Accident Data as a Tool for Highway Risk Management

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Transportation agencies at all levels of government have experienced a rash of suits involving alleged negligence. The devastating increase in the number of suits and in the magnitude of financial losses has been overwhelming to many of these transportation agencies. In an effort to minimize these losses, many agencies have organized "risk management" programs. The risk in this case is the probability that the agency will be sued following a highway accident. If all highway accidents could be eliminated, the risk would become zero. Because this is impossible, the next most desirable option is to reduce the number of accidents (especially high-severity collisions) and thus reduce the probability of being sued. Accident data offer an excellent technique for reducing risk by identifying those sites that are of greatest risk to the motorist and thus most deserving of safety treatment. In this paper, several innovative accident data programs are described, and sample computer listings of accident data for several of them are presented. The federal aid safety program, accident inventory listings, high-accident locations, wet pavement accidents, daylight-dark accidents, roadway defect investigations, high-exposure accidents, railroad grade crossings, roadside objects, and bridge collisions are a few of the topics included.

America's romance with the automobile has recently taken an ugly turn, and transportation agencies at all levels are suffering the legal consequences. Why are agencies currently so vulnerable to litigation? How can they protect themselves in the future? In this paper, a promising risk-reduction procedure is offered as a solution.

A NATION ON WHEELS

The classic American love affair may be condensed to two simple elements, a man and his car. We have become a people born to travel and have come to feel that we have a "constitutional right" to our individual mobility. Fifty years ago there was an average of almost five people in every automobile on the road. For today's typical trip to work, there are only 1.3 of us per vehicle (*1*). Other data show that we had 159 million drivers in 176 million vehicles traveling 1.8 trillion miles in 1986 (2). That means that for every five men, women, and children in the United States, there were four registered vehicles. Over 70 percent of the American population, regardless of age, was registered to drive. Americans love to travel, and they spend an average of $3,000 per year on each automobile in this country (*3*).

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Disadvantages of Travel Mania

There are dark sides to this frenzy for travel. First, 45,600 were people killed on our highways in 1985, and an additional 1.7 million suffered disabling injuries (*4*). Second, steady increases in vehicular travel have been the norm for almost 50 years, and the public has exerted an ever-increasing demand for more, better, and safer roads. Almost all state transportation agencies are in a mad scramble to find sufficient funds to maintain existing roads, provide new roads, and improve the safety of their highways.

Growing Threat to Transportation Agencies

Transportation agencies are under the shadow of another dark cloud. The specter of tort liability has raised an unparalleled threat of financial devastation in the courtroom. The number of suits against transportation agencies and the consequent financial losses have skyrocketed. Our nation's inherent belief in the right to travel is being paralleled by another inherent belief, the right to sue.

A few examples will illustrate the severe nature of the problem. Almost all states enjoyed sovereign immunity in the 1960s, but over the next 20 years, this status was overturned in the majority of states. Today, only a handful of states still enjoy

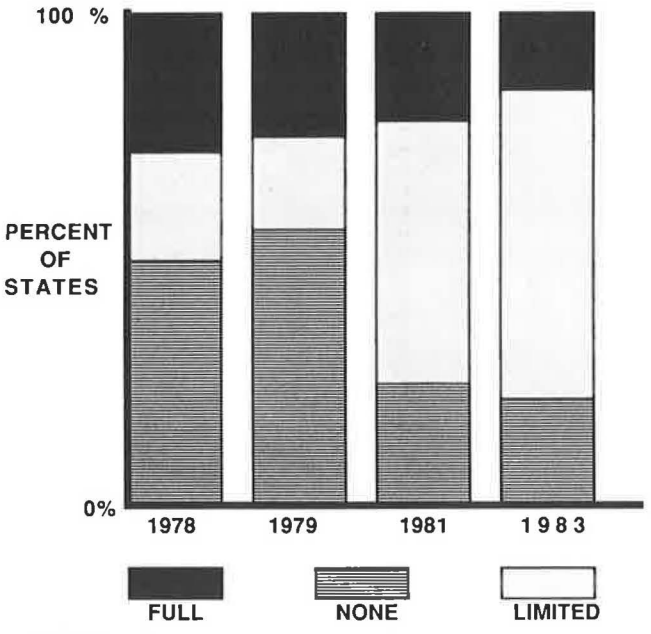


FIGURE 1 Survey of sovereign immunity (*5*).

sovereign immunity, although many of those who lost it have since found ways to return to limited immunity (claims courts, etc.). Figure 1 indicates the trend over several years, with more and more states being forcefully converted from full immunity to limited or none. In 1983 an AASHTO survey estimated pending tort liability claims reported by 40 states at almost $7 billion (5). Almost 7,000 suits were filed in 1982 alone, as shown in Table 1.

In the 5 years after loss of sovereign immunity, the Pennsylvania Department of Transportation spent $80 million defending and settling tort liability actions. By 1985, the amount was more than $20 million for a single year. A similar story may be told about Louisiana. In 1984, initial judgments and settlements against the Department of Transportation (LDOT) reached $38 million, while interest on these losses cost another $14 million (fortunately, several of these judgments were overturned on appeal). Table 2 gives a very revealing look at the nature of the claims against LDOT during 1979–1983. The types of suits in Louisiana are to a large extent representative of those all across the nation.

The usual assertion in these suits is that the governmental unit has failed to perform its duty in a reasonable manner, that is, it was guilty of negligence. On the basis of the data in Table 1, it would seem that 157 Louisiana plaintiffs have claimed that a lower shoulder or shoulder dropoff constituted a hazardous condition that caused or contributed to their collisions and the Louisiana DOT was negligent in allowing the shoulder condition to exist and contribute to the accident.

DUTY OF GOVERNMENT TOWARD "SAFE" ROADS

Because the failure of governmental units to perform their duty in a reasonable manner (negligence) is the basis for many suits, that duty needs to be understood by governmental employees. The function of government is to provide security and services

TABLE 1 CLAIMS AND SUITS FILED AGAINST STATE TRANSPORTATION AGENCIES (5)

