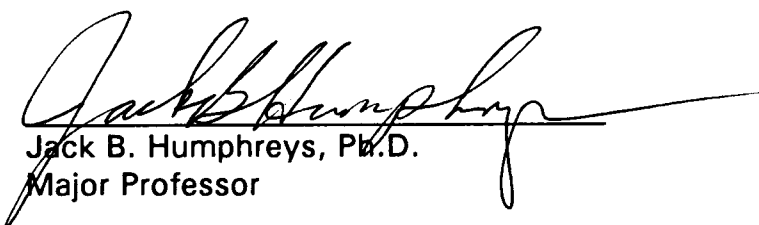


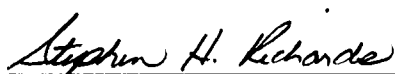
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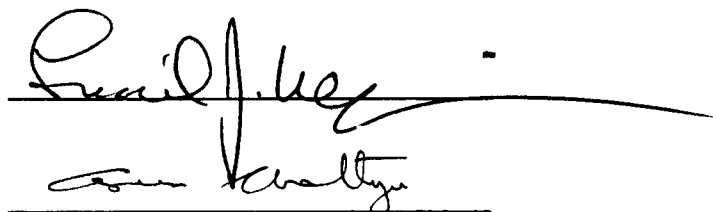


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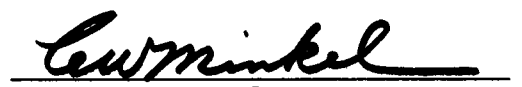


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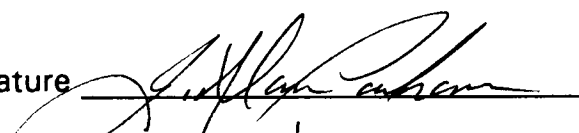
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**THE ELIMINATION OR MITIGATION OF HAZARDS
ASSOCIATED WITH PAVEMENT EDGE DROPOFFS
DURING ROADWAY RESURFACING**

A Thesis Presented

for the

Master of Science

Degree

The University of Tennessee, Knoxville

James Alan Parham

August 1994

DEDICATION

This is dedicated to my wife, Angelia for her continuous support and sacrifices this pursuit has involved. Without her assistance, this would have been very difficult for me to have accomplished. This is also dedicated to my daughter, Lucy, who inspires me to give her the very best.

Thank You, Angelia and Lucy!!!

ACKNOWLEDGMENTS

I wish to express my gratitude to the many people that facilitated the completion of this research project. I am especially appreciative of the guidance, direction, and overall inspiration contributed by Dr. Jack B. Humphreys, the major professor for this research. I am grateful to Dr. Frederick J. Wegmann for his motivation and insight which was of utmost importance to me in pursuing a graduate degree. I am grateful for Drs. Arun Chatterjee and William L. Grecco and their contributions and assistance in this pursuit. I wish to give a special word of appreciation for the time, encouragement, and assistance provided by Dr. Stephen H. Richards, Mr. Don H. Jones, Mr. Bill Kervin, and other staff members at the Transportation Center.

I also want to thank the AAA Foundation for Traffic Safety for funding the research and the Public Risk Insurance Managers Association for their assistance in providing the mailing list utilized in obtaining the data.

Finally, I want to express an exceptional thanks to my loving wife for her assistance with the development of this report and the pursuit of this goal and to my parents for their continued support and instilling a sense of tenacity to venture for a higher goal.

ABSTRACT

Unfortunately, roadways are often resurfaced without restoring the shoulder surface up to the resurfaced roadway elevation. When a vehicle's tires drop off a roadway with shoulders that are lower than the roadway, the act of reentering the roadway can lead to an accident.

This study sought to determine the extent of the pavement edge dropoff problem and to recommend changes in contract scope or performance that will eliminate or mitigate such occurrences. The study involved extensive interviews with city and county engineers, public works directors, transportation consultants, governmental legal departments, resurfacing contractors, and public risk managers nationwide. In addition, a questionnaire was sent to public risk managers and resurfacing contractors to determine the experience and opinions of those that had and had not been involved in litigation involving pavement edge dropoffs.

The findings of previous research was that dropoffs of 4 or more inches were unsafe if the roadway edge is at a 90° angle to the shoulder surface. Unsuspecting drivers whose tires slip off a resurfaced roadway and onto an unimproved shoulder are likely to lose control of the vehicle as they attempt to climb back onto the roadway. This can result in the vehicle entering the oncoming lane of traffic where it may strike another vehicle

head-on or in a side-swipe type collision, or the driver may lose control of the vehicle and have a one-vehicle accident.

Using a 45° angle fillet of asphalt provides a surface that may allow vehicles to climb back onto the resurfaced roadway without loss of control. Resurfacing contractors can attach a special edging device to their paving equipment.

Contract recommendations concerning scope of work in roadway resurfacing contracts to minimize the pavement edge dropoff hazard are to:

1. Perform shoulder resurfacing at the same time as the roadway resurfacing, resulting in no shoulder dropoff; or
2. Where resurfacing contracts must be bid separately, require the contractor to provide a 45° angle fillet of asphalt along the edge of the roadway as a part of the scope of work; and
3. Install signs warning the motoring public of the existence of a low shoulder. These signs are only effective for a short period of time, and the problem should be corrected shortly after the resurfacing is complete.

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CHAPTER 1

INTRODUCTION

Highways provide the predominant mode of transportation of people and products in the United States and many other parts of the world. The highway system in the United States consists of over 3,900,000 miles of public roads and streets, of which 3,100,000 miles are rural roads (1).

Highway traffic consists of a vast fleet of personal vehicles for transporting individuals and small groups, and commercial vehicles for transporting freight and larger groups of passengers. Vehicle ownership in the United States is the highest in the world. The national average is 0.56 passenger cars per capita (2). This travel is not without its costs. For example, each year 52,000 deaths and over 4,000,000 injuries occur on roadways within the United States and Canada (2, p. 29).

Features such as increased sight distance, increased lane widths, widened clear zones along the roadway, and wider higher type shoulders have been added to highway facilities in the United States to improve safety for the travelling public. These improvements work extremely well to provide adequate time for the driver to perceive approaching roadway conditions and/or to recover from an errant movement. However, in order to be effective, proper maintenance of such improvements is imperative.

One safety feature, the roadway shoulder, has been recognized as desirable since engineers began paving our roadways.

A shoulder is the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of the subbase, base, and surface courses. It varies in width from only 2 feet or so on minor rural roads . . . to about 12 feet on major roads (3, p. 338).

The width, uniformity, and stability of roadway shoulders vary greatly from roadway to roadway and along different sections of the same roadway.

Roadway safety standards have required that improvements be made in the integrity of the shoulder. This has been achieved by using construction materials that provide a more stable shoulder and by using a wider shoulder width, as shown in Figure 1. Also, shoulders are usually required along modern roadway pavement edges to provide a safer travel way for the motoring public.

Shoulders may be paved with concrete or asphalt, or stabilized with granular or other materials, and/or sodded. In some cases, roadways are resurfaced without restoring the adjacent shoulders to bring them up to the resurfaced roadway level (see Figure 2). This condition may lead to a vehicle's tires dropping off the pavement edge and, subsequently, lead to an accident. In fact, Zimmer and Ivey report a study which ranked pavement edge-shoulder dropoff among the top accident-related pavement disturbances (4).

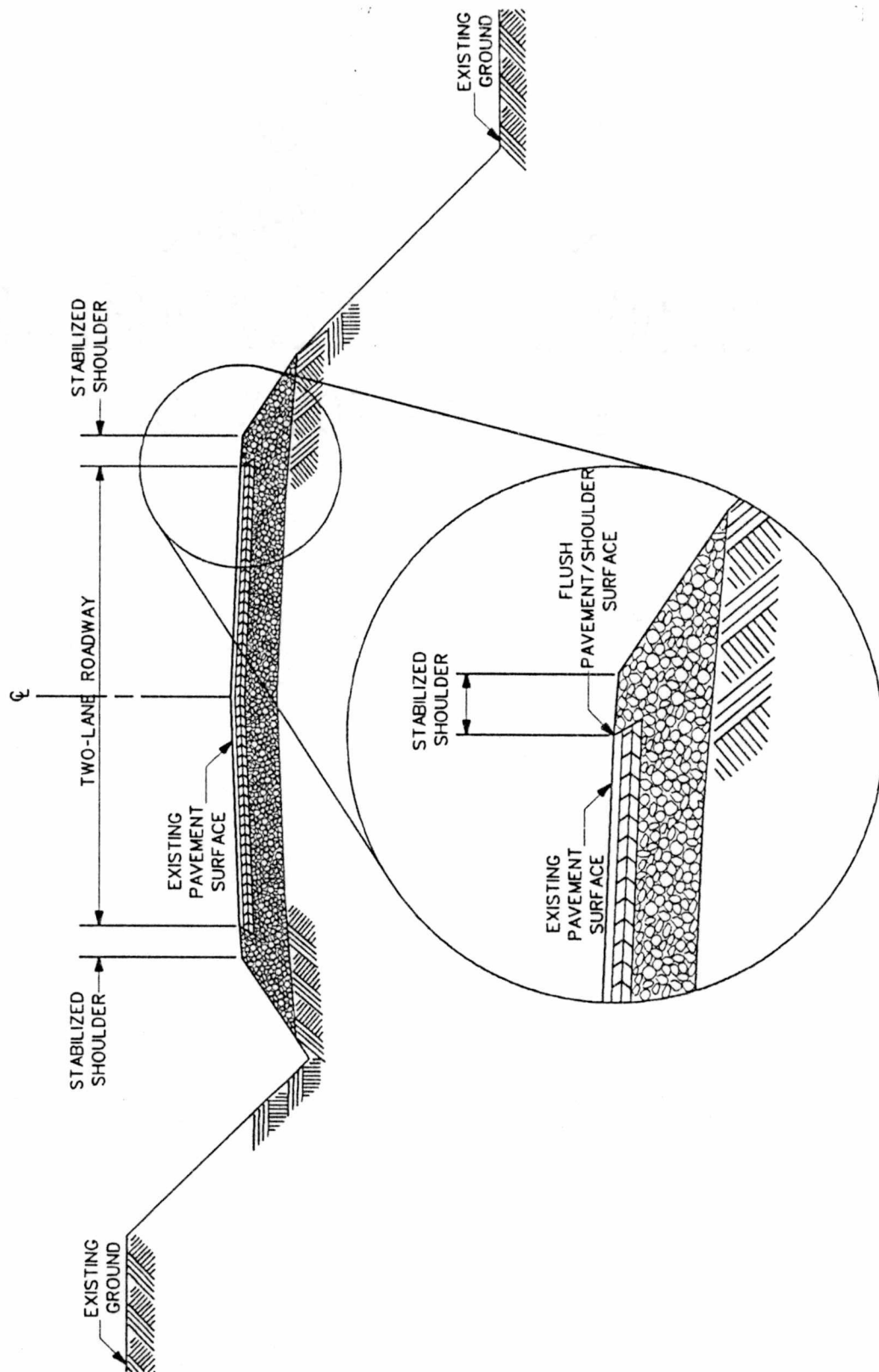


FIGURE 1: FLUSH PAVEMENT EDGE/SHOULDER JOINT DETAIL, BEFORE RESURFACING

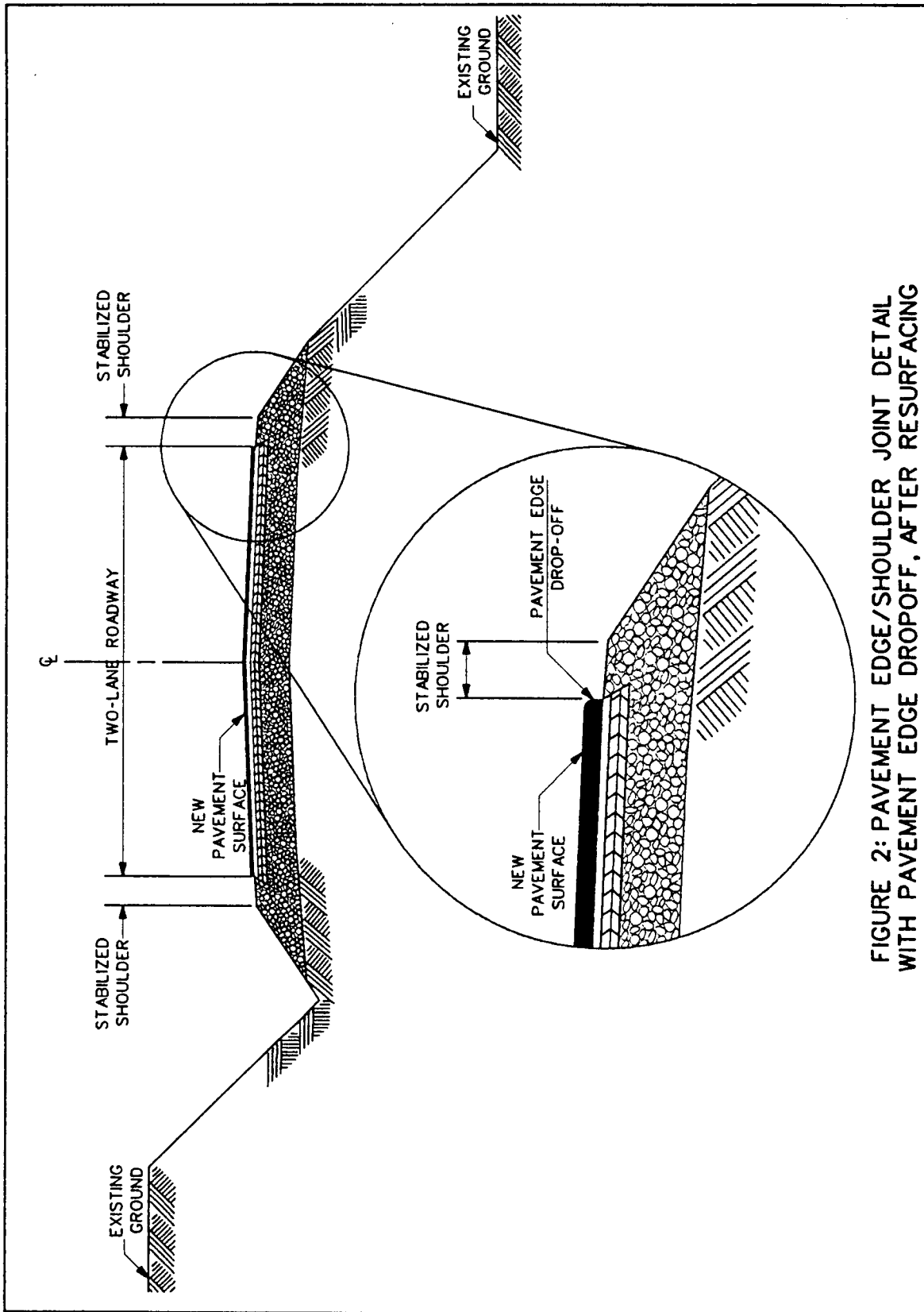


FIGURE 2: PAVEMENT EDGE/SHOULDER JOINT DETAIL WITH PAVEMENT EDGE DROP-OFF, AFTER RESURFACING

The function which roadway shoulders serve are defined as follows:

1. Provide stopping area for disabled vehicles or stopped vehicles.
2. Provide an area where a vehicle may avoid an immediate collision with an approaching vehicle.
3. Assist in protecting the edge of the travel lane from raveling and deterioration by water erosion.
4. Increase traffic carrying capacity of the roadway by:
 - (a) Providing effective additional lane width which offers greater steering tolerance.
 - (b) Providing additional lane space for slow-moving vehicle operations.
 - (c) Providing space for installing turning lanes, acceleration/ deceleration lane, or bypass lanes at intersections. Desirably, shoulders should be kept outside the turning lanes, but for lower volume facilities, they may serve as the turning lane.
 - (d) Providing space for detours around obstructions (work zone activities, etc.).
 - (e) Provide maintenance equipment work space.
 - (f) Provide access for pedestrians and bicyclist movement (5, p. 11-1).

