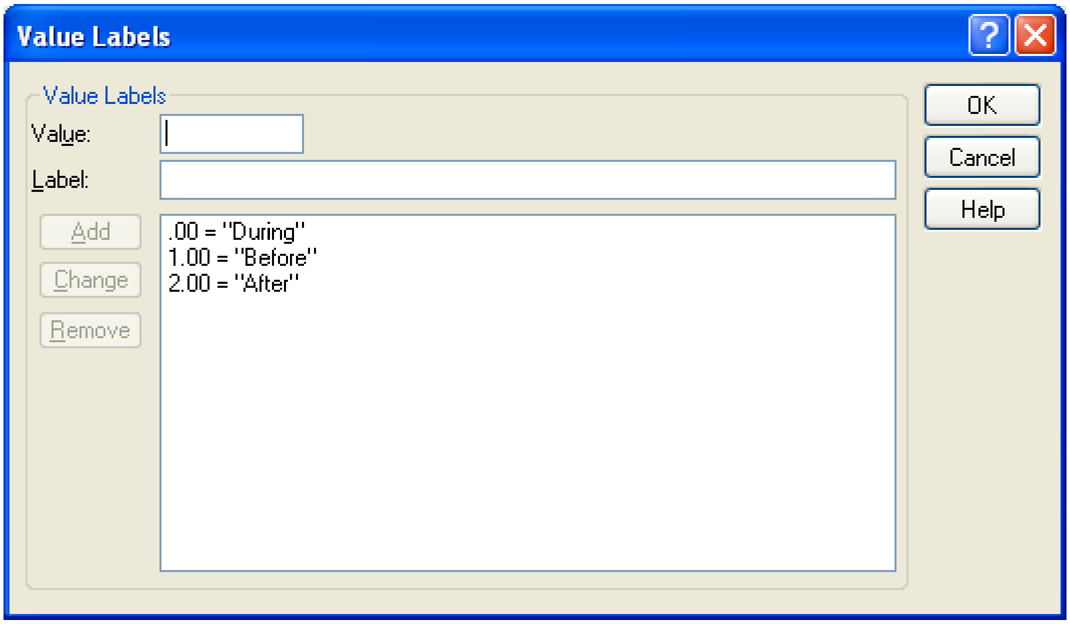

Figure 14. Construction Status for Statistical Analysis

The variable Crash type/description was defined as “Nominal” because the data values represented categories with no intrinsic order. The Crash type/description variable received a value between 1 and 4 for (Run Off Road and Overturn) as shown in Figure 15 and all other crash type/description received no value in this variable.