STATE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AL						233				262	172
AK							163	157	152	37	63
AZ	71	100	70	90	98	282	291	321	293	293	214
AR	125	98	100	83	132	132	200	122	154	170	165
CA	870	1,013	1,042	1,239	3,533	3,575	1,818	2,079	489	523	444
CL	2	8	7	11	7	23	12	65	55	89	126
CO	286	300	376	414	453	583	164	150	126	900	1,200
DE											
FL		5	65	71	35		447	189	89	92	73
GA							8		4		
HI							57	96			
ID	19	65	93	117	108	48	181	178	210	223	193
IL		9	30	65	142	60		118		45	114
IN	72	88	308	435	622	702	653	828	599	607	773
IA	80	108	90	129	126	136	152	185	338	184	182
KS					16	17		6	8	11	12
KN	242	249	241	275	250	333	405	590	383		
LA	22	80	111	118	145	147	420	612	520	448	514
MA							2	5	8	28	6
ME							5		6,277		
MS							121	60	150	150	166
MI				201	108	95	114	126	110		
MN					42	165	192	211	162	133	181
MS											
MO	0	3	2	1	1	3	2	15		27	39
MT							90	64			
NB	34	64	38	44	40	42	50	101	65	63	92
NV	20	19	22	19	13	40	8	43	69		
NH	2	3	0	2	4	1	8	8	7	26	24
NJ											
NM			13	9	17	18	21	101	10	20	30
NY		151	162	158	130	226	202	256	302	326	
NC											
ND											
OH				92	142	226	200	158	129	130	128
OK									14	8	7
OR							30	39		466	588
PA							212	622	520		
RI								14		100	100
SC	265	302	364	366	406	407	295	571	659	319	372
SD	0	0	1	0	1	1	0	2	2	0	0
TN							275	447			400
TX	12	15	19	41	28	27	37	37	59	58	69
UT						10	52	62		16	4
VT									90	90	90
VA							5		5		
WA	45	58	69	66	77	70		314	867	64	88
WV							200	282	280	308	228
WI	1	2	5	6	4	4	8	128	62		
WY			2	1	0	1	4	0	9	55	72
TOTAL	2,168	2,740	3,230	4,053	6,680	7,607	7,104	9,362	13,276	6,271	6,929

TABLE 2 LOUISIANA DEPARTMENT OF TRANSPORTATION SUMMARY OF CLAIMS RELATED TO HIGHWAY TORT LIABILITY FOR 1979–1983 (*6*)

Condition	Claim Amount ($)	No. of Claims
Shoulder	203,935,706	157
Design, etc.	201,049,525	107
Surface	123,683,633	161
Work site	121,102,215	107
Signs	94,664,421	96
Property	94,365,486	45
RR crossing	59,835,430	39
Bridge	59,713,449	55
Drainage	48,569,651	16
Signal	36,309,772	126
Marking	29,136,161	26
Sight distance	27,425,450	23
Traffic control	26,125,700	7
Maintenance	24,816,773	28
Left turn	10,893,211	18
Lighting	7,614,655	14
Equipment	6,400,870	4
Debris	6,386,497	13
Ferry	5,204,479	3
Mowing	4,062,350	4
Guardrail	3,511,109	6
Tunnel	2,350,000	1
Other	2,000,000	1
Steel cable	1,110,000	2
DOTD operator	227,000	1
Under $100,000	286,867	9
Total	1,200,780,410	1,069

for its citizens. Transportation is one of the services that governmental officials and employees are charged with providing. Normally, the goal of governmental transportation efforts should be the safe and efficient movement of people and goods, within reasonable fiscal constraints.

The courts have universally held that although governments are providing these transportation services, governments are not the absolute ensurers of the safety of a highway user. The total resources of any government are limited, and it would not be realistic to expect that the bulk of all funding be devoted to keeping the roads in an absolutely sound and safe condition. However, the courts have consistently held that governments are required to maintain streets and roads in a *reasonably safe* manner. Failure to do so may result in liability if a user suffers injury.

NEGLIGENCE

Negligence is generally defined as failure to use reasonable care in dealing with others. In other words, what would a reasonable person have done in the circumstances and situations that constitute the current court case? Negligence in one form or another is usually the key to tort liability cases, and officials should understand its general principles and applications. To win a negligence case, the plaintiff must prove that

1. The defendant had a duty of reasonable care toward the plaintiff;
2. The defendant breached that duty;
3. The defendant's negligence was the cause of plaintiff's injury;
4. The plaintiff was not guilty of contributory negligence that caused the injury (or was guilty of comparative negligence in some states); and
5. The plaintiff incurred resulting damages.

Officials should be interested in breaking the five-step chain of factors. Removing all negligence (the second factor, or link) would be the ideal way to prevent highway-related tort liability losses. The best defense to a lawsuit is a preventive defense.

EACH TRAFFIC ACCIDENT IS A POTENTIAL SUIT

Roadway liability almost always begins with a traffic accident. Each accident victim is a potential plaintiff in a lawsuit, and there are a great many of them. Most of us are overwhelmed when we first learn of the magnitude of traffic accidents in a typical year.

Over the last 40 years, there have been 40,000 to 50,000 traffic accident fatalities each year, and 1 to 2 million people per year have been injured. Fortunately, there have been decreases in both the number of people killed and the rate of fatalities per million miles driven; however, it would be wise to remember that there were 46,400 fatalities, 1.7 million disabling injuries, and 33 million drivers involved in accidents in 1985 (*4*). That amounts to millions of possible plaintiffs from suits generated by traffic accidents.

RISK MANAGEMENT PRINCIPLES

Because of the rapid increase in suits and the corresponding increase in financial losses, most transportation agencies have looked for ways to minimize their losses. The concept of risk management has been borrowed from the private sector. A successful risk management program involves the implementation of both risk finance (insurance) and risk control techniques. A well-designed risk management program achieves the following important goals:

- Minimize the potential number of lawsuits being filed;
- Minimize the number of lawsuits lost; and
- Minimize the damages from lawsuits lost.

Risk finance techniques (insurance) are generally most useful in achieving the third goal, which involves minimizing monetary damages to the agency from lost lawsuits. Risk control techniques, on the other hand, are useful in achieving all three goals. Risk control involves

1. Identifying the risk;
2. Measuring the risk (probability, severity, frequency);
3. Putting a plan in place to reduce or control the risk; and
4. Monitoring and adjusting the plan.

Many transportation agencies have recently attempted to minimize their liability through risk control. In general, this involves setting up a program specifically aimed at recognizing and reducing liability factors. Several of the most frequently used procedures will now be briefly outlined.

Importance of Good Records

The ideal situation for any agency under suit is for the plaintiff's attorney to discover documentation in the defendant's files that proves the defendant's position. The chance of this occurrence is greatly increased if the transportation agency is careful to keep accurate, complete, and timely records of its actions. These records are especially important when the agency deals with individual members of the public (complaint calls, requests for service) or when the agency deals with chronic problem areas (continuous congestion, chronic maintenance problems, etc.).

A good transportation manager can periodically review the agency's records to learn which departments and which employees are conscientiously executing their duties. The records serve not only as potential evidence for the courtroom but also as a tool for the agency manager.

Accident data make up one type of record of great importance in establishing and conducting a risk management program. Before discussing the use of accident records, several other types of records will be outlined.

Notice of a Defect and Documentation of Complaints

Once a public entity has received notice of a defect, it has a duty to repair the defect or to warn the public until the defect can be repaired. A prominent part of the plaintiff's negligence case is often an attempt to prove that the highway agency had notice of a defect.

The notice of a defect can take place in three ways. First, it can be actual notice, such as a complaint call. Second, it can be constructive notice. That is, a defect could exist long enough that a reasonable person would have found it. Third, the agency may receive notice if its own actions (improper repair, etc.) caused the defect.