In order to properly maintain a roadway, governmental agencies will either resurface deteriorated roadways themselves or contract the work to be performed by a resurfacing contractor. Typically, when this resurfacing activity is performed, the roadway travel lanes are resurfaced first and immediately following the shoulder areas are resurfaced. In some cases, the resurfacing contracts which are issued do not include the shoulder work portion. When these contracts are issued, it is typically with the understanding that the governmental agency will follow the contractor and resurface the shoulder area. Generally, this procedure is undertaken effectively. In some cases, the length of time between when the contractor

finishes the travel lane resurfacing and the agency finishes (or even begins) the shoulder resurfacing can be a period of several months.

During this time frame, the motoring public using this facility is exposed to a potentially hazardous condition. This type of dropoff condition can result in serious injury, death, and/or property damage. The repercussions of such an occurrence could involve a tort liability case where the governmental agency and/or contractor are named as defendants.

The purposes of this research are to identify general trends in the scope of work of resurfacing contracts which can lead to dropoffs, to identify the magnitude of contract work creating such dropoffs, and to recommend changes in the scope of work or practices covered by contracts to eliminate or mitigate dropoff conditions.

Conditions where existing roadway cross sections have side slopes which drop directly from the travel lane into a side ditch were not addressed in this study. These types of roadways typically do not have an existing shoulder. This study was confined to two-lane, rural roadways within the United States; however, the recommendations are valid for multilane facilities.

According to Dr. Jack B. Humphreys, professor emeritus of Civil Engineering at The University of Tennessee, over the past several years the number of traffic accident reconstruction cases allegedly caused by pavement edge dropoffs appears to have increased. Many of these

accidents have occurred where the roadway had been recently resurfaced and the shoulder had not been raised to the level of the roadway travel lane. In many of these contracts the shoulder restoration had been excluded and was intended to be performed by the agency work forces. Moreover, several legal jurisdictions have made specific judgments in regards to the pavement edge dropoff problems. These judgments relate to the duty and responsibility of the government to maintain a reasonably safe roadway, along with the specific magnitude of the dropoff in terms of height. Judgments have also been made concerning the amount of time the pavement edge dropoff is allowed to exist before the shoulder is to be improved.

In observing this pattern of traffic accident litigation, a decision was made to determine the magnitude of contractors accepting these types of contracts, and the magnitude of governmental agencies issuing these types of contracts. A proposal was then developed in response to a American Automobile Association Foundation for Traffic Safety request for proposals. The proposal was accepted and a contract was issued for the study.

CHAPTER 2

LITERATURE REVIEW

Roadway Shoulder History

Pavement edge dropoffs have been a known hazard for nearly forty years. In the 1954 and 1965 editions of the American Association of State Highway Officials (AASHO) *Policy on Geometric Design of Rural Highways*, it was stated that "unstabilized shoulders frequently are hazardous because . . . the shoulder at the pavement edge may be several inches lower than the pavement" and that "all types of shoulders should be constructed and maintained flush with the paved surface if they are to fulfill the function for which they are intended (6, p. 239). Recent editions (1984 and 1990) of the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets*, state that "regular maintenance is necessary to provide a flush shoulder. The dropoff can adversely affect driver control when driving onto the shoulder at any appreciable speed" (3, p. 342).

In 1979, Humphreys, Mauldin, and Sullivan at The University of Tennessee identified abrupt changes in elevation at the edge of the through-traffic lanes as a significant hazard in highway work zones (7). At the time of that study there were various aspects of the dropoff conditions

about which more information was needed, including the height of the dropoff, the time which the dropoff was to exist, and the level of traffic control which should be used for a specific condition. In their study, a high research priority was assigned to develop additional information regarding the vehicle dropoff and loss of control phenomenon.

Pavement Edge Dropoff Research

An extensive amount of research has since been performed on the topic of pavement edge dropoffs. The Texas Transportation Institute at Texas A&M University has completed several studies on the effects of driver response and vehicle reaction with respect to height and dropoff slope of a pavement edge dropoff. Dropoff related accidents typically begin when the right side tires of a vehicle drop from the roadway pavement surface to the shoulder. Then, upon the vehicle reentering the roadway, the driver oversteers, enters the oncoming lane of traffic, and is involved in a "head-on" or "side swipe" collision with another vehicle, or loses control and is involved in a single-vehicle accident.

Both tire and vehicle size are substantial factors in the influence a particular pavement edge dropoff has on a vehicle's ability to reenter the roadway. As the tire size (height) increases, the less influence the pavement edge dropoff has on the ability of the tire to mount the pavement edge. For example, a larger vehicle uses the tire size and vehicular momentum to

overcome the resistance force of the pavement edge which is induced on the tire.

Pavement edge dropoff slopes have different effects on the tire and reentry path depending upon their "effective edge height." Effective edge height is defined as "the point at which the tire rubs on the edge to generate an edge mounting force system" (8). Results of this research indicate that if the top edge of the dropoff is rounded, the characteristics may be generally the same as a sharp edge dropoff (Figure 3). Terms used to describe the relative degrees of safety in Figure 3 are defined as follows:

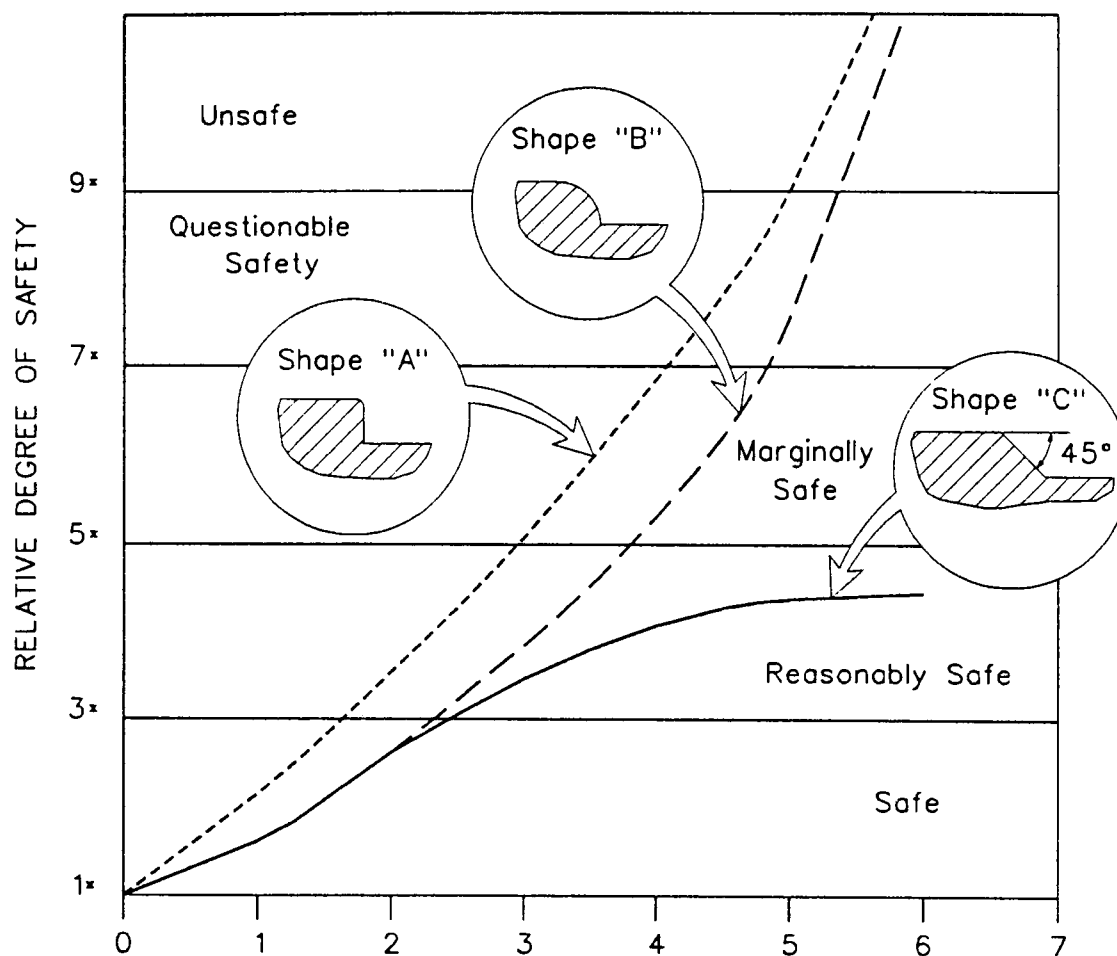
SAFE- No matter how impaired the driver or defective the vehicle, the pavement edge will have nothing to do with a loss of control. (This includes the influence of alcohol and/or drugs and any other infirmity or lack of physical capability.) (Includes the subjective severity levels 1 through 3.)

REASONABLY SAFE- A prudent driver of a reasonably maintained vehicle would experience no significant problem in traversing the pavement edge. (Includes the subjective severity levels 3 through 5.)

MARGINALLY SAFE- A very high percentage of drivers could traverse the pavement edge without significant difficulty. A very small group of drivers may experience some difficulty in performing the scrubbing maneuver and remaining within the adjacent traffic lane. (Includes the subjective severity levels 5 through 7.)

QUESTIONABLE SAFETY- A high percentage of drivers would experience significant difficulty in performing the scrubbing maneuver and remaining within the adjacent traffic lane. Full loss of control could occur under some circumstances. (Includes the subjective severity levels 7 through 9.)

UNSAFE- Almost all drivers would experience great difficulty in returning from a pavement edge scrubbing condition. Loss of control could occur under some circumstances. (Includes the subjective severity levels 9 through 10) (4, p. 46).



LONGITUDINAL EDGE ELEVATION CHANGE (inches)

* These numbers are subjective severity levels.

FIGURE 3: RELATIVE DEGREES OF SAFETY FOR VARIOUS EDGE CONDITIONS

Source: "Pavement Edges and Vehicle Stability --
A Basis for Maintenance Guidelines", page 45.

Meanwhile, pavement edge slopes of 1:1 (45°) or flatter present a lesser effective dropoff height as illustrated in Figure 4 (4, p. 45). This figure represents an effort to summarize all research and testing available for interpretation, including testing from CALTRANS, Systems Technology, and the Texas Transportation Institute.

Other factors which influence the path of the vehicle when reentering the roadway are the vehicle's speed and proximity of the tires to the edge of the roadway. Tires which have dropped off and are immediately adjacent to the pavement edge create a "scrubbing" condition (see Figure 5). When a scrubbing condition exists, a greater steering angle is required to climb the dropoff than when tires have dropped off and are several inches away from the edge of the pavement. The approach angle of the tire relative to the pavement edge then greatly affects the driver's ability to steer the vehicle onto the pavement and to remain in control without penetrating into the adjacent lane. The inability of the driver to remain in the right lane is due to the dynamics of the forecasting on the vehicle at the time the scrubbing tire reenters the roadway. In a fraction of a second, the resisting force acting against the tire is conquered. Consequently, research shows that before the driver can react (in less than one wheel revolution) "the cornering force may have doubled due to increases in the available friction on the pavement and the right front wheel load due to cornering." Then, "the vehicle yaws radically to the left, pivoting about the right rear tire, until that wheel can be

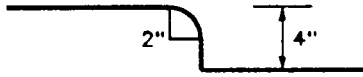
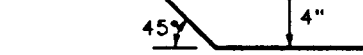
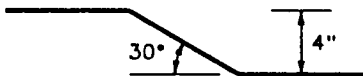
Condition	Pavement Edge Profile	Effective Edge Height, h_e , inches
1		4.0
2		2.5
3		1.5
4		0.75
5		0.75
6		0.75
7		0.50
8		0.20

FIGURE 4: PAVEMENT EDGE PROFILES, EFFECTIVE EDGE HEIGHTS, AND INITIAL STEER ANGLES

Adapted from: Don L. Ivey and Dean L. Sicking, "The Influence of Pavement Edge and Shoulder Characteristics on Vehicle Handling and Stability", page 35.