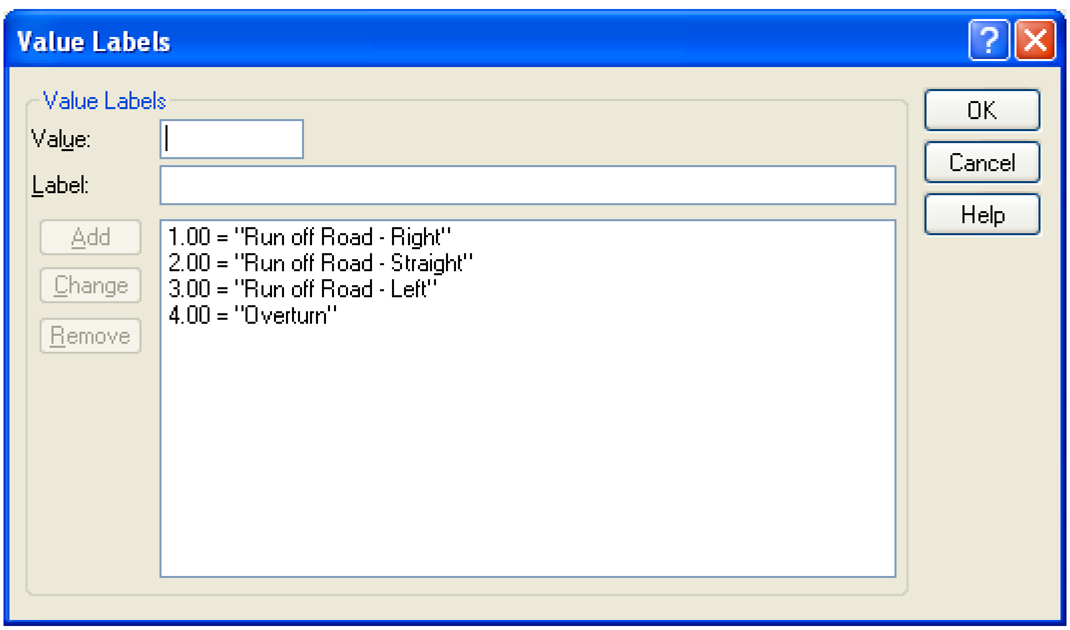

Figure 15. Crash Type/Description for Statistical Analysis

The lighting condition was defined as “Nominal” because the data values represented categories with no intrinsic order. This variable received a value between 1 and 5 as shown in Figure 16.

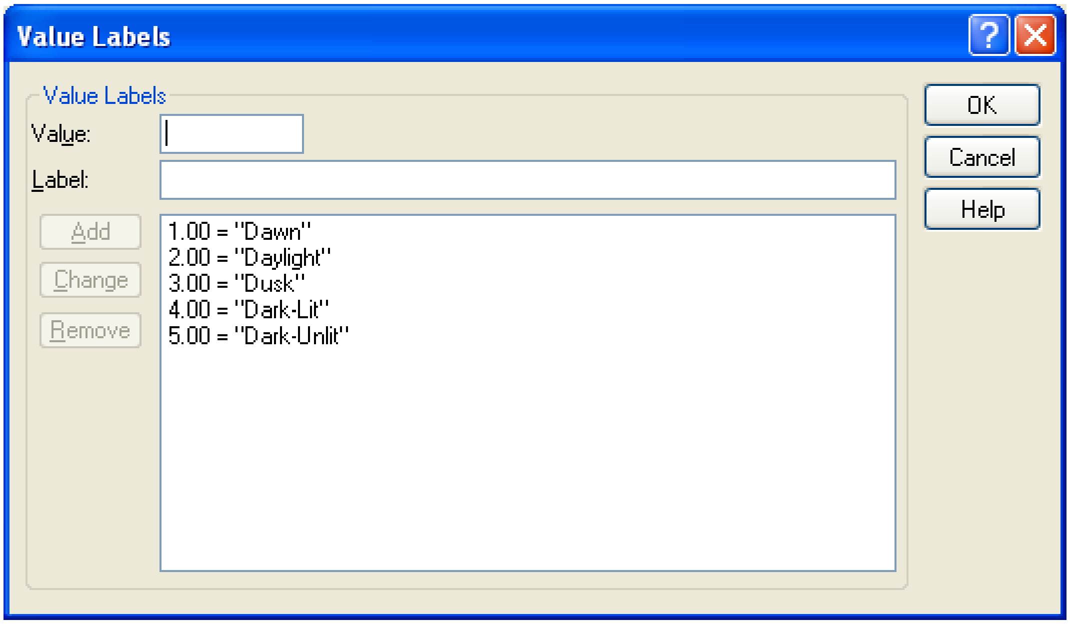

Figure 16. Lighting Conditions for Statistical Analysis

The Road Conditions and Crash Injury Severity were also defined as "Nominal" with the value shown in Figure 17.