Because notice of a defect is such a strong portion of a negligence case, the transportation agency should use due care in how it receives and handles complaint calls. Procedures should be set up to record key information, determine the severity of the reported defect, and take appropriate action on the defect. These records should be carefully preserved for possible later use in court.

Examples of good procedures for recording complaint call information are illustrated by Figures 2 and 3. In each case, key facts are recorded about the call (date, time, location, caller, receiver, nature of call, etc.), the name of the individual or unit to whom the request was assigned, and the disposition of the action. Both of these forms require explicit data entries.

Maintenance Records

Records of maintenance and construction activities include work undertaken, names of supervisors, materials used, and dates and times of activities. These records may later prove to be the agency's strongest allies in defending a court case. Witnesses tend to forget specific times, dates, and details, and they are sometimes tempted to exaggerate on the stand to emphasize their testimony. A good system of maintenance record keeping may often provide key pieces of data to refute erroneous testimony or to strengthen the defense's case by giving specific facts to the jury. These records may also be used to establish that the agency took reasonable action in addressing a specific problem at a specific site.

Inventory Records

Future suits may be deterred by recognizing existing defects through field inventories and then removing the defects. For example, signs and traffic signals are two items that are frequent topics of suits. The highway agency might prevent many future suits by carefully comparing each existing sign to the *Manual on Uniform Traffic Control Devices* (*8*). Once the inventory is completed, the agency should routinely replace those signs and signals that do not meet requirements, updating the inventory as they do so.

Other types of inventories are also useful in court. Video logs and photo logs are two that are often used as evidence in support of the defense.

ACCIDENT DATA AND ACCIDENT REDUCTION PROGRAMS

The heart of any good risk management system should be a program to reduce accidents, injuries, and fatalities. Realistically, it must be recognized that all traffic accidents can never be eliminated, but it may be possible to decrease the number of collisions by altering the roadway environment. Specifically, emphasis should normally be placed on improving situations and locations that have demonstrated potentially high risk to the motorist.

The accident reduction program might proceed in the following manner:

1. Ensure that local police know why accident data are needed, that accident reports are correctly filled out, and that they are filed in a manner that facilitates cross-classification and retrieval;
2. Prepare a high-accident situation or location list;
3. Look for patterns of accident types and causes;
4. Develop alternative corrective measures for each site and determine the most cost-effective treatment;
5. Develop a priority list among competing sites and program corrective actions on the basis of the list;
6. Erect warning signs at sites that cannot immediately be repaired or take routine maintenance actions to improve safety at the site;
7. Review projects after completion;
8. Periodically reassess the priority list and the need for warning or minor improvements at sites not yet completed; and
9. Keep good records of all portions of the program.

Obviously, there are many details that might be added to this list to specify the manner in which the individual tasks are performed. The details vary with the type of highway, degree of hazard, and other factors.

High-accident locations can be identified by reviewing accident data. In the simplest case, police accident reports may be examined and accident locations marked with pins on a street map. On the other hand, most transportation agencies have

STATE OF ALABAMA
HIGHWAY DEPARTMENT
INCIDENT REPORTING/RESPONSE RECORD

__ __ __ __ __ __ __
Div Dist Seq.No.

TYPE INCIDENT:
Complaint or Request
___ Routine Maintenance
___ Hazardous, Routine Repair
___ Hazardous, Safety-Related

____ Catastrophic Event*
____ Hazardous Material Accident*
____ Natural Disaster*
____ Other (describe)_____

HAZARDOUS MATERIALS ONLY
___ State Troopers Notified
___ ADEM has been Notified
___ Division has been Notified
___ Highway has been closed
___ Highway Dept. assisted in Clean-up

* Report immediately to Division

DATE:_____ TIME RECEIVED:_____ RECEIVED BY:_____

REPORTED BY:_____ TELEPHONE NO.:_____

HOW REPORTED:_____

LOCATION:_____

_____

_____

_____

DESCRIPTION:_____

_____

_____

_____

_____

_____

_____

ASSIGNED TO:_____ DATE ASSIGNED:_____ TIME ASSIGNED:_____

ACTION TAKEN:_____

_____

_____

_____

_____

_____

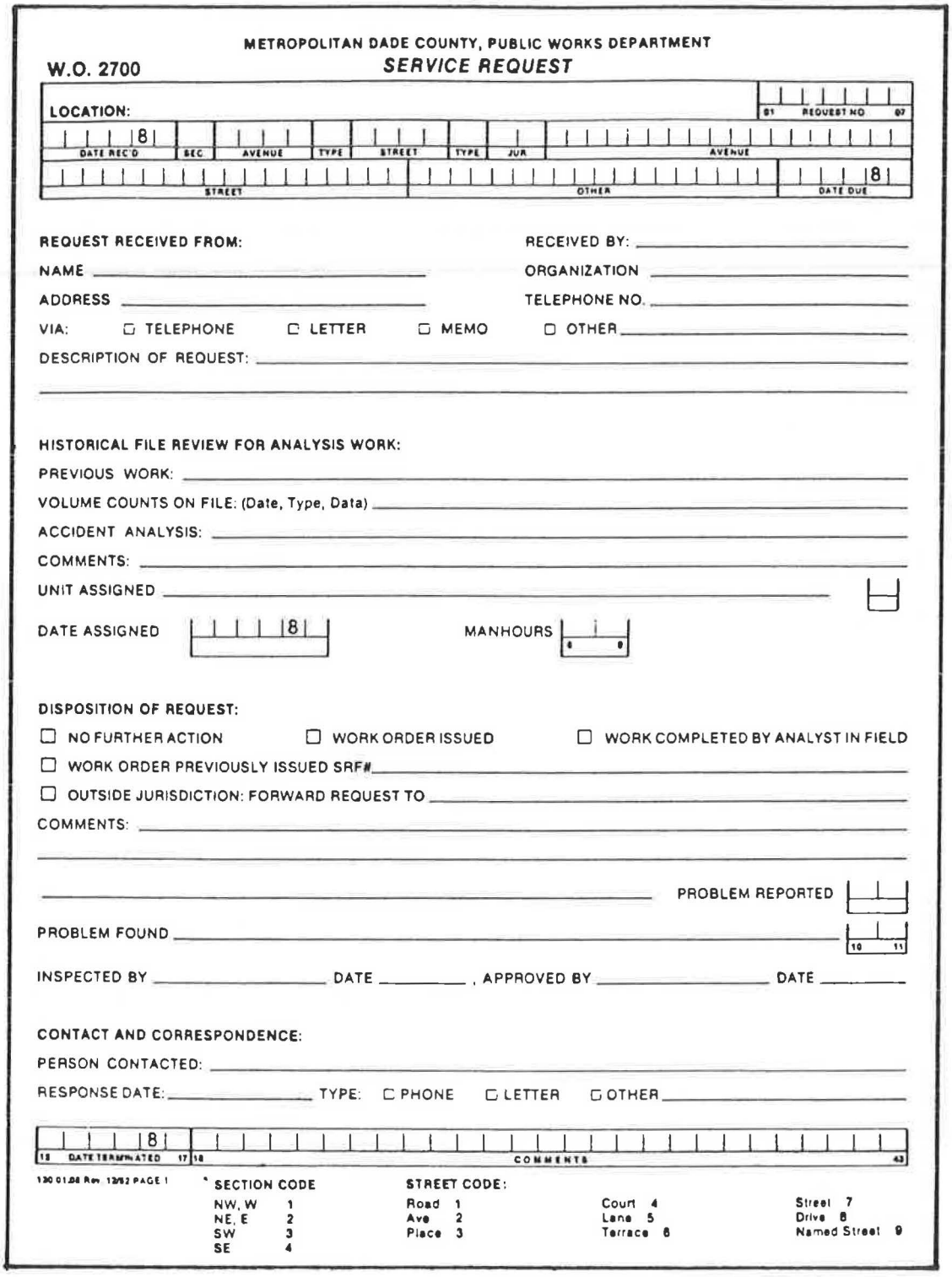
DATE COMPLETED:_____ TIME COMPLETED:_____