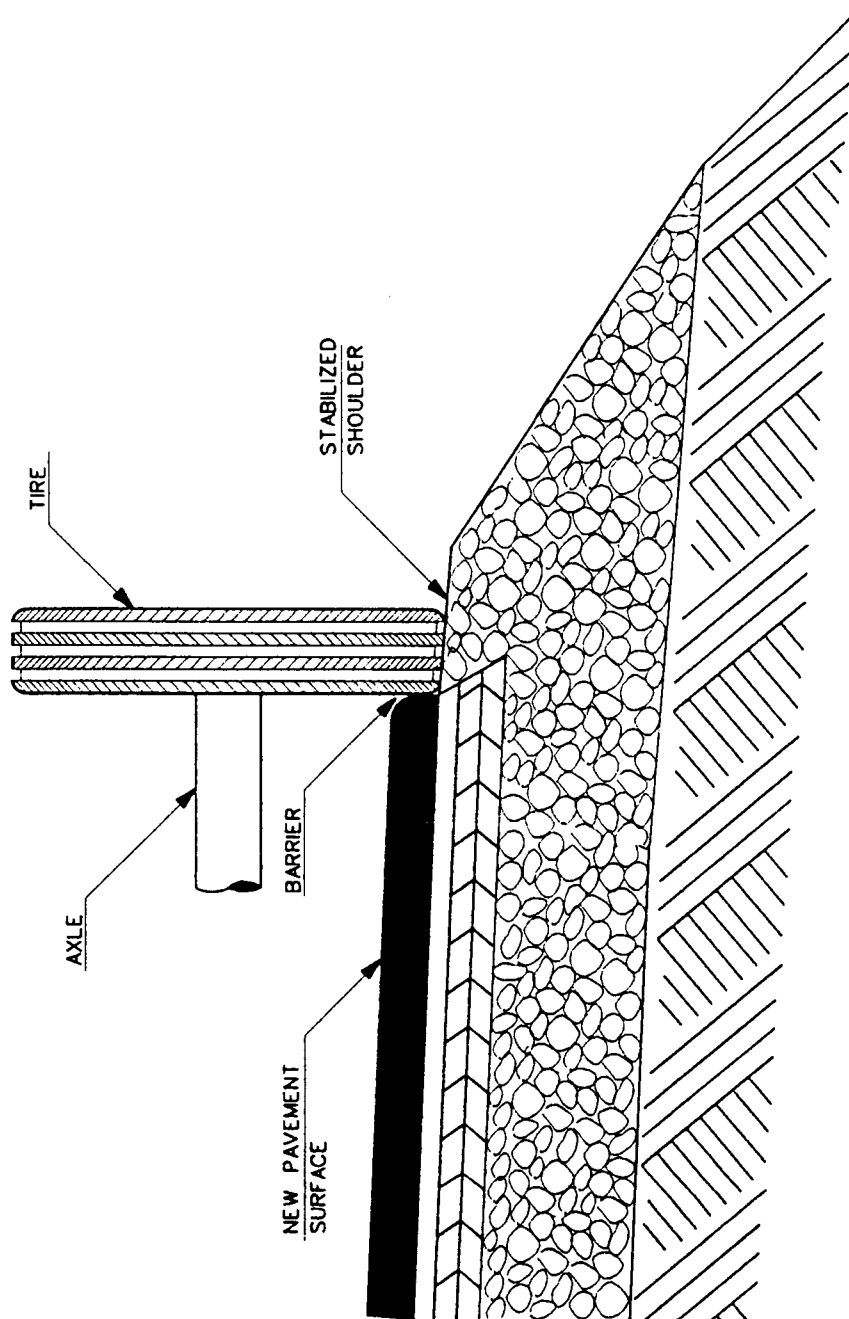


FIGURE 5: TIRE AGAINST BARRIER OF PAVEMENT EDGE DROPOFF

dragged upon the paved surface" (4, p. 42). This results in the redirection of the vehicle toward and/or into the adjacent lane.

Resulting Behavior on Vehicle Dynamics

Resulting behavior on vehicle dynamics, due to a pavement edge dropoff, is that when a driver attempts to bring a tire back onto the roadway, the dropoff acts as a barrier against the tire, preventing it from easily reentering the roadway. This barrier is directly influenced both by the effective edge height of the pavement edge dropoff and whether or not the tire is scrubbing against the pavement edge. If the right front tire is scrubbing, the driver turns the tire sharply toward the roadway and applies more steering force to the tire than would be necessary if the tire was not scrubbing. When this condition occurs and the tire mounts the dropoff, the driver has usually oversteered which then results in the driver losing control of the vehicle. As a consequence of this loss of control, any of the following may occur (9):

1. The vehicle may have a head-on collision with or side-swipe an oncoming vehicle in the opposing lane of travel.
2. The vehicle may strike the ditch or other physical obstacle on the opposite side of the roadway.
3. The vehicle may go into a skid condition on the roadway and perhaps overturn.

4. The driver may overcompensate to the right and strike the ditch or other physical obstacle on the right side of the roadway.
5. The condition may be corrected and no accident occurs.

One solution to this problem is to install a asphalt fillet with at least a 45° angle. Research shows that "the use of a beveled edge, with a bevel angle of 45°, was found to greatly reduce the control problems attributable to edge drops" (10, p. 99). As shown in Figure 6, adding a 45° fillet along the pavement edge dropoff enables a vehicle to reenter the roadway more easily without oversteering into the oncoming traffic lane (Figure 7). During a meeting with Dr. Jack B. Humphreys at the Texas Transportation Institute, Dr. Don Ivey stated that "a 45° slope is better for all cars and trucks under all conditions."

Typical Construction Procedures

Typical roadway construction procedures include the maintenance of shoulders. This demands continuous attention as a protection to traffic because the failure of many pavements starts at the edge of the travel way. Also, "shoulders should be maintained smooth and flush with the pavement" (11, p. 33). In order to obtain a smooth and flush transition between the roadway travel lane and the shoulder, the travel lane is first resurfaced followed by resurfacing of the shoulder area. When the shoulder area is resurfaced, the asphalt spreader is allowed to ride along the travel lane

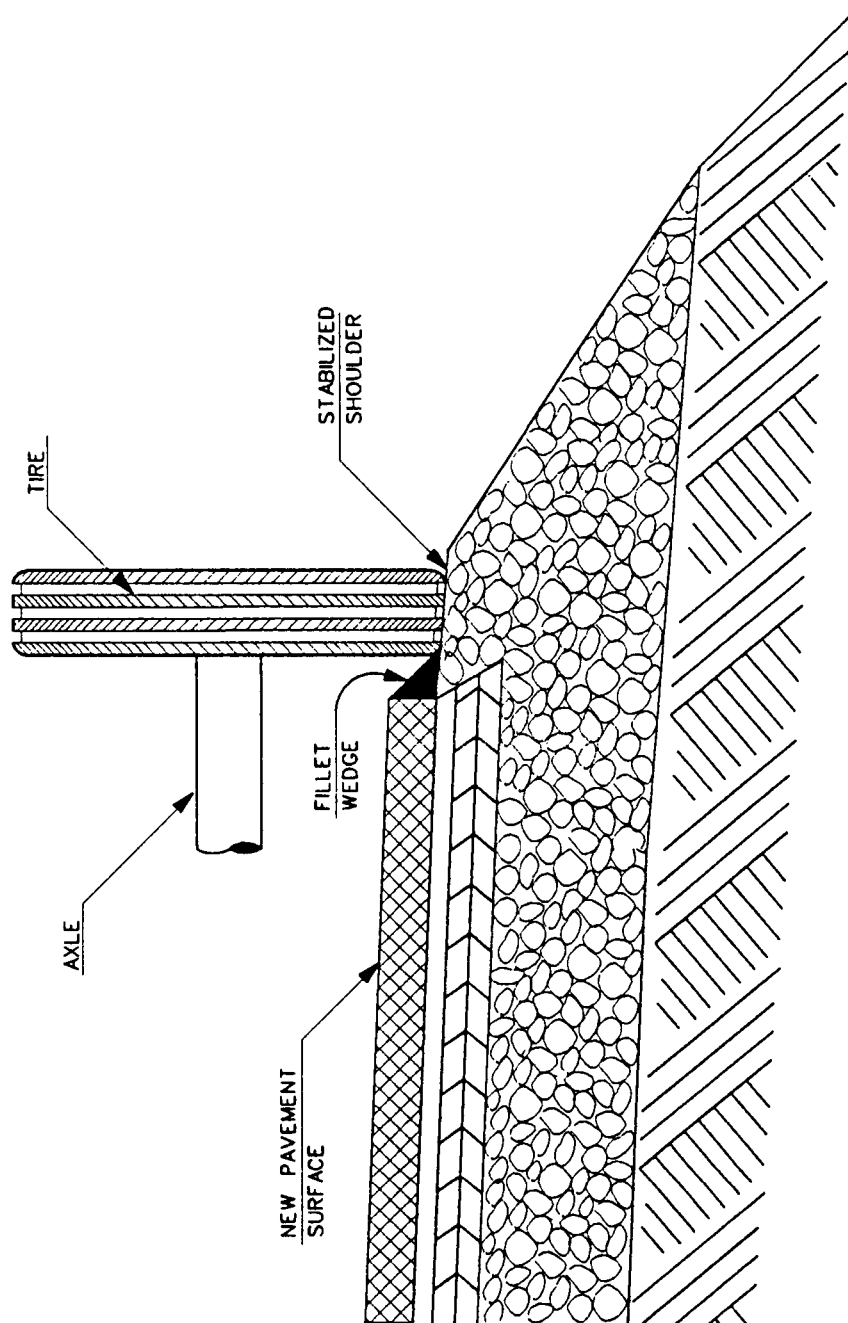


FIGURE 6: TIRE AGAINST PAVEMENT FILLET WEDGE

NOTES ABOUT TEST CONDITIONS:

- 1.) LANE WIDTHS OF TWELVE (12) FEET WERE USED; AND
- 2.) INITIAL VEHICLE SPEED OF 50 MPH (73.33 F/S).

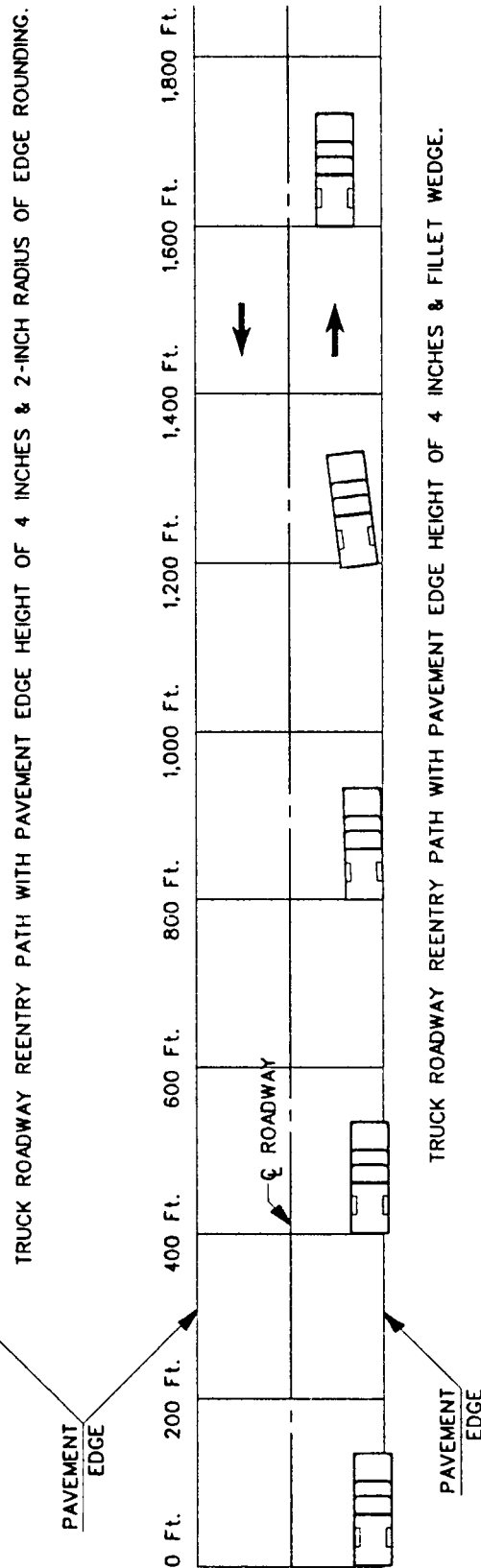
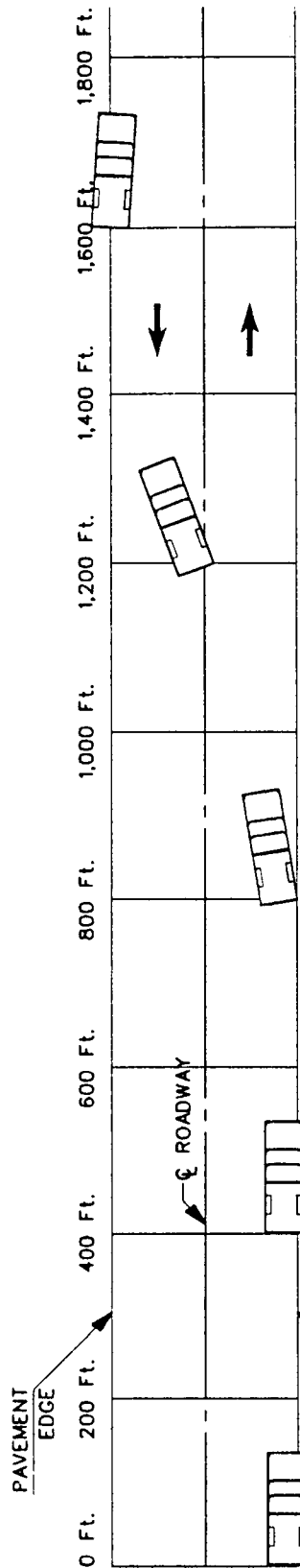


FIGURE 7: INFLUENCE OF DIFFERENT PAVEMENT EDGES ON VEHICLE REENTRY PATH

Source: Don L. Ivey and Dean L. Sicking, "The Influence of Pavement Edge and Shoulder Characteristics on Vehicle Handling and Stability", pages 37 & 38.

surface in such a manner as to produce a perfect match. Typically, these operations are performed within a relatively short time period. A shorter time period corresponds to less exposure time the motoring public has to a potentially hazardous roadway condition. When a pavement edge dropoff condition is allowed to exist for a long period of time, the probability of an accident occurring increases dramatically.

Additionally, construction signs are typically installed to warn the motorist of the change in the roadway condition. The "LOW SHOULDER" sign is commonly used for this particular problem. Barricades, drums, or vertical panels are sometimes used to delineate the edge of the safe travel lane. These traffic control devices provide a positive guidance system for the motorist to follow.

Accident Statistics

Accident data statistics related to pavement edge dropoffs were very difficult to obtain. Many publications either do not include this type of data or note that the data are troublesome to decipher accurately. This was due both to the lack of detail given in many traffic accident reports about the cause of the accident or to having more than one causative factor mentioned in a report.

During the search for accident statistics, the Federal Highway Administration (FHWA) Office of Highway Safety was contacted in regard to

pavement edge dropoff accident statistics. The records kept in their office are developed from police accident reports. They reported that information of that degree of detail is usually not identified by the investigating officer.

Overall, it was difficult to obtain statistics on the number and severity of traffic accidents that were actually caused by the problem of pavement edge dropoffs. However, the amount of research completed on this subject indicates that other engineering professionals recognize the severity of the problem. In order to obtain additional information, a legal case review was conducted to further determine the impacts of accidents involving pavement edge dropoffs. The legal case reviews are discussed in the following chapter.