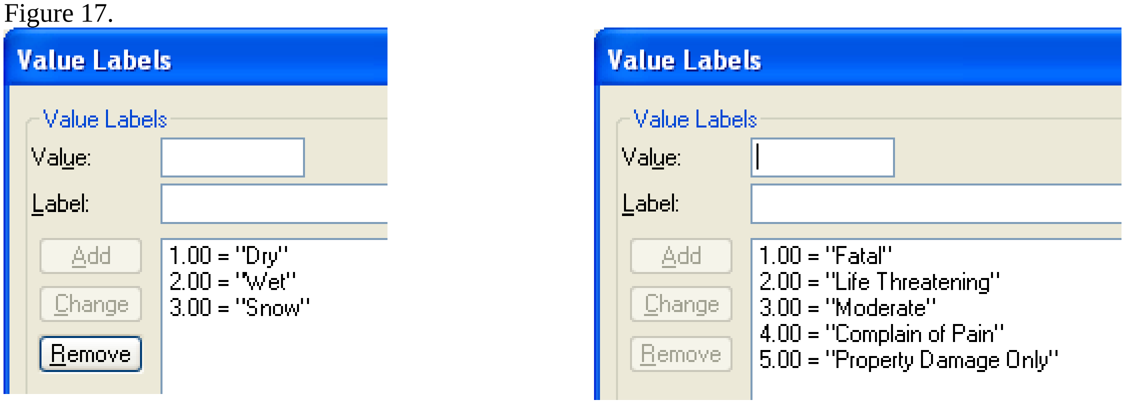

Figure-17. Road Conditions and Crash Injury Severity for Statistical Analysis

Consolidation of All the Data

After restructuring the information received from each divisions and districts, the next step was to consolidate (or integrate) all of the data sets into one master data file. The variables: "Segment ID" and "Date" were identified as the common field among all the data sets. The dashed arrows pointing in two directions, in Figure 18 show these two variables common among all the data sets. Therefore, "Segment ID" and "Date" were used as key fields and the data from all the data sets was copied into one master data set with the fields shown in Table 2. As a result of this consolidation, a total of 1564 records were integrated into the master data set as shown in Table 3.