STATUS WHEN CLOSED OUT:
____ Completed ____ Scheduled As Routine Maintenance
____ No Action Required
____ Further Study, Forwarded To: _____
____ Other (describe):_____

FIGURE 2 Complaint form used by the State of Alabama Highway Department.

automated records of accidents and use computers to determine high-accident locations. There are excellent computer programs for use in accident reduction efforts, including those that calculate accident rates for all state routes, county and city accident totals, high-accident locations, and collision diagram information.

Once the high-accident situations or locations are known, patterns of accidents should be identified and matched to causes, if possible. This process may be as simple as reviewing a few reports to see the types of accidents that occur at an intersection, or it may require using supporting data (collision diagram, condition diagram, traffic counts, warrant analysis,



METROPOLITAN DADE COUNTY, PUBLIC WORKS DEPARTMENT

W.O. 2700 *SERVICE REQUEST*

LOCATION: 01 REQUEST NO 07

DATE REC'D | SEC | AVENUE | TYPE | STREET | TYPE | JUR | AVENUE

STREET | OTHER | DATE DUE

REQUEST RECEIVED FROM: RECEIVED BY: _____

NAME _____ ORGANIZATION _____

ADDRESS _____ TELEPHONE NO. _____

VIA: ☐ TELEPHONE ☐ LETTER ☐ MEMO ☐ OTHER _____

DESCRIPTION OF REQUEST: _____

HISTORICAL FILE REVIEW FOR ANALYSIS WORK:

PREVIOUS WORK: _____

VOLUME COUNTS ON FILE: (Date, Type, Data) _____

ACCIDENT ANALYSIS: _____

COMMENTS: _____

UNIT ASSIGNED _____

DATE ASSIGNED MANHOURS

DISPOSITION OF REQUEST:

☐ NO FURTHER ACTION ☐ WORK ORDER ISSUED ☐ WORK COMPLETED BY ANALYST IN FIELD

☐ WORK ORDER PREVIOUSLY ISSUED SRF# _____

☐ OUTSIDE JURISDICTION: FORWARD REQUEST TO _____

COMMENTS: _____

PROBLEM REPORTED

PROBLEM FOUND

INSPECTED BY _____ DATE _____ , APPROVED BY _____ DATE _____

CONTACT AND CORRESPONDENCE:

PERSON CONTACTED: _____

RESPONSE DATE: _____ TYPE: ☐ PHONE ☐ LETTER ☐ OTHER _____

DATE TERMINATED | COMMENTS

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SECTION CODE: NW, W 1; NE, E 2; SW 3; SE 4

STREET CODE: Road 1; Ave 2; Place 3; Court 4; Lane 5; Terrace 6; Street 7; Drive 8; Named Street 9

FIGURE 3 Sample complaint form (7).

summary of key facts, field observations, etc.) for complex locations. Procedures for making these studies are well documented elsewhere. Likewise, processes for matching corrective measures to accident patterns and for choosing the most cost-effective improvements are well documented in the same references.

In summary, good accident reduction programs may take many different forms. Discretion should be exercised in devising a program to fit the local situation and to maximize the use of public funds.

Federal Aid Safety Program

The primary safety effort of most state transportation agencies is the Federal Aid Safety Program. Section 209 – Hazard

Elimination Program funds are used to make safety improvements at high-hazard locations. Section 203 – Rail Highway Safety Program funds are used specifically to improve grade crossings. Support for highway improvements made under these two programs is 90 percent federal funds and 10 percent state or local agency funds. Projects funded by these two sections offer prime opportunities to reduce tort liability exposure by removing roadway hazards.

Consideration of accident data is a requirement and an essential element for operating the Federal Aid Safety Program. Use of accident data to identify locations and to set priorities for the best use of safety funds is an integral portion of the safety program and thus of a good risk management program.

In addition to normal safety program uses, there are several innovative uses of accident data that may go far toward reducing an agency's tort liability exposure. The following section includes a discussion of several of these.

High-Accident Locations

A prominent part of most accident reduction programs is the deliberate, well-planned feedback of information to managers and field forces. This information is used for both general education and site-specific (or characteristic-specific) studies. It is educational in that field forces become familiar with general accident trends and characteristics in the state. This procedure allows employees to recognize unusual characteristics that should be addressed for safety treatment. Specific information is usually received in the form of lists of sites that exhibit unusual characteristics, such as a high number or rate of accidents.

The general education function can be fulfilled by summaries of accident characteristics. One example is demonstrated in Figure 4. This report is a very simple listing of the number of accidents that happened in one highway department jurisdiction. Care should be used in dispensing these types of reports. Employees should be made aware that the number of accidents is not the best criterion for selecting treatment sites. These listings do, however, allow employees to maintain a general feeling for the local accident situation.

The second type of information feedback is site specific. The best methods for selecting treatment sites are those that involve examination of both the number of accidents and the accident rate at any given site or a more sophisticated process, such as the rate/quality control technique. Figure 5 is a listing that was derived by the latter method, which produces a statistically sound sample of sites for each type of roadway and provides emphasis on individual sites that have accident numbers and rates higher than other roadways of similar character. This technique allows comparison of freeway segments to other freeway segments, two-lane rural routes to other two-lane rural routes, and so on, and provides the safety engineer with a strong tool for choosing the sites most worthy of treatment.

The transportation agency's overall safety program is based on the premise that good accident data are available and that soundly conceived procedures are used to review these data and to select sites for treatment. The rate/quality control procedure is the most widely accepted technique for selecting statistically valid samples of sites. It should be adopted in those cases for which the transportation agency has the data and expertise to utilize the procedure.