CHAPTER 3

LEGAL LIABILITY CASE REVIEW

Safety related issues have become a more important concern not only to the vehicle drivers but to courts as well. The responsibility of providing driver and passenger safety is challenged frequently in court. In some cases, the forfeiture of safety is due to some action(s) by the driver; however, in other cases it is the failure of a governmental agency to maintain a reasonably safe roadway. In many cases:

The courts across the nation have held that although the state governments are not the insurer of the safety of the user of the highway. However, they have indicated that state and local governments are required to maintain streets and road in a reasonably safe condition for the users. (2, p. 439)

Where an agency is negligent in its duty to maintain a reasonably safe roadway, tort liability action may be successfully brought against the agency.

Tort Liability

Tort liability is basically defined as a civil wrong. It is an overt act or omission that results in injury or loss to a person (plaintiff) or damage to a person's property. When tort liability cases involve serious injury or death, the affected person may seek compensation through a civil lawsuit.

Therefore, the governmental agency (defendant) causing the wrong may be liable for repayment of the damages (12).

Typically there are five elements a plaintiff must establish in order to prove negligence against a governmental agency:

1. The defendant had a duty to the injured. For example, public entities have a duty to maintain their street and road system in a reasonably safe condition.
2. There was a breach of that duty. For example, there was a failure or an abuse of discretion in the design, or a failure, in the operation or maintenance of the system.
3. The breach of duty was the *proximate cause* of the injury. The proximate cause is the legal cause of the injuries or damages that are sustained. Generally, when an accident has occurred it has two causes:
 - a. The actual cause: For example, the cause of a right angle intersection crash was the fact that the traffic signals were completely out, not operating.
 - b. The proximate cause: the proximate (legal) cause in the example was the fact that the signals were not maintained properly. The breach of the proximate (legal) cause determines how liability will be assigned to a particular individual or public entity.
4. There was no contributory negligence on the plaintiff's part. In some states, if the plaintiffs have contributed to their own injuries, they are precluded from any recovery. . . .
5. There must have been damages. To recover, the injured party must have suffered some kind of personal injury or property damage. The purpose of the award is to put the injured parties back in the position in which they were prior to the accident, either to rehabilitate them, or to reimburse them for the monetary loss. (2, p. 439)

In many pavement edge dropoff litigation cases, the defendant is willing to settle the claim out of court. This may be for several reasons, such as minimized costs associated with legal defense, reduced publicity of the accident, weakness of defense, and/or possibility of courts awarding the

plaintiff a larger compensation. As a result, these pavement edge dropoff cases are not recorded in legal records. The following case examples illustrate several topics associated with pavement edge dropoffs.

Court Judgments of Shoulder Defects

Courts recognize the fact that in cases where the roadway shoulder condition was an issue, highway officials must anticipate traffic accidents and consider that fact when operating a highway system (13).

According to the courts, it is now well established that governmental agencies have a duty to exercise reasonable diligence to maintain their streets and highways in a reasonably safe condition. This duty applies to the uses for which the roads were established and extends to the road shoulders. In some cases, there is disagreement among the courts concerning the extent of this duty. When a defendant uses the defense that the plaintiff was using the shoulder area of the roadway for a nonemergency driving surface, concern may arise regarding the intended use of the roadway shoulder. In many cases, the defendant perceives the use of the shoulder is for emergency use only. However, many courts believe that whether the shoulder is to be used for emergency use or nonemergency use is not associated with the issue of a dropoff condition. In many cases, the courts have approached the nonemergency use issue as no defense. Additionally, the courts have addressed two primary issues related to the

scope of this research. First is the amount of time that is reasonable in which to expect a governmental agency to complete the shoulder restoration and second is the height magnitude of a dropoff that constitutes a dangerous condition.

The issue of whether a party using the shoulder in a nonemergency situation may recover for injury and/or damage caused by a defect in the shoulder is discussed in the following cases.

Nonemergency Use of the Shoulder. The courts rejected the view that the governmental entity's duty to maintain its shoulders in a reasonably safe condition applies only where use of the shoulder was necessitated by an emergency. This rejected the contention of the governmental agency that it owed no duty to maintain the shoulders of a highway other than to a driver who was compelled to leave the traveled portion of the highway in an emergency situation. In the 1971 case of *Terranella v. City and County of Honolulu*, the Supreme Court of Hawaii held that: (1) a statute, giving the county the duty to maintain and repair all county highways, contemplated a duty on the part of the county authorities to exercise ordinary care to keep safe not only the part of the road or highway customarily used by the traveling public but also the part contiguous to the traveled area; and (2) at least where the defendant had or should have had knowledge of the

irregularity in the shoulder, the county should be held liable where the shoulder was found to be defective (14).

The court reasoned that the determination of what was and what was not an "emergency" would be exceedingly difficult and could only lead to hopeless confusion. Furthermore, such a rule would create a temptation, on the part of an injured driver, to describe the circumstances surrounding a departure from the paved portion of a highway as having been required by an "emergency" regardless of his real reason for using the shoulder (14).

A similar 1991 ruling by the New York Supreme Court, Appellate Division appears in the case of *Protzman v. State* (15). The case is described thus:

Passenger in automobile struck by vehicle, whose driver's attempts to regain highway from three to four inch drop to shoulder resulted in vehicle shooting across road and striking vehicle in which passenger was riding, brought action against State alleging neglect in its duty to properly maintain shoulder of highway and in permitting dangerous condition to exist after notice. (15, p. 147)

The court ruled that the State had a duty to maintain the shoulder of the highway in a reasonably safe condition. Moreover, while the nonemergency use of the shoulder may have been a defense in an action by the driver of the out-of-control vehicle" it could not be used for defense against the plaintiff because the plaintiff did not use the shoulder of the roadway or act in any way to contribute to the accident. The decision was in favor of the plaintiff on the issue of liability.

Negligence in Delaying to Repair Dropoff. In the case of *Brandon v. State, Through Department of Highways* (1979), passengers in a vehicle were injured and/or killed when their vehicle went onto the shoulder, which was several inches below the recently resurfaced highway, and overturned. The Court of Appeal of Louisiana, Second Circuit, held that the highway department was negligent in failing to bring the shoulders up to grade for five months after the overlay was complete. The court recognized that the department had installed construction and low shoulder signs during construction. However, the courts noted that the department had a duty to remove construction hazards within a reasonable time. The court also noted that what constitutes a reasonable time depends on such factors as the extent of the project, availability of materials and manpower, safety and economic aspects of construction, and nature and degree of the hazard created. The court observed that once the department has created a hazardous condition during construction, the priorities that would excuse noncompletion would have to be of high order and almost emergency proportions (16).

Roadway Travel Lane and Shoulder Connection. The issue in *Edwards v. State, Department of Transportation & Development* (1981) was the roadway travel lane and shoulder connection (17). The Court of Appeal of Louisiana, Third Circuit, stated that the department was negligent in allowing

a three-inch dropoff resulting from a road surface overlay to exist for a period of more than two months before the accident occurred. The plaintiff alleged that it is an absolute necessity for the functional use of a shoulder to have a connection between the roadway and shoulder that allows for a safe and gradual movement between the surfaces. The court concluded that the department was negligent because it was aware of the obviously dangerous dropoff but failed to correct it within a reasonable time. The court further held that the department was strictly liable under a state statute. The court explained that the department was strictly liable because: (1) it had custody over the highway and its shoulders; (2) the shoulder was defective at the time of the accident; (3) the defect in the shoulder created an unreasonable risk of injury; and (4) the defect was a cause-in-fact of the plaintiff's damages.

Summary. These examples of actual legal cases indicated that there are many different aspects associated with accidents involving pavement edge dropoffs. Nevertheless, the court systems generally have held that the governmental agencies have a duty to maintain a reasonably safe roadway for the travelling public.

CHAPTER 4

REVIEW OF PRACTICES

Roadway Maintenance Responsibilities

Roadway maintenance responsibilities are categorized differently from state to state. Some states, such as North Carolina and Virginia, perform all of the roadway design, construction, and maintenance outside city limits; therefore, counties and local governments in these states are not involved in the roadway process at all. Other states, such as Arizona, Florida, Illinois, Maryland, and Oregon, require that county and local governmental agencies be responsible for design, construction, and maintenance for a portion of the roadway facilities. Consequently, some local governmental agencies are free to chose to administer roadway management as they deem necessary.

Focusing on the aspect of roadway resurfacing, some governmental agencies choose to do the maintenance with their own work forces, while others choose to contract the entire maintenance procedure to a private maintenance contractor. Still others choose to contract a portion of the roadway maintenance work. If the latter is chosen, a contract may be written with the scope of work requiring the contractor only to resurface the roadway from edge of pavement to edge of pavement, excluding the restoration of roadway shoulders. The shoulder restoration is then to be

accomplished by the responsible governmental agency. In many cases, a timely shoulder restoration is performed and a safe driving surface is achieved. In other cases, when the resurfacing is added to the roadway surface the contractor has fulfilled his contractual requirements. The contractor is then compensated and released from the project. Meanwhile, the shoulder has not been raised to the same elevation as the edge of pavement and will not be until the governmental agency crews can schedule the project. Often this may take several weeks, or months, during which time the roadway has a pavement edge dropoff but the roadway is open for public use. Reasons for the governmental crews not performing timely shoulder work vary but commonly include the following:

1. Work crews may be behind schedule on other projects;
2. Work crews may be experiencing heavy work loads; and
3. Capital funds may be exhausted for the fiscal year.

During the time the roadway has a pavement edge dropoff, safety may be severely compromised and, depending upon the height and slope of the dropoff, the hazard may be serious.

Pavement Edge Dropoff Development Factors

Situations which can lead to a pavement edge dropoff are not purely due to the new layers of pavement added to the existing roadway surface. In many cases, the existing roadway shoulder may have been worn away by

traffic prior to the installation of the new pavement. As these areas of wear vary along a roadway edge, so does the amount of dropoff. Thus dropoffs unrelated to paving may vary from a negligible amount up to several inches. Areas of greater dropoff usually occur where drivers change the direction of their vehicles, such as at the insides of curves. The off-tracking associated with trailers can contribute to dropoff development on the inside of curves. When a typical 2.5-inch overlay of new asphalt is applied, a nominal dropoff can easily exceed 4 inches. In these situations, a driver may encounter a difficult section of roadway which may result in the tires dropping from the roadway surface at a point where the tires of many other vehicles had dropped off prior to the resurfacing. Immediately after repaving the dropoff may reach a height that seriously challenges the ability driver to steer the vehicle to reenter the roadway.

Pavement Edge Dropoff Solution

Since research and common sense show that a sloped edge is easier for a tire to climb, the use of an asphaltic fillet or angled edge would help alleviate the problems associated with pavement edge dropoffs. Installation of this asphaltic fillet can be accomplished easily with today's modern paving equipment. By simply attaching a device known as a "molding shoe" to the paving machine, an asphaltic fillet can be formed along the pavement edge as the overlays are placed on the roadway surface. The molding shoe

not only forms the shape of the asphalt fillet, but it also reduces the amount of hand work required to finish the pavement edge.

Compaction of the asphalt fillet can then be accomplished by the use of an edge compacting device attached to the compaction rollers. "It consists of a hydraulically powered wheel which rolls alongside the compactor's drum while simultaneously pinching the edge of the mat towards the drum and providing lateral resistance" (18, p. 9). Different types of molding shoes are in use today in the paving industry. Many are fabricated by individual contractors to fit their own paving screeds and may be adjusted to provide various angles or side slopes at the edge of a paving pass. In general, the lay-down costs associated with using the molding shoe are insignificant.

Pavement Edge Dropoff Solution Cost

Additional material quantities and costs are minimal for the added fillet wedge. For example, when resurfacing a typical 24-foot wide, two-lane rural roadway with two 12-foot lanes, a 1.5-inch leveling course of asphalt and 1-inch surface course of asphalt are typically used for a total of a 2.5-inch overlay. The corresponding asphalt volume required per mile of overlay is 978 cubic yards. The volume of asphalt required to place a 45° fillet along each side of the same roadway is 8.5 cubic yards. This fillet

wedge volume equates to less than 1 percent of the roadway asphalt overlay requirement.

Many rural roadways may have sections with dropoffs of 1-2 inches or more before resurfacing is undertaken. In such cases overlays with a 45° fillet will require somewhat more asphaltic concrete, but not an excessive amount. For example, where the dropoff could be as much as 4.5 inches (2.5 inches of new asphalt and 2 inches of existing dropoff), the asphalt volume required to place a continuous fillet along both sides of a 1 mile length of roadway would be 27.5 cubic yards or 2.8 percent of the roadway asphalt overlay requirement. According to discussions with resurfacing contractors, the effort might be considered as incidental and would not increase the unit cost of asphalt placement. Thus, the increased cost, usually paid for in dollars per ton of asphalt, would only be 1-2 percent of the typical resurfacing contract.

Pavement Edge Dropoff Solution Benefits

Benefits of using an asphaltic fillet are profitable for both the long-term life of the roadway and the short-term duration of the repaving project. These benefits are as follows:

1. Increased safety during construction, due to the ease of bringing a tire back onto the roadway surface after it has dropped to a

shoulder that has not been raised to the new roadway surface elevation;

2. Increased future safety for drivers trying to reenter the roadway once the shoulder material is again worn away over time by tires on the roadway shoulder and by erosion; and
3. Added protection from roadway drainage for the roadway base and subbase materials.

These improvements in of roadway resurfacing will increase both roadway life and user safety at a minimal cost and effort.

CHAPTER 5

DATA COLLECTION METHODS

Study Approach Outline

The first step was to ascertain whether or not resurfacing of rural roads without bringing the shoulder up to the roadway grade was a problem of national scope. The sampling strategy was primarily directed toward the county or small town/city environment. This was because the work force personnel are required to perform several different seasonal work tasks and budgets are typically more limited about contracting work. With this in mind, the results of questionnaire returns were expected to be gross general trends and not specific patterns.

Several methods were employed to determine the magnitude of contracts issued nationally that did not include shoulder work. The following outline shows the study approach strategy which was used in obtaining the data for this research:

1. Organized discussions and interviews were conducted at a roundtable meeting with county engineers, public works directors, transportation consultants, transportation training specialists, and a staff member of the National Asphalt Paving Association at the

national 4-R Roads and Bridges Conference in Cincinnati, Ohio, in December 1991.

2. Questionnaires were developed and mailed nationwide to resurfacing contractors to determine the experience and opinions of contractors who had been involved in litigation involving pavement edge dropoffs and to locate company contacts to discuss the problems associated with contracts which exclude shoulder work.
3. Questionnaires were developed and mailed nationwide to members of the Public Risk Insurance Managers Association in order to obtain a viewpoint of an organization which is in the business of protecting governmental agencies from liability in matters such as pavement edge dropoffs.
4. Structured meetings and telephone conversations were conducted with contractor contact persons listed in the returned contractor questionnaires. Discussions revolved around any experience with traffic accident litigation relative to contracts excluding shoulder work, and how the problems associated with this type of contract could be solved or mitigated.
5. Structured personal meetings were held with city and county engineers to discuss their experiences, viewpoints, and

awareness of contracting roadway resurfacing with the exclusion of shoulder work.