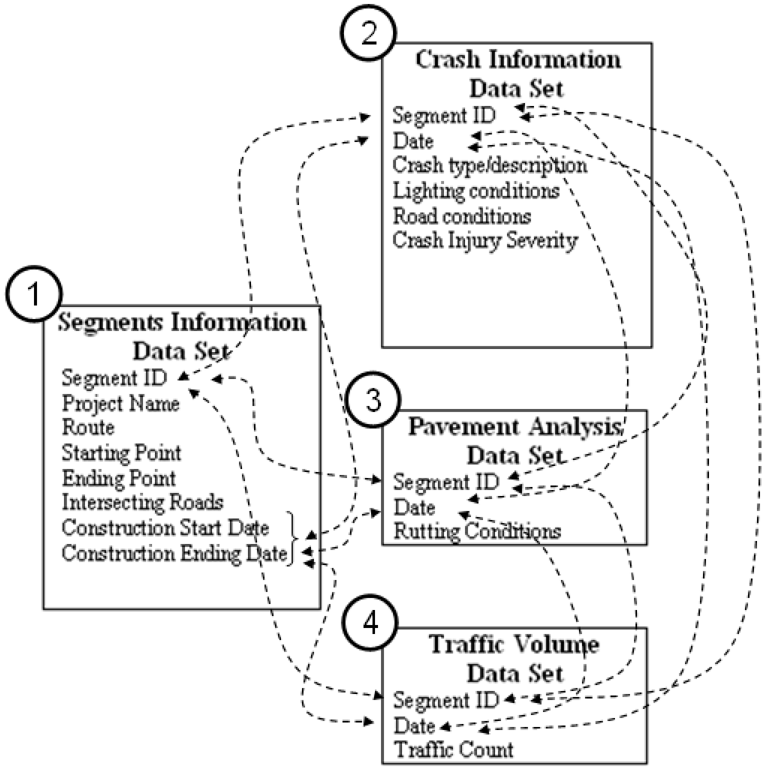

Figure 18. Data Set Consolidation

Table-2. Date Set Variables, Type of Variables and Value Codes

Variable	Type of Variable	Value Codes	Source
Segment ID	Nominal	Not Applicable	1,2,3,4
Before Date	Ordinal	Not Applicable	1
After Date	Ordinal	Not Applicable	1
Accident Year	Ordinal	Not Applicable	Generated
Accident Month	Ordinal	1: Jan → 12: Dec	Generated
Months Before	Scale	Not Applicable	Generated
Months After	Scale	Not Applicable	Generated
Crash Type/Description		1: Run off Road – Right 2: Run off Road – Straight 3: Run off Road – Left 4: Overturn	2
Lighting Conditions		1: Dawn 2: Day Light 3: Dusk 4: Dark-Lit 5: Dark-UnLit	2
Road Conditions	Nominal	1: Dry 2: Wet 3: Snow	2
Crash Injury Severity	Ordinal	1: Fatal 2: Life Threatening 3: Moderate 4: Complain of Pain 5: Property Damage	2
Traffic Count	Scale	Not Applicable	4
Rutting Conditions	Scale	Not Applicable	3
Construction Status	Ordinal	0: During 1: Before 2: After	Generated

Table 3. Number of Records Restructured From the Data Sets

Source	Records after Restructuring
Total Records in the Master Data Set	1564

LESSONS LEARNED

The use of rumble stripes to improve the safety of drivers is of paramount importance for all the Mississippi Department of Transportation Divisions and Districts that graciously share their information with the research team. It is important to highlight that all Divisions and Districts were very willing to collaborate in the data consolidation process. However, collecting, archiving and retrieving information was not a main priority for any of these Divisions and Districts. Additionally, no general guidelines for data structuring was communicated among the Divisions and Districts. Therefore, it is evident that input into the data gathering process before the data is collected rather than after the fact, could greatly improve the process of accessing the impact of other safety programs currently implemented by MDOT. By defining the data to be collected, the method for collecting the data, the formatting of the data, the timeframes for collecting the data (before, during and after construction), all the participating Divisions and Districts would be able to share information and to demonstrate the impact of their performance to stakeholders. It was also learned that the restructuring of the data was of paramount importance for the consolidation of the data. Identifying the variable types and the possible values for each variable facilitated the comparison of variables to decide whether or not to use the same variable or to create a new variable for each data set. The identification of common data components among the data set was critical for the consolidation of all data sets. The use of the common data components to transfer data among data sets proved to be an effective way to complete the data sets with information from another data set (another agency).

The research team was able to combine, reform, integrate and analyze the data to produce quantifiable results.

Finally, although each division and district participating in this project had a different mission and collected different data, it is possible to create a data structure that allow these divisions and districts to share common data for common purposes and reduce the cost of the data collection efforts.

SUMMARY

Maintenance and construction programs are arguably one of the most important functions of States DOT (as represented by the percentage of the budget invested). MDOT through the Traffic Engineering Division is commitment to improve Mississippi highway safety. MDOT has invested valuable resources to implement a series of safety improvement programs such as the "Rumble Stripes" program. Despite MDOT's high commitment and efforts to improve highway safety, MDOT does not know the impact of the "Rumble Strip" program in reducing crashes. In other words, MDOT lacks quantifiable evidence that demonstrates the effectiveness of this program. This paper focused on the process implemented to structure the data obtained from multiple Divisions and Districts used to measure the effectiveness of the "Rumble Stripes" program. The content of this paper was them used as the foundation for the statistical analysis.

During the construction period, there are temporary traffic disruptions, which increase the number of accidents with associated deaths and injuring thousand of people every year. One of the special measures implemented in construction zones by several departments of transportation around the United States to reduce the number of crashes is the increase of law enforcement surveillance. This chapter focuses on the process implemented to structure the data obtained from multiple agencies to be able to measure the impact of law enforcement in construction zones. The content of this chapter was later used as the foundation for the statistical analysis.

The results presented in this chapter reveal that segmentation of the data and the structure of the data is a major barrier to assess the impact of law enforcement surveillance in construction zones. Due to the willingness of the Divisions and Districts to collaborate in the data consolidation process, it was possible to restructure and consolidate the data to perform statistical analysis. It is also expected that the restructuring process presented in this chapter could be used by other research teams to perform similar analysis of law enforcement surveillance or others methods implemented around the U.S. to reduce the deaths and injuries in road construction zones.

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