Wet Pavement Accidents

Many pavements become smoother under the wear and tear of traffic. As the aggregates "polish" and become smoother, they decrease the ability of motorists to stop quickly under emergency situations. This is especially true if the pavement is wet. Most transportation agencies now measure this skid resistance through a standard friction test on wet pavement and classify

STATE OF ALABAMA HIGHWAY DEPARTMENT
DESIGN BUREAU - TRAFFIC ENGINEERING
ACCIDENT IDENTIFICATION SECTION
INTEGRATED MODEL TRAFFIC RECORDS SYSTEM

TIME PERIOD: 01/01/86 TO 12/31/86

INVENTORY OF HIGH ACCIDENT SEGMENTS
URBAN AREAS - ALL ROADS
DEFINING CRITERIA: MIN OF 5 ACCIDENTS

SEQ. NO.	COUNTY	CITY	LINK	BEGIN NODE	END NODE	ACCIDENT SEVERITY TOTAL	P.D.O.	INJURY	FATAL	PERSONS NON-FATAL	PERSONS FATAL
1	LEE	AUBURN	5015	314	315	16	15	1		1	
2	LEE	AUBURN	5047	315	316	12	11	1		1	
3	LEE	AUBURN	5093	313	934	12	12				
4	LEE	AUBURN	5015	315	591	12	10	2		2	
5	LEE	AUBURN	5015	73	75	11	7	4		7	
6	LEE	AUBURN	5015	341	351	10	7	3		3	
7	LEE	AUBURN	5047	315	933	10	10				
8	LEE	AUBURN	5015	92	375	10	7	2	1	3	1
9	LEE	AUBURN	5015	86	93	9	5	4		5	
10	LEE	AUBURN	5015	64	73	9	8	1		1	
11	LEE	AUBURN	5136	316	590	7	7				
12	LEE	AUBURN	5015	322	331	6	6				
13	LEE	AUBURN	5015	824	849	6	6				
14	LEE	AUBURN	5089	614	615	6	5	1		1	
15	LEE	AUBURN	5093	313	319	6	6				
16	LEE	AUBURN	5093	300	934	6	6				
17	LEE	AUBURN	5155	74	75	6	6				
18	LEE	AUBURN	5015	702	834	5	5				
19	LEE	AUBURN	5046	578	588	5	4	1		1	

FIGURE 4 Example of a "general education" accident summary report.

STATE OF ALABAMA HIGHWAY DEPARTMENT
DESIGN BUREAU/TRAFFIC ENGINEERING SECTION
ACCIDENT INDENTIFICATION & SURVEILLANCE BRANCH
INTEGRATED MODEL TRAFFIC RECORD SYSTEM
INTERSTATE, URBAN, 4 LANES

CRITICAL ACCIDENT RATE ANALYSIS OF SEGMENTAL ACCIDENTS
FROM: 04/01/83 TO 12/31/85

RANKING	COUNTY	ROAD	BEGIN MILE-POST	END MILE-POST	SECTION LENGTH	SECTION ADT	ACTUAL ACC. RATE	CRITICAL ACC. RATE	DEVIATION	*** NUMBER OF ACCIDENTS *** TOTAL	P.D.O.	INJURY	FATAL
1	MOBILE	I010	28.00	28.04	0.04	33127	9.02	0.54	8.48	12	8	4	0
2	ETOWAH	I059	181.00	181.26	0.26	9701	3.95	0.65	3.30	10	6	4	0
3	MOBILE	I010	14.80	15.25	0.45	26066	2.46	0.56	1.90	29	21	8	0
4	MONTGOMERY	I065	169.50	174.72	5.22	24806	2.42	0.56	1.86	315	229	85	1
5	MONTGOMERY	I065	168.80	169.40	0.60	24806	2.34	0.56	1.78	35	29	6	0
6	JEFFERSON	I020	132.80	133.10	0.30	37586	2.12	0.53	1.59	24	20	4	0
7	MOBILE	I010	19.00	19.25	0.25	37725	2.11	0.53	1.58	20	11	8	1
8	MONTGOMERY	I065	168.00	168.25	0.25	24806	2.09	0.56	1.53	13	11	2	0
9	MOBILE	I065	13.00	13.40	0.40	18035	2.07	0.59	1.48	15	9	5	1
10	LEE	I085	59.80	60.33	0.53	12698	2.07	0.62	1.45	14	6	8	0
11	MONTGOMERY	I065	175.00	175.40	0.40	31038	1.76	0.54	1.22	22	16	6	0
12	MOBILE	I065	9.00	9.30	0.30	30797	1.72	0.54	1.18	16	14	2	0
13	MOBILE	I065	9.80	11.50	1.70	27874	1.56	0.55	1.01	74	49	25	0
14	JEFFERSON	I020	131.00	132.25	1.25	37613	1.53	0.53	1.00	72	55	17	0
15	MONTGOMERY	I065	176.00	176.21	0.21	31038	1.38	0.54	0.84	9	5	4	0
16	TUSCALOOSA	I059	76.00	76.60	0.60	16561	1.40	0.59	0.81	14	10	4	0
17	MOBILE	I010	20.00	20.25	0.25	37725	1.16	0.53	0.63	11	6	5	0
18	MOBILE	I010	17.75	18.00	0.25	34381	1.16	0.54	0.62	10	5	5	0
19	MONTGOMERY	I085	5.90	7.20	1.30	34797	1.14	0.53	0.61	52	38	14	0
20	MOBILE	I010	13.80	14.20	0.40	26066	1.15	0.56	0.59	12	10	2	0
21	MOBILE	I010	10.50	11.25	0.75	21324	1.12	0.57	0.55	18	8	8	2

FIGURE 5 Sample rate/quality control listing of potential sites for safety treatment.

their pavements on a scale of 0 to 100. Friction numbers in the 40s or above are normally believed to give good stopping resistance.

A second way to classify the skid resistance of pavements is to analyze the percentage of accidents that happen in wet weather. This type of analysis is shown in Figure 6. A site with particularly smooth pavement will often have a large number of wet weather accidents. The most useful analysis is to compute the percentage of accidents that happen in wet weather. Normally, a site might be investigated if the wet weather percentage is twice the systemwide average.

For example, in the southeastern states, approximately 20 to 25 percent of accidents occur in wet weather, even though the pavement is wet only 5 to 7 percent of the time. If 50 percent of the accidents at a given site occurred in wet weather, that site could normally be assumed to have pavement that was "slicker" than other pavements and might need additional attention.

Figure 6 presents the total number of accidents at any site, the number that occurred on wet pavement, and the percentage that occurred on wet pavement. A skid-reduction program should concentrate on "wet" accident sites, so one way to prioritize a treatment program would be to start with the sites with the greatest number of wet accidents, as long as these sites had a rate greater than twice the system average.