6. Telephone conversations were conducted with governmental legal departments to discuss the viewpoints of perceived liability and to determine if these departments had been involved in any lawsuits involving alleged pavement edge dropoff accidents.
7. Reviews were made of previous pavement edge dropoff litigation cases to determine existing conditions of the accident scene, events leading up to the accidents, common factors that were considered in these cases, and the court rulings.

Questionnaire Development

When developing the questionnaires, careful consideration was given to comments which had been made in the structured meetings and other discussions with contractors and governmental officials. These comments helped promote questions that aided in determining the philosophy of both the contractors and public risk managers.

In order to uniformly compare the responses from the questionnaires which were sent to resurfacing contractors and to public risk insurance managers, the same basic questions and format were used.

Information requested on the contractor questionnaire included the following, with reasons for the requested information shown in parentheses:

1. State(s) in which company normally does business (to determine in what region of the country the company operates and how large of an area it serves);
2. Number of years in operation (to gauge the experience of the company and possible exposure to this type of resurfacing problem);
3. Average dollar amount of rural, two-lane roadway resurfacing (to determine size of the company's operation);
4. Approximate number of miles of rural, two-lane roadway resurfacing (to gauge the approximate amount of roadway resurfacing performed annually);
5. Approximate percentage of contracts that do not require the contractor to build the shoulder back to grade (to determine both the amount of contracts being issued without shoulder work and the relative degree of exposure to the problem of pavement edge dropoffs);
6. Extent of warning of shoulder dropoff if shoulder work is not included in the contract (to determine if contractor puts forth an extra effort for safety);
7. Involvement in any legal actions where it was alleged that a traffic accident resulted from a pavement edge dropoff where shoulder restoration was not included in the contract and, if so,

how many (to obtain information about the problems and results with this type of contract);

8. Contractor opinions as to whether or not adding 2.5 inches of resurfacing to a rural, two-lane roadway without bringing the shoulder up to grade results in a hazard to the motorist (to determine contractor thoughts about the pavement edge dropoff hazard); and
9. Willingness to discuss the issue and, if so, name and number of contact person (to obtain name and number of person to speak with about the problem and possible recommendations or thoughts about how to correct this type of problem).

Copies of the questionnaires for both contractors and public risk insurance managers are included in the Appendix.

Survey Administration

First, discussions and interviews were conducted at the roundtable meeting at the national 4-R Roads and Bridges Conference in Cincinnati, Ohio, in December 1991. Several of the engineers and public works officials attending expressed concerns and told of their experiences regarding roadway pavement edge dropoffs. A few of the engineers in attendance were unaware of the problems associated with the pavement edge dropoff.

The overall consensus was that pavement dropoffs, especially during construction, present significant problems that need to be addressed.

Contractor Questionnaires

Next, a contractor questionnaire and corresponding form letter were developed to obtain the information required to determine the proportion of the resurfacing contracts that do not include shoulder work as a part of the scope of work of the project. The responses to the questionnaire also aided in determining the magnitude of the problem of pavement edge dropoff accidents. A mailing list of resurfacing contractors covering 14 states was obtained, and the form letter and questionnaire were mailed. States included in the resurfacing contractors survey were Alabama, Arizona, Arkansas, Florida, Georgia, Kansas, Kentucky, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

Maps of the United States have been developed to illustrate the distribution of the questionnaires and corresponding returns. Each of these maps outline the states that make up the FHWA region boundaries. The FHWA boundaries divide the country into ten different regions. Region II contains federal lands, and national parks and is not included in this study.

FHWA developed these regions by considering the total amount of federal roadway work performed annually across the nation. This total was then divided equally into nine regions plus Region II. Therefore, by using this

division, all regions across the nation should be proportionally represented by the percent of questionnaire returns. For the purposes of this study, the U.S. territories were excluded from these maps. This method of dividing the United States is commonly recognized in the field of transportation engineering.

Figure 8 illustrates the nine different FHWA regions sampled in this study. Figure 9 illustrates the national distribution of questionnaires that were sent to resurfacing contractors. Figure 10 illustrates the national distribution of questionnaires that were returned from resurfacing contractors.

Upon receiving the mailing, many of the contractors contacted their corporate attorneys, who in turn contacted the researcher to find out more about how the questionnaires were going to be used. After the researcher assured the attorneys that all data having any identifying information would be removed (company name, respondent name, and location of business), most attorneys still declined to participate in the study. As a result, only a few of the contractor questionnaires were returned. This low questionnaire return by the contractors (only 10 percent of 71 questionnaires mailed) made it necessary to personally contact some of the contractors that had not responded. Some of the contractor representatives were very helpful, while others displayed a reluctance to talk about the problem of pavement edge dropoff. Others requested that the direct contact be made through their

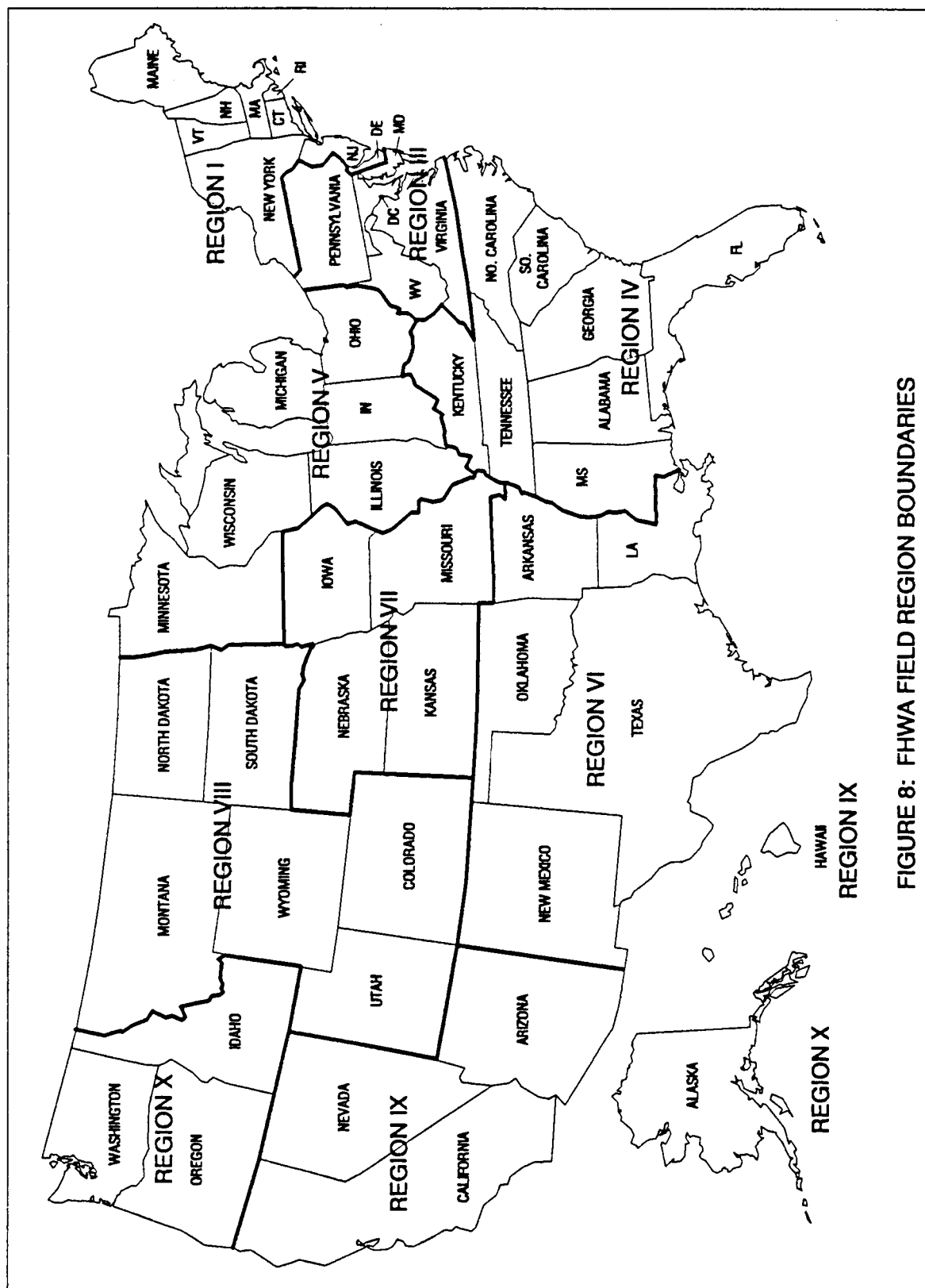
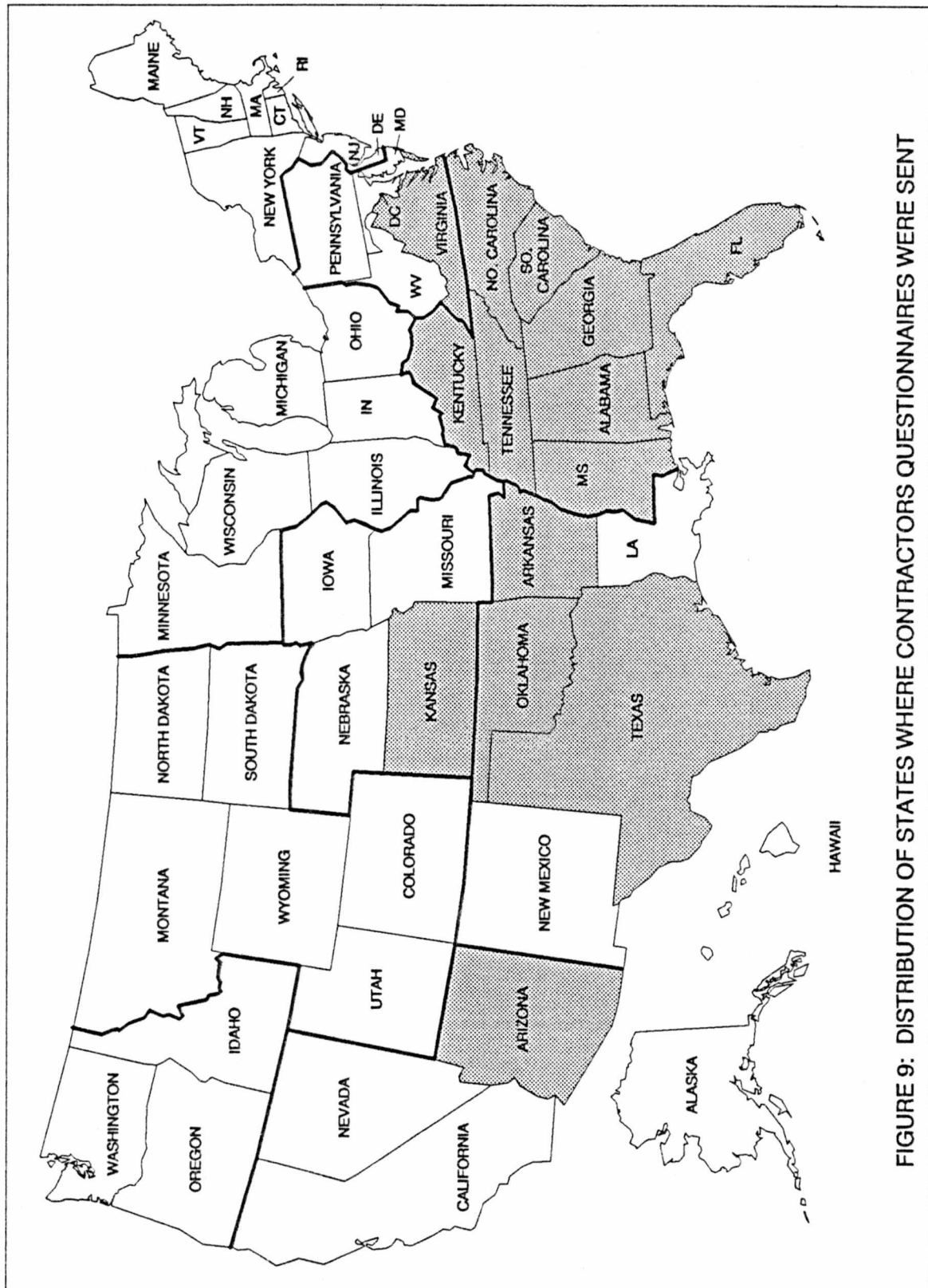