DESIGN BUREAU/TRAFFIC ENGINEERING SECTION
ACCIDENT IDENTIFICATION & SURVEILLANCE BRANCH
INTEGRATED MODEL TRAFFIC RECORDS SYSTEM

SKID TESTS/ACCIDENT DATA FOR RURAL, 2 LANES
STATE ROUTES IN THE 2ND DIVISION

COUNTY	RT	BEGIN MILE-POST	END MILE-POST	SECT LENGTH	ADT	SEG ACC PER MVM	NIGHT SEG ACC/MVM	WET SEG ACC/MVM	SKID NO.	TYPE MIX	ACCS/ MILE	% WET ACCS	NUMBER OF SEG. ACCS.* TOT.	P.D.O.	INJ.	FATAL
LAWRENCE	33	31.00	32.00	1.00	2621	5.93	1.40	1.40	0	416A	17.00	24	17	8	9	0
LAWRENCE	33	30.20	31.00	0.80	2863	3.99	1.20	0.80	0	416A	12.50	20	10	6	4	0
LAWRENCE	33	22.70	23.00	0.30	2492	3.67	0.00	1.22	0	416A	10.00	33	3	2	1	0
LAWRENCE	157	44.00	45.00	1.00	3800	2.89	0.96	0.96	0	416A	12.00	33	12	10	2	0
LAUDERDALE	101	28.00	29.00	1.00	3436	4.52	1.06	1.06	0	411A	17.00	24	17	11	6	0
LAWRENCE	101	24.00	24.50	0.50	3649	6.01	1.50	1.50	0	411A	24.00	25	12	8	3	1
WINSTON	5	213.00	214.00	1.00	4645	1.97	0.59	0.98	0	411A	10.00	50	10	8	2	0
MARION	17	288.00	288.42	0.42	2049	9.56	1.06	4.25	0	411A	21.43	44	9	4	4	1
MARION	5	218.00	219.00	1.00	4674	4.30	0.98	1.56	0	411A	22.00	36	22	17	5	0
MARION	5	217.15	218.00	0.85	7834	1.51	0.27	0.55	0	411A	12.94	36	11	11	0	0
WINSTON	74	30.00	30.68	0.68	1998	4.71	0.67	1.35	37	301E	10.29	29	7	5	2	0
LAUDERDALE	17	342.00	343.00	1.00	3751	3.41	1.22	0.49	46	411A	14.00	14	14	9	5	0
LAWRENCE	24	57.00	57.80	0.80	4228	3.78	0.27	0.54	47	416A	17.50	14	14	6	7	1
LAWRENCE	24	63.91	65.00	1.09	6676	3.01	1.13	0.50	49	416A	22.02	17	24	17	7	0
LAUDERDALE	17	341.00	342.00	1.00	4023	3.18	0.45	0.68	49	411A	14.00	21	14	11	3	0
LAWRENCE	24	63.00	63.91	0.91	5720	2.11	0.18	0.70	50	416A	13.19	33	12	3	9	0
LAUDERDALE	13	338.00	339.00	1.00	4766	3.26	1.34	0.96	51	424	17.00	29	17	10	7	0

FIGURE 6 Sample computer report for a wet pavement accident analysis.

A second point is illustrated by Figure 6. The accident data follow a random, statistical process. Small samples (i.e., sites with few accidents) are subject to great variability from year to year. More confidence can be placed in sites with large numbers of accidents, and engineers usually choose a minimum (threshold) number of accidents necessary to consider a site for improvement.

The most certain way to analyze loss of skid resistance is to combine wet weather accident records with friction test results. Any site that has low friction numbers and a high percentage of wet weather accidents should be a candidate for further investigation.

Daylight-Dark Accidents

Analyses of the percentage of accidents happening during nondaylight hours can be used to identify areas where motorists are having difficulty seeing the roadway or determining which driving maneuver to execute. These analyses are conducted in the same manner as wet pavement analyses. That is, any site that is having twice the percentage of accidents in nondaylight hours than the system average becomes a candidate for investigation to determine whether the installation of street lights is necessary. Lighting should only be installed in those cases for which improved visibility would reduce the types of accidents or the severity of accidents occurring at that particular site.

A sample daylight-dark analysis is given in Figure 7. The purpose of this computer report is similar to that of the wet pavement report (Figure 6), and the report is utilized identically.

Roadway Defect Investigations

Most accident investigation forms include a section on any roadway defects that might have contributed to the accident. Typically, law enforcement officers might enter comments regarding high shoulders, low shoulders, malfunctioning traffic control devices, potholes, or other defects. Transportation agencies might utilize these data for their risk management programs.

If defects do exist and contribute to traffic accidents, they become a liability for the transportation agency. The courts might find that a reasonable action for the agency would have been to find and remedy the defects before they caused additional accidents.

A roadway defect program might consist of the following steps:

1. Accident data are screened for roadway defects.
2. When defects are found, field forces are notified of the date and location of the accident and supplied with the accident report.
3. Field forces investigate the site, making observations, measurements, and photographs of conditions.
4. If a defect is found, its extent is noted and any possible contribution to the accident is documented. The defect is remedied or scheduled for routine maintenance.
5. If no defects are noted, the law enforcement officer is contacted to discover the reasons for the incorrect accident report.

This program offers three distinct advantages. First, it documents field conditions for possible future use in defending court cases. Second, field forces become acquainted with roadway situations that contribute to accidents and consequently learn to minimize these situations. Third, field forces and law enforcement officials are forced into contact with each other. Frequently, the law enforcement officials become better informed about the use of accident data and the result is an improvement in the quality of these data.

A sample road defect computer printout is presented in Figure 8. It contains enough data about the accident that field forces can conduct a simple field investigation without having a

ANALYSIS OF ACCIDENTS OCCURRING DURING DARKNESS
SYSTEM WIDE TOTAL ACCIDENTS: 5069, % DURING DARKNESS: 0.076, FOR THE PERIOD: 10/01/81 - 9/30/82

5 OR MORE ACCIDENTS					LESS THAN 5 ACCIDENTS				
STREET CODE	STREET NAME	TOTAL ACCIDENTS	TOTAL DARK	PERCENT DARK	STREET CODE	STREET NAME	TOTAL ACCIDENTS	TOTAL DARK	PERCENT DARK
1216	PORKY STREET	5	3	0.600	2460	HERTZ DR	1	1	1.000
488	EDGEVILLE RD	6	3	0.500	2378	LITTLE SQUAW SE	1	1	1.000
981	BLUE AVE NW	8	3	0.375	2299	SPORTING LANE	1	1	1.000
748	MUDD ISLAND RD	9	3	0.333	2045	LAURA DRIVE	1	1	1.000
80	NEW PARKWAY CIRCLE S	36	10	0.277	1956	WINNER DRIVE	1	1	1.000
974	MASON DR	11	3	0.272	1742	FAIRGROUND AVE	1	1	1.000
1040	DEVILLE ST	12	3	0.250	1727	WILLOW COVE	1	1	1.000
996	MEADOW DR	14	3	0.214	1607	BIGTOP BLVD	1	1	1.000
2357	HILLTOP CIRCLE	5	1	0.200	1572	JVC CIRCLE	1	1	1.000
1428	BLUE RIDGE AVE NW	15	3	0.200	1530	LITMUS AVE	1	1	1.000
1353	SEVENTH ST	5	1	0.200	1494	JERICO AVE	1	1	1.000
1215	POTTER AVE	5	1	0.200	1393	MARJORIE ST	1	1	1.000
942	BRIDGE AVE	5	1	0.200	1349	LEE ANN DRIVE	1	1	1.000
689	HALLEY AVE	5	1	0.200	1193	PHILPOT AVE	1	1	1.000
467	BATTLE VIEW AVE	5	1	0.200	1118	OAKDALE COURT	1	1	1.000
316	CLOVERDALE MALL ST	5	1	0.200	1068	THRILL LANE	1	1	1.000
222	HIGH AVE	5	1	0.200	1016	MESA BUTTE RD	1	1	1.000
181	BRANDON AVE	5	1	0.200	988	LIMMA VIEW DR	1	1	1.000
43	TUNA ST	5	1	0.200	921	BIG BEND AVE	1	1	1.000

FIGURE 7 Sample computer report for a daylight-dark accident analysis.

STATE OF ALABAMA HIGHWAY DEPARTMENT
DESIGN BUREAU/TRAFFIC ENGINEERING SECTION
ACCIDENT IDENTIFICATION & SURVEILLANCE BRANCH

FROM: 01/01/87 TO 07/02/87

INTEGRATED MODEL TRAFFIC RCORDS SYSTEM

ACCIDENTS WITH REPORTED ROAD DEFECTS ON INTERSTATE AND STATE ROUTES
DIVISION: 1 COUNTY: DEKALB CITY: ---RURAL---

SEQ. NO.	CONTRB RD DEF	ACCIDENT NUMBER	DATE	TIME	LIGHT	WEATHER	ST	NODE 1	NODE 2	DIST	NODE	MILE POST	DIR TRL	PRIM CAUSE	FIRST HARM EVENT	EST SPD	NO. VEH	INJ I	INJ K
1*	OTHER	7003403	12387	2215	DK-NL	CLDY	I059	1076	7087	3.25	2	228.00	S	DR NOT CTL	HIT CLVRT	50	1	0	0
2*	SH LOW	7020646	31287	1445	DAY	CLEAR	S035	987	7185	0.75	2	15.50	N	DUI	HIT NPK VH	60	1	2	0
3*	SH LOW	7036555	43087	100	DK-NL	CLEAR	S035	35	7846	0.50	2	27.30	W	USN OBJ/PN	FGN MAT RD	55	1	0	0
4*	SH LOW	7001949	11687	2253	DK-NL	RAIN	S227	7647	7648	1.50	2	26.50	N	VH LEFT RD	HIT CLVERT	50	1	0	0
---------- ACCIDENTS ENTERED SINCE LAST REPORT ----------																			
5	SH LOW	7055335	62087	220	DK-NL	CLDY	S007	7989	7992	0.50	1	244.00	S	DUI	HIT UTL PL	50	1	0	0

FIGURE 8 Sample computer report for a program to investigate accidents with reported road defects.

copy of the police accident report. However, in many cases the police report is necessary to supply enough detail about the collision so that field forces may conduct a comprehensive site investigation.

High-Exposure Accident Investigation

Some types of accidents, by their very nature, are likely to result in suits. Accidents with fatalities or serious injuries are the types that usually breed suits. Others, like those that generate large amounts of publicity, are also likely to result in suits. When the transportation agency becomes aware of these types of accidents, it is a good idea to visit the site, make key measurements, and document conditions through photographs and interviews with witnesses or local residents. This information is then placed in a file for possible later use. Although the majority of these accidents may not result in suits, the data gathered in such investigations will prove invaluable in those few instances in which suits are filed.

Most states allow plaintiffs to wait 1 to 2 years after the accident before filing the suit. In this period of time, evidence such as skid marks, debris, damaged vegetation, and so on, will disappear from the site. Unless the transportation agency has conducted an investigation soon after the accident, it will be very difficult to conduct a valid defense, due to lack of supporting field evidence.

The State of Alabama Highway Department obtains accident data 24 to 72 hours after the local law enforcement officials complete their investigation. These data are screened daily by computer. Each fatal accident is identified, and the field office closest to the accident is notified via computer printout soon after the accident data are coded. The field office then goes to the site and conducts a proper investigation. Figure 9 is a copy of the computer output used to notify field offices of the need to conduct an investigation.

Roadside Objects

Over the past few years, the most popular topics for highway liability suits have been low shoulders and improper traffic control devices. The most rapidly increasing topics of concern now appear to be single-vehicle accidents involving roadside objects and accidents that occur due to limited site distance. The former category is relatively easy to identify by a simple scan of accident data.

Because collisions with roadside objects are normally very severe and frequently result in fatalities and severe injuries, transportation agencies might benefit by targeting them for safety programs. The most common types of these accidents involve trees, poles, drainage devices, mailboxes, or bridges, barriers, or safety hardware. In general, the closer these objects are to the edge of the roadway, the less safe the driving environment becomes. Accident data can be used to identify roadway locations or situations where these accidents occur most frequently. Safety improvements can be made by pinpointing these locations and removing the roadside objects entirely or moving them farther from the roadway. Locations that have experienced the worst safety records become the leading candidates for roadway improvements.

Bridge Accidents

A special category of fixed objects consists of bridges, bridge barriers, and bridge approach barriers. Because the majority of bridges in the United States are over 50 years old, many of them are narrow, on poor alignment, or otherwise more likely to experience accidents than other roadway locations. Once a plaintiff has been awarded a large judgment, a series of these lawsuits usually follows because these bridges are highly visible and prominent on the roadways. They thus become easy targets for lawsuits.

STATE OF ALABAMA HIGHWAY DEPARTMENT
DESIGN BUREAU/TRAFFIC ENGINEERING SECTION
ACCIDENT IDENTIFICATION & SURVEILLANCE BRANCH
INTEGRATED MODEL TRAFFIC RECORDS SYSTEM

NOTIFICATION OF FATAL ACCIDENTS OCCURRING ON STATE
ROUTES & INTERSTATES IN ALL DIVISIONS

SEQUENCE NUMBER	DATE	ACCIDENT NUMBER	COUNTY	CITY	ROUTE	NODE 1	NODE 2	MILE POST	INJURIES KILLED	INJURIES INJURED
--------- 1ST DIVISION ---------										
1	6/25/87	7056129	MADISON	--RURAL--	S001	7285		352.6	1	2
2	6/17/87	7056128	MADISON	--RURAL--	S001	8221	8406	329.2	1	2
--------- 2ND DIVISION ---------										
THERE WERE NO FATAL ACCIDENTS IN THE 2ND DIVISION ENTERED INTO THE COMPUTER SINCE THE LAST REPORT										
--------- 3RD DIVISION ---------										
THERE WERE NO FATAL ACCIDENTS IN THE 3RD DIVISION ENTERED INTO THE COMPUTER SINCE THE LAST REPORT										
--------- 4TH DIVISION ---------										
THERE WERE NO FATAL ACCIDENTS IN THE 4TH DIVISION ENTERED INTO THE COMPUTER SINCE THE LAST REPORT										

FIGURE 9 Sample computer report for a program to investigate "high-exposure"–type accidents.