FIGURE 8: FHWA FIELD REGION BOUNDARIES



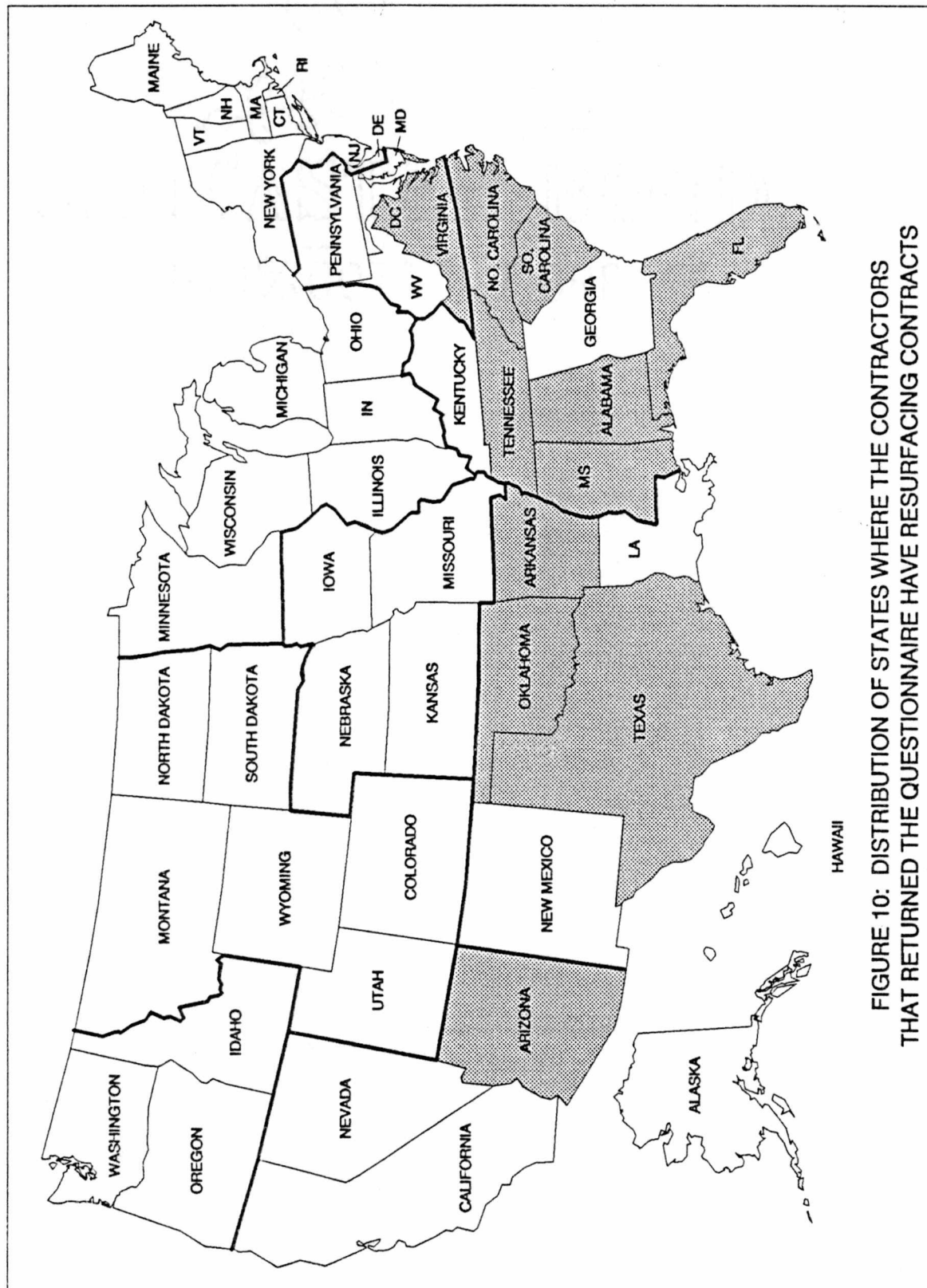


FIGURE 10: DISTRIBUTION OF STATES WHERE THE CONTRACTORS
THAT RETURNED THE QUESTIONNAIRE HAVE RESURFACING CONTRACTS

corporate attorneys. These attorneys were also concerned about who was conducting the study, why the study was being conducted, and who would see the final report. Again, even with assurances that the sources of the data would not be divulged, these attorneys still responded with short, vague answers. They expressed concern about governmental agencies reading a report in which the agencies were criticized, possibly causing agencies to ban the contractors from future projects.

Subsequent telephone conversations with the contractors that did respond pointed out that the problem of pavement edge dropoffs is very real. These contractors told of cases where the governmental agencies would be several months behind in raising the shoulder. These and other contractors stated that some governmental agencies would not approve or pay for placing signs along a roadway where pavement edge dropoffs exist. Contractors also reported that most dropoff related accidents occur late at night in a section of the project that has been completed.

Public Risk Manager Questionnaire

After the limited response by the contractors, other sources were sought and contacted. The Public Risk Insurance Managers Association was contacted at the national level and asked to assist in this research by providing a randomly generated mailing list of public risk managers across the nation. After the association's board of directors approved, a list of 417

names and addresses of public risk managers in 42 states was provided and used to distribute another questionnaire. This questionnaire was developed for public risk managers by modifying the contractor questionnaire to apply to the governmental sector. The use of a modified version contractor questionnaire allowed a more analogous comparison between the two groups.

Some of these questionnaires reached practitioners in the public sector other than agencies responsible for roadway resurfacing, such as public school systems and hospitals. Nevertheless, questionnaires from agencies responsible for resurfacing roadways were returned from 32 states. States from which questionnaires were received are Alabama, Arizona, California, Colorado, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Utah, Virginia, Washington, and Wisconsin. Figure 11 illustrates the national distribution of questionnaires that were sent to public risk managers. Figure 12 illustrates the national distribution of questionnaires that were returned from public risk managers. Tables 1 and 2 illustrate the distribution of questionnaire mailings and returns, respectively, by FHWA region. These tables show a relatively even distribution obtained across the nation for both the mailings and returns in the public risk manager questionnaire.

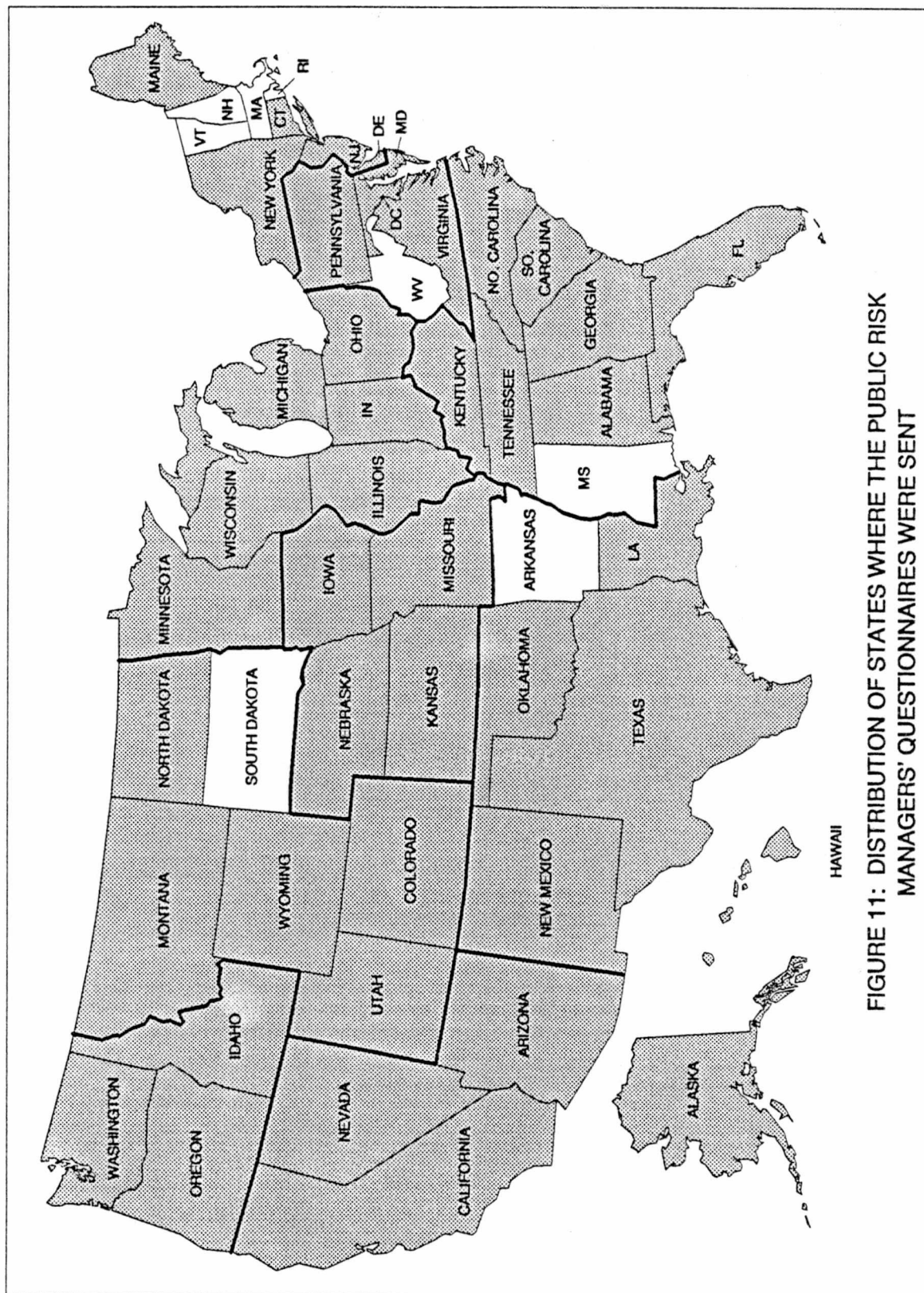


FIGURE 11: DISTRIBUTION OF STATES WHERE THE PUBLIC RISK MANAGERS' QUESTIONNAIRES WERE SENT

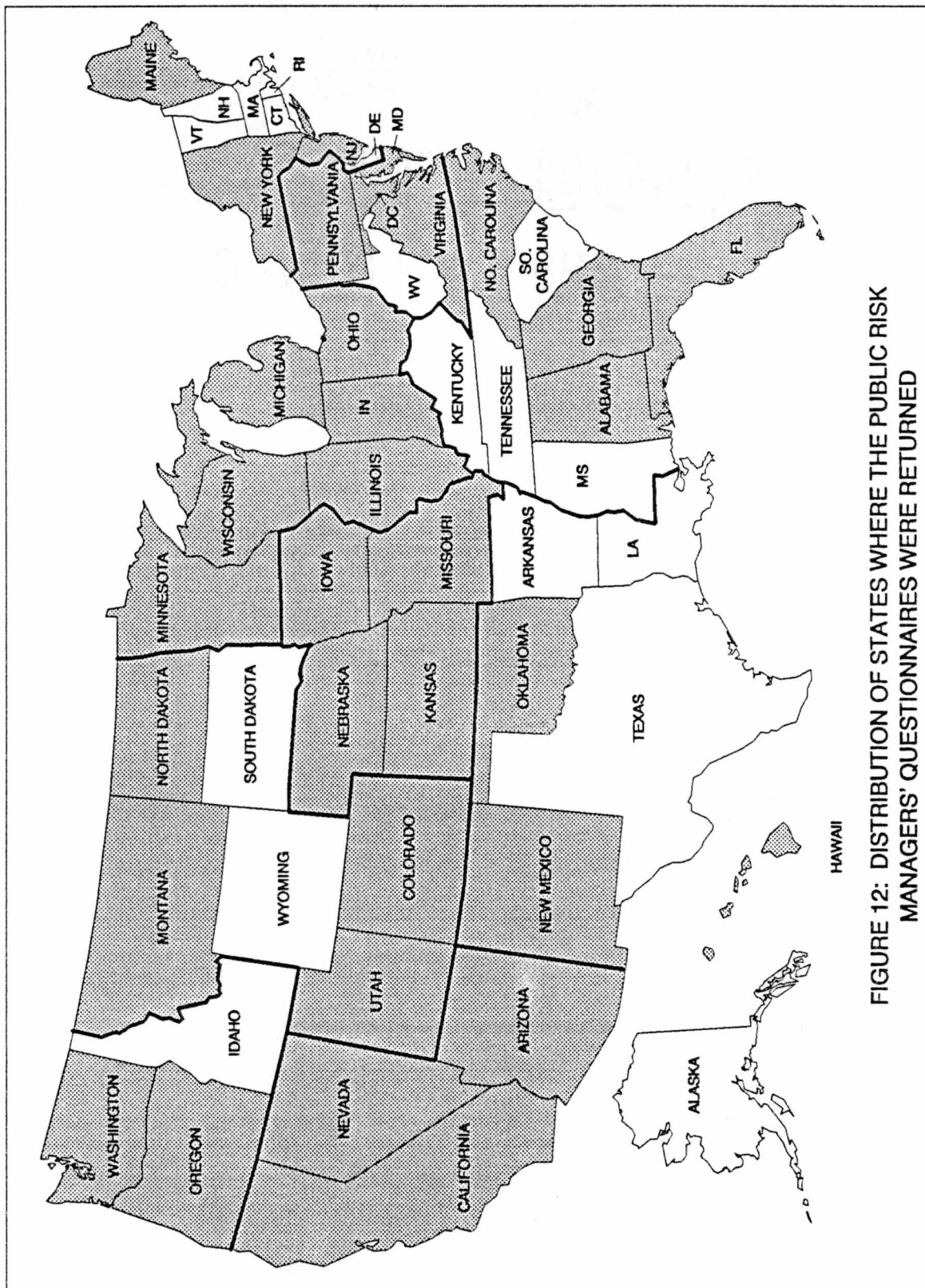


FIGURE 12: DISTRIBUTION OF STATES WHERE THE PUBLIC RISK
MANAGERS' QUESTIONNAIRES WERE RETURNED

Table 1: States' Questionnaire Distribution by FHWA Region.

FHWA Region	Percentage of Region's States That Received Contractors' Questionnaires	Percentage of Region's States That Received Public Risk Managers' Questionnaires
I	0	50
II	N/A	N/A
III	0	80
IV	100	88
V	0	100
VI	60	80
VII	0	100
VIII	0	83
IX	25	100
X	0	100

Table 2: States' Questionnaire Returns by FHWA Region.

FHWA Region	Percentage of Region's States That Returned Contractors' Questionnaires	Percentage of Region's States That Returned Public Risk Managers' Questionnaires
I	0	38
II	N/A	N/A
III	0	60
IV	75	50
V	0	100
VI	60	40
VII	0	100
VIII	0	67
IX	25	100
X	0	50

These questionnaires were completed by public risk managers or the engineers responsible for administering resurfacing contracts. Of these returns, 18 of the 116 total returns (17 percent) were from agencies which had been involved in litigation involving an accident allegedly caused by a pavement edge dropoff. Returns from these questionnaires varied from very little response to detailed information. Contained within the detailed responses were items such as contract copies, specifications, maps, and construction details. Contract scopes of work and procedures for dealing with longitudinal pavement edge dropoffs varied from no information or guidance to very specific details.

Survey Reaction

At this point, the comments and information obtained from both sets of questionnaires corresponded with the expectations and past experiences of the researchers. These responses also paralleled the philosophies of contractors and governmental officials expressed during roundtable discussions, telephone conversations, and personal interviews. During these discussions, some of the contractors and governmental officials noted their awareness of lawsuits relating to pavement edge dropoffs, whether from personal experience or information from a neighboring area. Other county engineers and governmental agencies representatives were unaware of the problems associated with pavement edge dropoffs. Those who were aware

of the problem expressed great concern about how to combat this problem. Some resurfacing contractors go beyond the contract requirements and pull the shoulder up to the edge of the resurfaced roadway with a motor grader, at their own cost, in order to minimize the hazard to the motoring public and to minimize their exposure to lawsuits. Some of the contractors involved in accidents allegedly caused from pavement edge dropoffs stated that they refuse to leave the project site until "Low Shoulder" signs or other precautions have been implemented to protect/warn the motoring public of the pavement edge dropoff hazard. Meanwhile, other contractors do not go beyond the limits of the scope of work specified in the contract, and they leave the pavement edge dropoff exposed. Various governmental agencies require that contractors obtain approval for sign placement within a construction work zone. Some contractors have been denied the required approval to place "Low Shoulder" warning signs on their projects. Thus, the public is left unaware of the existing pavement edge dropoff hazard. Furthermore, some contracts have plans included that show a one to two foot shoulder throughout the entire project, when in fact the roadway may not have any shoulder due to wear or erosion. In these cases, some contractors reported that they required the governmental agencies to change their typical sections in the contract to show zero to two feet. This is an effort to reduce the contractor liability in case an accident does occur because of an inadequate shoulder.