STATE OF ALABAMA HIGHWAY DEPARTMENT
DESIGN BUREAU - TRAFFIC ENGINEERING
ACCIDENT IDENTIFICATION

TIME PERIOD: 04/01/83 TO 12/31/85
SORTED BY: ACCIDENT RATE
INCREMENT LENGTH: 0.15

INTEGRATED MODEL TRAFFIC RECORDS SYSTEM
ACCIDENT RATES FOR BRIDGES OF
THE ALABAMA INTERSTATE SYSTEM

SEQ NO	COUNTY	CITY	ROUTE	MILE POST	BRIDGE LOCATION	ADT &	YR	RDWAY BDG WIDTH	BRIDGE LENGTH	SEG ACC PER MV	**SEGMENTAL ACC** TOT=	PDO	+INJ	+FAT	BDG ACC
277	CULLMAN	--RURAL--	I065	298.54	MARIOT CREEK	17160	83	0.00	71	0.29	5	4	0	1	0
278	MOBILE	MOBILE	I010	19.50	MOORES CREEK	17780	83	28.00	204	0.28	5	3	1	1	0
279	LEE	--RURAL--	I085	68.00	HALLAWAKEE CREEK	10360	83	28.00	204	0.28	3	2	1	0	0
280	MONTGOMERY	MONTGOMERY	I065	17.24	BRANCH	7085	83	0.00	31	0.28	2	2	0	0	0
281	MOBILE	MOBILE	I065	18.82	US 43	7085	83	51.20	445	0.28	2	1	1	0	0
282	SHELBY	LEEDS	I020	144.29	LITTLE CAHABA RIVER	17500	83	0.00	38	0.28	5	1	4	0	0
283	SHELBY	--RURAL--	I065	140.68	BRANCH	11005	83	0.00	30	0.27	3	2	1	0	0
284	MOBILE	PRICHARD	I065	8.38	ILLINOIS CENTRAL GULF RR	14515	83	38.50	229	0.27	4	3	1	0	0
285	BLOUNT	--RURAL--	I065	289.44	BRANCH	17850	83	0.00	42	0.27	5	4	1	0	0
286	JEFFERSON	FAIRFIELD	I059	119.18	41ST STREET	22050	83	38.50	170	0.27	6	2	4	0	0
287	BALDWIN	--RURAL--	I010	60.82	ALLEN SPRING BRANCH	7500	83	0.00	37	0.26	2	2	0	0	1
288	SHELBY	--RURAL--	I065	229.26	SOUTHERN RR	7385	83	28.00	169	0.26	2	2	0	0	1
289	JEFFERSON	--RURAL--	I065	264.95	SOUTHERN RR	15248	83	39.20	393	0.26	4	4	0	0	0
290	JEFFERSON	BIRMINGHAM	I065	266.10	US 31	15245	83	39.20	360	0.26	4	2	1	1	0
291	JEFFERSON	BIRMINGHAM	I065	259.72	5TH AVE SOUTH	52555	83	50.50	193	0.26	14	13	1	0	0
292	ESCAMBIA	--RURAL--	I065	57.44	BRANCH	7410	83	0.00	43	0.26	2	2	0	0	0
293	MOBILE	MOBILE	I065	49.94	FLETCHER CREEK	3705	83	28.00	272	0.26	1	1	0	0	0
294	ESCAMBIA	--RURAL--	I065	51.14	BRANCH	3705	83	0.00	28	0.26	1	1	0	0	0

FIGURE 10 Sample computer report for a program to investigate bridge-related accidents.

Figure 10 is a sample computer summary of bridge accidents. It displays high-accident sites, high-accident rate sites, and high-severity sites as part of one state's risk management program. Care must be used in establishing a bridge accident summary report because these collisions are relatively rare events. A very large volume of data must be used to pinpoint individual structures that need treatment. Difficult decisions must be made regarding the criteria for identifying bridge accidents. For example, are accidents accepted for analysis if they occur on a bridge approach? If so, how close to the structure must they be to count as a "bridge hit"? Because very few structures are hit with great frequency, it is often difficult to isolate clear trends. States may have to group similar bridges together to get enough data to choose the types of structures for treatment.

Railroad Grade Crossing Accidents

A final example category of accident reports involves rail-highway grade crossings. Because of the nature of the vehicles involved, these collisions are normally of high severity for the occupants of automobiles. The potential for fatalities and

serious injuries and the virtual certainty of publicity marks this as one category of accidents with a high probability of resultant court cases. Plaintiffs' attorneys have been relatively successful in convincing juries that the large conglomerate railroads have been the cause of injuries to occupants of highway vehicles and have thus collected a sizable number of substantial judgments and settlements.

Rail-highway grade crossings have been the subject of a federal safety emphasis for a number of years. Section 203 – Rail Highway Safety Program funds have been used specifically to address safety deficiencies in this area. As a result, most states have already developed computer programs to review rail-highway accident data. If that is the case, the agency's emphasis might be best directed at developing and maintaining realistic site selection criteria. A priority list using these concepts is an excellent risk management tool—if the list is actually followed. If the priority list was the basis for the expenditure of safety funds, it is easy to demonstrate to a court that the agency was doing all that could be reasonably expected.

SUMMARY

Almost all transportation agencies have experienced a rapid and significant increase in monetary losses from tort liability suits. Usually, alleged negligence on the part of the agency is the basis for the suit.

Traffic accident records play a critical part in minimizing these suits. For example, these data may be used in routine safety programs to identify and remove hazardous locations. A critical element in a good risk management program is the demonstration that the agency is effectively doing all that it can to remove these safety hazards through a well-planned and well-executed safety program.

Specialized accident reduction efforts can be very beneficial in minimizing tort liability losses. Wet pavement analyses, daylight-dark investigations, roadway defect investigations, high-exposure accident monitoring, and roadside object analysis programs were used as examples of these special studies.

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REFERENCES

1. *Summary of Travel Trends.* FHWA, U.S. Department of Transportation, Nov. 1985.
2. *Our Nation's Highways: Selected Facts and Figures.* Report HPM-1014-87 (35M)E, FHWA, U.S. Department of Transportation, 1987.
3. Car Costs Up in '86 to $3,002. *USA Today,* July 21, 1987.
4. *Accident Facts, 1986 Edition.* National Safety Council, Chicago, Ill., 1987.
5. *Survey of the Status of Sovereign Immunity Among the States, 1983.* Subcommittee on Legal Affairs, AASHTO, Washington, D.C., 1983.
6. *Transportation Research Circular 308: Tort Claims Involving Roadside Safety.* TRB, National Research Council, Washington, D.C., 1986.
7. S. Pivnik. *County Action Guide Series,* Vol. 1, No. 7, *Tort Liability.* National Association of County Engineers, Ottumwa, Iowa, 1985.
8. *Manual on Uniform Traffic Control Devices.* FHWA, U.S. Department of Transportation, 1984.

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