When questioned as to why resurfacing contracts are issued without shoulder work being included, one governmental official stated that:

During the winter motor grader operators are busy keeping snow removed from the roadway, and in order to keep these operators employed during the warmer months of the year, they are responsible for building up the shoulders to match the resurfaced roadway.

From remarks such as this one, it is easy to understand why so many contracts do not include restoration of shoulders to grade. Other such comments were made in the returned contractor and public risk manager questionnaires such as:

[The] shoulder is not intended as [a] driving surface. Edge dropoffs of 2.5 inches will occur in any case as [a] result of erosion, tire impact, etc. It would be unreasonable to expect the shoulder to always be flush with the pavement due to the cost of maintenance.

Such comments indicate that many agencies and contractors are not aware of the severity of both the safety and liability problems associated with a pavement edge dropoff condition.

CHAPTER 6

DATA INFORMATION SUMMARY

Data returned in the contractor and public risk manager questionnaires are summarized and described in the following pages. Both the contractor and public risk manager questionnaires contain potentially sensitive material and the respondents identities need to be protected. For this reason, copies of the actual questionnaires returned are not included in the appendix of this report and will be destroyed upon completion of this paper.

Where appropriate, statistical analyses were performed in order to draw possible conclusions as to the typical trends of the returns. Due to the nature of the data collection methods and the limited number of responses from contractors, it was not appropriate to perform statistical analysis on all of the data groups. Also, it was not within the scope of this research project to perform statistical analysis all of the data groups. The purpose of the research was to find general trends and not specific values in the data groups. As expected, data that were obtained from public risk managers do indicate general trends.

Statistical Methods Summary

The chi-square test statistical method was used to analyze the data received from the risk managers of governmental (county) agencies. A chi-square test was not performed on the contractor response data because of the small sample size.

The chi-square test is a two tail, null hypothesis test that determines if there is a statistical difference between a null hypothesis and the research hypothesis. A null hypothesis usually states that there is not a difference between data groups. Likewise, a research hypothesis usually states that there is a difference between the data groups.

The chi-square test may not always be a valid method if the cell value is less than five (19). In many circumstances, the cell block values used in the analysis were less than five. For this reason, some of the statistical differences may have appeared to be at a lower confidence level.

Generally, the statistical analysis revealed that in some data groups the statistical difference is greater than in other data groups. The confidence level in these findings is generally only about the 80 percent level. Since the confidence level is only moderate, the chi-square test results are not included in this report. Although this confidence level is not high, the it is within a range which allows for trends to be seen.

Contractor Questionnaire Returns Summary

Table 3 illustrates the contractor questionnaire responses concerning the number of miles of resurfacing contracted annually. This table is partitioned to show ranges of miles contracted. Also, Table 3 represents responses from contractors which have and have not been involved in pavement edge dropoff litigation within the past five years. The N/A category is for the contractors that left the question blank or did not know their annual amount of roadway resurfacing. Due to the low number of responses, Table 3 does not have an apparent trend relating number of contracted resurfacing mile to dropoff litigation occurrence.

Table 4 illustrates the contractor questionnaire distribution of responses concerning the percentage of resurfacing contracts where the scope of work does not require the contractor to rebuild shoulder back to the roadway grade. This table is partitioned into percentages of contracts without shoulder work. Table 4 represents responses for contractors which have and have not been involved in pavement edge dropoff litigation within the past five years. The N/A category is for the contractors questionnaire that left the question blank.

Table 4 does not have an apparent trend relating the percent of contracts without shoulder work to contractors involved in litigation cases. Nevertheless, responses for this question were higher from contractors which had not been involved in dropoff litigation than contractors involved in

Table 3. Contractor Responses to Annual Resurfacing.

	Number of Miles Contracted for Resurfaced Annually						
	0-50	50-100	100-200	200-300	300-500	> 500	N/A
Number of Contractors Without Litigation	1	0	0	1	0	0	3
Number of Contractors With Litigation	0	1	1	0	0	0	0

Table 4. Contractor Contracts Without Shoulder Restoration.

	Percentage of Contracts Without Shoulder Work						
	0	20	40	60	80	100	N/A
Number of Contractor s Without Litigation	0	2	1	0	0	1	1
Number of Contractor s With Litigation	0	1	0	1	0	0	0

dropoff litigation. This response pattern reflects the problems noted earlier concerning contractors with dropoff litigation being reluctant to respond to the questionnaire.

Table 5 is a summary of the contractor questionnaire distribution of responses concerning the number of contractors which have been involved in litigation where it was alleged that a traffic accident resulted from a pavement edge dropoff. Table 5 shows a distribution of responses that was typical with the contractors questionnaire. As discussed earlier, the resurfacing contractors were hesitant to respond to the questionnaire. This was especially apparent for the contractors that had been involved in dropoff litigation as illustrated in Table 5.

Table 6 summarizes the contractor questionnaire distribution of responses concerning whether the contractor did anything to eliminate or warn of a pavement edge dropoff after passing final inspection and until the shoulder has been raised to the roadway level. This involves any function that will notify the motorist of the hazard or temporarily eliminate/minimize the dropoff hazard. These items include actions which are above and beyond the scope of the contract requirements. The contractors do not receive any payment for performing this type of work. The N/A category includes the contractors that left the question blank on the questionnaire or all of their contracts include shoulder restoration.

Table 5. Contractors Recently Involved in Dropoff Litigation.

	Involved in Litigation Within Past Five Years	
	Yes	No
Number of Contractors	2	5
Total Percentage of Contractors	28.6%	71.4%

Table 6. Contractors That Warn of or Eliminate a Dropoff.

	Warning or Elimination of Pavement Edge Dropoff				
	Yes			No	N/A
	Place Signs	Grade Shoulder	Place Barricades		
Number of Contractors Without Litigation	2	0	0	1	2
Number of Contractors With Litigation	0	2	0	0	0

Basically, the responses in Table 6 are divided into two categories, YES and NO. The YES category includes any activity that warns of or eliminates a dropoff hazard. Furthermore, the YES category can be classified as ACTIVE and PASSIVE. The ACTIVE classification includes methods of positive guidance (such as the use of channelization devices) along the dropoff or elimination of the hazard. Items such as placing barricades along the resurfaced roadway edge and/or grading the shoulder to meet the resurfaced roadway level are classified as ACTIVE. Meanwhile, the PASSIVE classification includes the use of warning signs. Table 6 illustrates that most of the contractors that responded do something beyond the contract requirement to warn of or eliminate a pavement dropoff. Table 6 does not show an apparent trend relating the contractors practice (either active or passive) to the occurrence of litigation.

Table 7 illustrates the contractor questionnaire distribution of responses concerning whether the agency believes that by adding an overlay of 2.5 inches without raising the shoulders up even with the road creates a hazard to the motoring public. Table 7 shows the summary for responding contractors that have and have not been involved in pavement edge dropoff litigation within the past five years. The N/A category includes the contractors that left the question blank on the questionnaire.

The data trend in Table 7 is that if the hazard is perceived by the resurfacing contractor, there is a less chance of the contractor being

Table 7: Contractor View of a 2.5 Inch Overlay Creating a Hazard.

	Does a 2.5 Inch Dropoff Create a Hazard		
	Yes	No	N/A
Number of Contractors Without Litigation	5	0	0
Number of Contractors With Litigation	1	1	0

involved in dropoff litigation. This may have some correlation to the data in Table 6 as to whether or not the contractor goes beyond the minimum requirements of the contract to warn of or eliminate a dropoff.

Public Risk Manager Questionnaire Returns Summary

Figure 13 and Table 8 illustrates the risk manager questionnaire distribution of responses by category. Figure 13 shows the organizational dispersion of the returns according to the type of governmental agency and litigation incidents. Table 8 summarizes the public risk manager questionnaire distribution in two primary categories — liable and non-liable governmental agencies. Liable agencies are responsible for roadway maintenance and other highway-related issues. Non-liable agencies are not responsible for roadway maintenance and other highway-related issues. Each of the two primary categories are subdivided into more refined classifications. Liable agencies are classified as state and county/city. Non-liable agencies classification includes non-liable counties and miscellaneous counties. The non-liable counties classification includes counties located in states where the state agency is responsible for the roadway maintenance and other highway-related issues, and the Miscellaneous classification includes agencies responsible for hospitals, schools, and miscellaneous public facilities. Only the liable agency category is of importance for the purposes of this report; however, for completeness of data, the entire

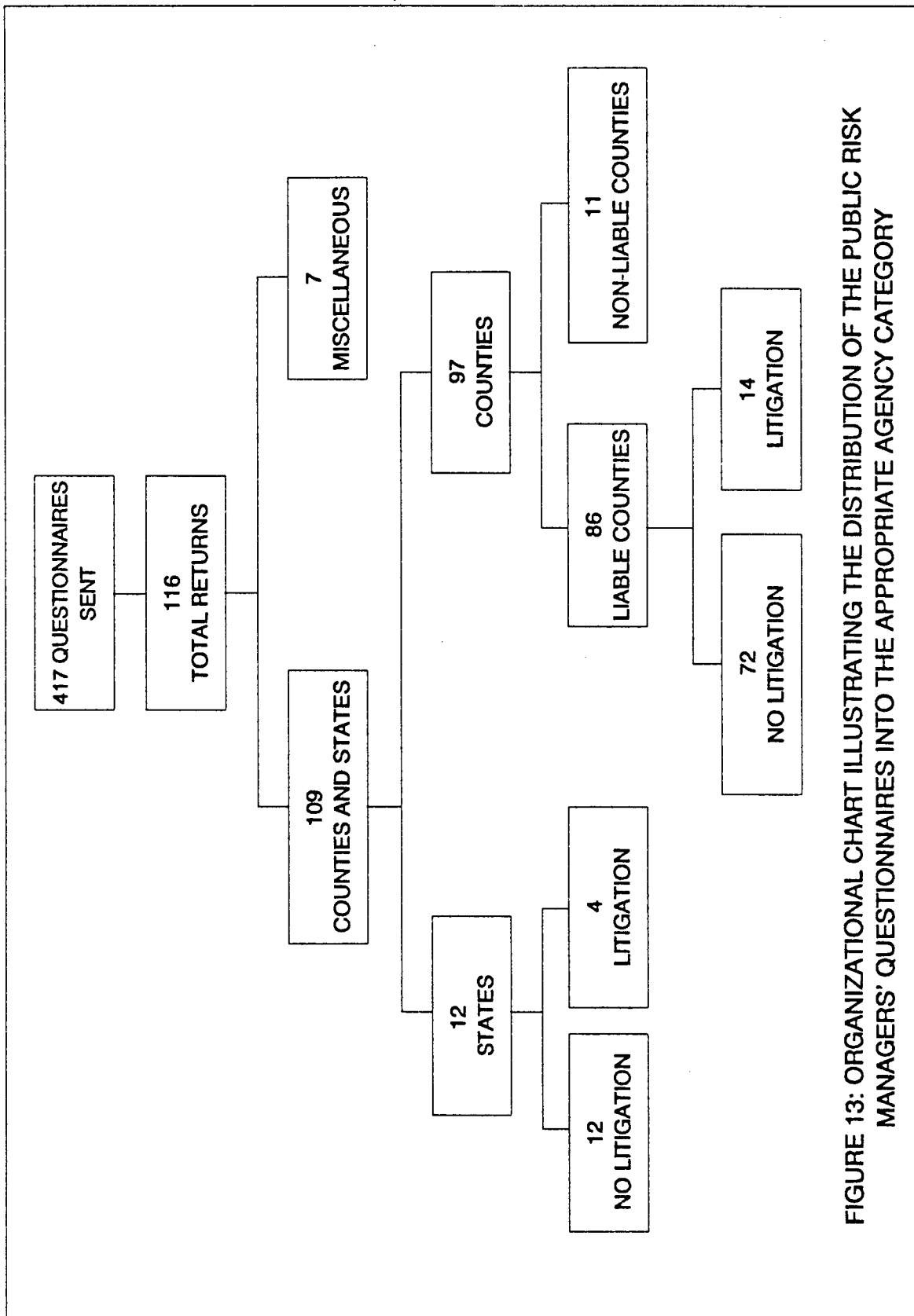


FIGURE 13: ORGANIZATIONAL CHART ILLUSTRATING THE DISTRIBUTION OF THE PUBLIC RISK MANAGERS' QUESTIONNAIRES INTO THE APPROPRIATE AGENCY CATEGORY

Table 8: Agency Classification and Distribution Summary of
Public Risk Manager Questionnaire Returns.

	Public Risk Managers' Governmental Agency			
	Liable Agencies		Non-Liable Agencies	
	State	County/ City	Non-Liable Counties	Misc.
Total Number of Returns	12	86	11	7
Percentage of Total Returns	10.4	74.1	9.5	6.0
Number of Liable Agency Returns	98		Data in this section are not within the scope of this project.	
Percentage of Liable Agency Returns	12.2	87.8		

summary of returns is shown. Also, the City classification has been added to the County because some cities have rural sections of roadway. In following tables, the County/City title will be consolidated to a title of County.

Returns were received from all five of these different agency classifications. Table 8 details the refinement of this data by summarizing the data into four groups as follows — Total Number of Returns which illustrates the overall distribution of the returns; Percent of Total Returns shows the percentage distribution of the returns; Number of Liable Agency Returns illustrates the sum total of the three liable classifications (state, county, and city); Percent of Liable Agency Returns shows the actual classification percentage of total liable agency returns.

Public Risk Manager Questionnaire Data Summary

Due to the fact that some of the returned questionnaires were not fully completed, it should be noted that the values in Tables 9-13 may not total to equal the values in Table 8.

Table 9 illustrates the Public Risk Manager Questionnaire distribution of responses concerning the number of miles contracted for resurfacing annually. These tables show both state and county classifications of the governmental agency in ranges of miles contracted. Table 9 represents responses for governmental agencies which have and have not been involved

Table 9: Agency Amounts of Annual Resurfacing Contracted.

	Number of Miles Contracted for Resurfaced Annually						
	0	0-10	10-20	20-50	50-100	> 100	N/A
Number of State Agencies Without Litigation	0	0	0	0	0	6	0
Number of State Agencies With Litigation	0	0	0	0	0	4	0
Number of County Agencies Without Litigation	14	26	18	11	1	2	11
Number of County Agencies With Litigation	0	3	5	5	0	1	0

Table 10: Agency Contracts Without Shoulder Restoration.

	Percentage of Contracts Without Shoulder Work						
	0	20	40	60	80	100	N/A
Number of State Agencies Without Litigation	5	0	0	0	0	0	0
Number of State Agencies With Litigation	0	2	0	0	3	0	0
Number of County Agencies Without Litigation	31	4	1	3	4	17	23
Number of County Agencies With Litigation	7	3	1	1	0	2	0

Table 11: Number of Agencies Recently Involved on Dropoff Litigation.

	Involved in Litigation Within Past Five Years	
	Yes	No
Number of State Agencies (percentage of state agencies)	4 (33.3)	8 (66.7)
Number of County Agencies (percentage of county agencies)	14 (16.3)	72 (83.7)
Total Percentage of Liable Agencies	14.3%	85.7%

Table 12: Number of Agencies That Warn of or Eliminate a Dropoff.

	Warning or Elimination of Pavement Edge Dropoff				
	Yes			No	N/A
	Place Signs	Grade Shoulder	Place Barricades		
Number of State Agencies Without Litigation	1	0	0	1	6
Number of State Agencies With Litigation	1	1	0	2	0
Number of County Agencies Without Litigation	16	3	5	9	39
Number of County Agencies With Litigation	6	0	0	3	5

Table 13: Agency Views of a 2.5 Inch Overlay Creating a Hazard.

	Does a 2.5 Inch Dropoff Create a Hazard		
	Yes	No	N/A
Number of State Agencies Without Litigation	5	3	0
Number of State Agencies With Litigation	2	2	0
Number of County Agencies Without Litigation	59	6	18
Number of County Agencies With Litigation	11	3	0

in pavement edge dropoff litigation within the past five years. The N/A category is for the agencies that are in the Other Counties classification or perform their own roadway resurfacing.

A general trend in Table 9 is that as the number of miles contracted annually increases so does the number of litigation cases involving pavement edge dropoffs. Although the chi-square test indicated that this is not statistically different, the general trend is illustrated by the fact that 3 litigation cases out of 29 responses (10 percent) were in the 0-10 mile range compared to 5 litigation cases out of 16 responses (31 percent) in the 20-50 mile range.

Table 10 illustrates the public risk manager questionnaire distribution of responses concerning the percentage of resurfacing contracts where the scope of work does not require the contractor to rebuild the shoulder back to the roadway grade. In other words, these are resurfacing contracts where the scope of work does not make the contractor responsible for restoring the shoulder to the resurfaced level of the roadway. These contracts are usually issued by agencies where their own work crews will perform the task of shoulder restoration after the contractor has finished with resurfacing the travel lanes of the roadway. This table shows both state and county classifications of the governmental agency in percentages of contracts without shoulder work. Table 10 represents responses for governmental agencies which have and have not been involved in pavement edge dropoff

litigation within the past five years. The N/A category is for the agencies that are in the Other Counties classification or perform their own roadway resurfacing.

By observation of the response distribution in Table 10, it is apparent that responding agencies generally either do or do not include shoulder work in all of their resurfacing contracts (i.e., most of the responses are in the 0-20 percent or 80-100 percent categories). Therefore, a mix of contract types for a given agency is not customary.

It was anticipated that the apparent trend from the responses would be that agencies issuing resurfacing contracts, which include shoulder restoration, are less likely to be involved in pavement edge dropoff litigation than those that do not. But, as the responses indicate, this is not necessarily the trend. From these responses, the trend is that when the shoulder work is included in the contract the number of litigation cases increases. There are several factors that may affect this trend. These include random occurrence of traffic accidents, random occurrence of litigation resulting from traffic accidents, details involved in the dropoff litigation (i.e., if the litigation occurred during or after resurfacing), lapsed time between when the contractor finished the resurfacing and when the agency restored the shoulder, number of miles of resurfacing contracted annually, and immunity of governmental agencies. Moreover, it should be

kept in mind that the chi-square test displayed that there is not a statistical difference between the groups.

Table 11 is a summary of the public risk manager questionnaire distribution of responses concerning the number of governmental agencies which have been involved in litigation where it was alleged that a traffic accident resulted from a pavement edge dropoff.

Table 12 illustrates the public risk manager questionnaire distribution of responses concerning whether the agency does anything to warn of or eliminate a pavement edge dropoff after the contractor has passed final inspection and until the shoulder has been raised to the roadway level. The N/A category includes the agencies that perform their own resurfacing or the question was left blank on the questionnaire.

Basically, the responses in Table 12 are divided into two categories, YES and NO. The YES category includes any activity that warns of or eliminates a dropoff hazard. Furthermore, the YES category can be classified as ACTIVE and PASSIVE. The ACTIVE classification includes methods of positive guidance (such as the use of channelization devices) along the dropoff or elimination of the hazard. Items such as placing barricades along the resurfaced roadway edge and grading the shoulder to meet the resurfaced roadway level are classified as ACTIVE. Meanwhile, the PASSIVE classification includes using warning signs.

The general trend from the data illustrated in Table 12 is that if a county agency does something to warn of or eliminate a pavement edge dropoff, the chance of being involved in dropoff litigation case is reduced (i.e., NO has 3 of 12, or 15 percent, involved with litigation whereas YES has 6 of 30, or 20 percent, involved with litigation). Furthermore, agencies which execute an ACTIVE technique are further removed from the chance of dropoff litigation than agencies that perform a PASSIVE method (i.e., ACTIVE has 0 of 8, or 0 percent, involved with litigation whereas PASSIVE has 6 of 22, or 27 percent, involved with litigation).

Table 13 illustrates the public risk manager questionnaire distribution of responses concerning whether the agency believes that by adding an overlay of 2.5 inches without raising the shoulders to the resurfaced roadway level creates a hazard to the motoring public. Table 13 is the summary for the responding agencies that have and have not been involved in pavement edge dropoff litigation within the past five years. The N/A category includes the agencies that perform their own resurfacing or the question was left blank on the questionnaire. An agencies philosophy about the perception of this hazard may have a influence upon whether the shoulder work is included in the resurfacing contracts.

Table 13 data illustrates a general trend relating to agency perceptions of dropoff hazards. This trend is that agencies which perceive a dropoff of 2.5 inches as a hazard are less prone to be involved in dropoff litigation.

Results of a chi-square test indicates there is not a statistical difference between these categories. In any case, Table 13 reveals 11 out of 70 (16 percent) of agencies involved in dropoff related litigation perceive this hazardous condition. Furthermore, Table 13 indicates 3 out of 12 (25 percent) of agencies involved in dropoff related litigation do not perceive this hazardous condition.

In order to summarize the data collected in this research project, it is important to consider the contractor and public risk manager responses separately. Also, it should be noted that comments contained in responses from both survey groups added valuable information to the development of the recommendations and conclusions in this report. These comments were varied and cannot be easily incorporated into a table format.

Due to the limited amount of responses received from contractors, it is difficult to develop trends that related different factors of resurfacing to the occurrence of litigation. Nevertheless, comments included in the contractor responses were informative. These comments confirmed the researcher's concern about the problems associated with pavement edge dropoffs and working with resurfacing contracts that do not include shoulder work.

Data obtained from the public risk manager responses were divided into two basic groups representing state agencies and county agencies. County agencies provided a larger number of responses than the state agencies. Trends were evident in the county agency group. These trends related the

many different factors associated with resurfacing contracts to the occurrence of dropoff litigation.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSIONS

The Transportation Research Board of the National Research Council has determined that "pavement edge drop hazards are greater than previously believed" and that "in addition, pavement edge drops are a common source of tort claims against highway agencies" (10, p. 202). All sources that were investigated indicate that pavement edge dropoffs produced as a result of roadway resurfacing can and do cause traffic accidents and ensuing lawsuits. Many governmental officials are unaware of the severity of the problems related to pavement edge dropoffs. This is because they or their agencies have not been involved in lawsuits related to this condition or have not been educated as to the ramifications surrounding pavement edge dropoffs. On the other hand, contractors are aware of these problems but are unable to implement a standard solution due to the lack of power over the contracting agencies or the cost of implementing such a solution (which would consume a portion of their small operating profit in a very competitive business).

Data collected in this research project indicate that both the governmental agencies and resurfacing contractors generally perceive the dropoff problem. However, some of the governmental agencies and

resurfacing contractors do not perceive the dropoff problem as a hazard. Trends in response data from both of these illustrate that by taking active measures to warn of or eliminate the dropoff hazard prior to restoring the shoulder, the chance of dropoff litigation is reduced. Also, the reluctance of contractors to respond to the questionnaire is an indication of the severity of the problem.

Officials of governmental highway agencies must be made aware of the risk and liability associated with the types of roadway resurfacing contracts that lead to the dropoffs. A simple and cost-effective mitigation of this problem would be to require the installation of a 45° angle asphalt fillet along each side of the roadway as a resurfacing standard. This contract standard would tie the existing shoulder into the resurfaced roadway and allow a vehicle to reenter the travel lane pavement from the shoulder in a reasonably safe manner. This type of resurfacing standard would still allow a governmental agency to use its own forces to completely restore the shoulder after a contractor had resurfaced the roadway.

Therefore, it is strongly recommended by the author that the most effective ways of solving the problems associated with pavement edge dropoffs which are due to resurfacing are:

1. To eliminate the issuance of contracts where shoulder work is excluded or not included in the resurfacing contract;

2. To require that a 45° asphalt fillet be installed along the edge of the roadway as a part of the roadway resurfacing;
3. To require, as a non-pay item, that shoulder materials be pulled up to the new surface until the shoulder is restored to the resurfaced roadway level; and
4. To require that appropriate signing remain along the roadway to inform the motoring public of the existence of a low shoulder condition.

The cost of such an asphalt fillet is minimal in comparison to the total amount of the resurfacing contract, and the fillet would save countless dollars in lawsuits, human lives, and property damage.

If, for whatever reason, the governmental agency still believes there is a need to issue "no shoulder work" type contracts, as a minimum, one of the following recommendations should be implemented into resurfacing contracts in order to provide safer roadways and to help minimize the exposure to liability:

1. Require that a 45° asphalt fillet be installed as a part of the roadway resurfacing along the edge of the roadway;
2. To require, as a non-pay item, that shoulder materials be pulled up to the new surface until the shoulder is restored to the resurfaced roadway level;

3. To require that appropriate signing remain installed along the roadway to inform the motoring public of the existence of a low shoulder condition;
4. To require both recommendations 1 and 3; or better still
5. To require both recommendations 1 and 2.

It is believed that implementation of this policy could best be accomplished through public risk insurance management companies. A policy adopted by these companies that requires that these recommendations be followed and strictly enforced could save governmental agencies countless dollars in litigation and make the roadways a safer place to travel. In this manner, governmental agencies would be required to look after their own best interests as well as that of the public without adding large costs to their budgets. Implementation at the contractor level is not feasible because the contractor cannot easily change the scope of a contract.

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APPENDIX



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CONTRACTORS' ROADWAY RESURFACING &
SHOULDER IMPROVEMENT QUESTIONNAIRE

In what state(s) does your company normally do business? _____

Number of years in operation? _____

Approximate annual average dollar amount of rural two-lane roadway resurfacing? _____

Approximate number of miles of rural two lane roadway resurfaced annually? _____

Approximate percent of rural two-lane resurfacing that does not require the contractor to rebuild the shoulder back to grade?

(Please circle one) 0 20 40 60 80 100 Percent

Would you be willing to share, in confidentiality, a copy of a typical resurfacing contract which does not include shoulder work? If so, please send it with the questionnaire. (Feel free to remove any items that may identify the source.)

If shoulder work is not included in a contract, does your company do anything to eliminate or warn of the shoulder drop-off? (YES NO) If yes, please describe. _____

Has your company been involved in any legal actions where it was alleged that a traffic accident resulted from a pavement edge drop-off, where shoulder restoration was not included in the contract? (YES NO)

If yes, how many over the past five years? _____

Do you believe that adding 2.5 inches of resurfacing on a rural two-lane roadway without bringing the shoulder up even with the resurfacing results in a hazard to the motorist? (YES NO)

Why or why not? _____

Please indicate whether or not you would be willing to briefly discuss this issue (YES NO).

If yes, please give name of person to contact, and telephone number. _____

Name of your company (optional). _____



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PUBLIC RISK MANAGER'S ROADWAY RESURFACING &
SHOULDER IMPROVEMENT QUESTIONNAIRE

In what state is your government located? _____

Type of government (State or County)? _____

Approximate annual number of miles of rural two-lane roadway resurfacing let in contract? _____

Approximate percent of rural two-lane resurfacing where the scope of work does not require the contractor to rebuild the shoulder back to grade?

(Please circle one) 0 20 40 60 80 100 Percent

Would you be willing to share, in confidentiality, a copy of a typical resurfacing contract which does not include shoulder work? If so, please send it with the questionnaire. (Feel free to remove any items that may identify the source.)

If shoulder work is not included in a contract, does your agency do anything to eliminate or warn of the shoulder drop-off after the contractor has passed final inspection and until the shoulder has been been raised to the roadway level? (YES NO) If yes, please describe. _____

Has your agency been involved in any legal actions where it was alleged that a traffic accident resulted from a pavement edge drop-off where shoulder restoration was not included in a resurfacing contract? (YES NO)

If yes, how many over the past five years? _____

Do you believe that adding 2.5 inches of resurfacing on a rural two-lane roadway without bringing the shoulder up even with the resurfacing results in a hazard to the motorist? (YES NO)

Why or why not? _____

Please indicate whether or not you would be willing to briefly discuss this issue (YES NO).

If yes, please give name of person to contact and telephone number. _____

Name of your governmental agency (optional). _____

VITA

James Alan Parham was born in Asheville, North Carolina, on July 31, 1962, the son of James Lonnie (J.L.) and Verneta Sheffield Parham. He graduated from Pisgah Senior High School in 1980, received an Associates of Applied Science Degree in Civil Engineering Technology from Asheville-Buncombe Technical College in 1982, and received a Bachelor of Science Degree in Civil Engineering from The University of Tennessee, Knoxville, in 1985.

While working on his Bachelor's degree, Mr. Parham worked with engineering consultants and the North Carolina Department of Transportation. Upon receiving his Bachelor's degree, he accepted a Project Engineers' position with Law Engineering Testing Company in Houston, Texas. In June 1987, he began working for Urban Engineering, Incorporated, of Farragut, Tennessee, as a Project Engineer. Mr. Parham started to pursue his Master of Science degree in Civil Engineering in 1988 while continuing to work full time. In September 1989, he accepted a position with Wilbur Smith Associates as a Transportation Design Engineer. In June 1993, he accepted the position of Research Associate at the Transportation Center at The University of Tennessee where he is working with the Tennessee Transportation Assistance Program.

Mr. Parham is currently active with several professional societies and is a Registered Profession Engineer in the State of Tennessee. He and his wife, Angelia Hicks Parham reside in Knoxville, Tennessee with their daughter Lucy.