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Reducing Tort Liability on Low-Volume Roads Through Analysis of Case Law

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Low-volume roads appear particularly susceptible to lawsuits since they are typically constructed to lower standards than high-volume routes and because funding levels are not adequate to deal with problem locations. Integrating information from highway case law into low-volume-road decisionmaking offers the potential to reduce liability risk and to provide safer roads. Two types of analyses were conducted: a quantitative analysis of seven years of data from the West Virginia Court of Claims and a qualitative analysis of more than 50 years of appellate court decisions from the South Eastern Reporter for the southern Appalachian region. The case law provided valuable insight into problems on low-volume roads. Relevant claims were classified into one of seven categories: construction signs, traffic-control devices, holes in roadways, wet and slippery roads, bridges, impassable roads, and maintenance activities. The types of claims encountered on low-volume roads followed the same pattern as those on other functional classes of road. However, certain claims on low-volume roads were overrepresented with respect to the amount of travel occurring on them. For example, of all claims involving traffic-control devices, one-third occurred on low-volume roads. Holes in roadways and bridges and impassable roads were the leading causes of claims on low-volume roads. It was concluded that highway agencies could reduce their liability risk through judicious use of case law in conjunction with standard procedures such as record-keeping and warning systems.

The increased amount of litigation in every area of society has been a cause of concern to highway engineers, who may be liable for accidents attributable to a deficiency in highway design or operation. Low-volume roads appear particularly susceptible to lawsuits since they typically are constructed to lower standards than high-volume routes and, because of the magnitude of the system, funding levels are not adequate to deal with problem locations. In view of the limited resources available, it is important that funds for corrective action be spent where they will do the most good. This can be difficult on low-volume roads since accident records normally are not sufficient to identify problem locations.

Much of the concern that exists about lawsuits is unjustified and is due to a lack of reliable information on road liability law. Many times, the information the engineer receives comes from the news media, which may cite an unusual or spectacular case and omit important details. Such a single decision involves only one facet of a problem; focusing on one decision may lead to an erroneous impression about highway law. To manage highway systems effectively, individual court cases need to be put into a broader perspective.

The existing situation presents a number of problems. Engineers may concentrate on roadway improvements that are helpful in avoiding lawsuits but that have little safety benefit. Likewise, engineers sometimes hesitate about making improvements at a particular location, fearing that this will be an admission of unsafe conditions. In still other cases, misunderstandings about liability may lead to a "cookbook" reliance on standards and guidelines instead of development of creative and imaginative solutions to traffic safety problems. It is important to note at this point that the legal duty to provide reasonably safe roads is really the same objective as that desired by engineers. The problem is to maximize safety while at the same time minimize liability potential.

One way to reduce the liability risk and provide safer roads is to integrate information from highway case law into decisionmaking about low-volume roads. An analysis of legal cases can help identify common types of low-volume road safety problems and where they are most likely to exist.

The study described here reviewed the circumstances presented in published court decisions involving low-volume roads in West Virginia and was supplemented by similar information from surrounding states. Two types of analyses were conducted: a quantitative analysis of seven years of data from the West Virginia Court of Claims and a qualitative analysis of more than 50 years of appellate court decisions from the South Eastern Reporter for the southern Appalachian region of the United States. Cases that could be attributed to a highway deficiency were studied to detect trends, patterns, and characteristics in the accidents that led to the lawsuits. Claims characteristic of low-volume roads were compared with those of other road functional classes.

BACKGROUND

There have been a number of recent articles in the traffic engineering literature offering suggestions on how engineers can reduce the risk of tort liability. A few of these (1,2) have dealt with the special problems of low-volume roads. Most of the literature is based on the experiences and opinions of the writers as opposed to formal research or data collection on the topic.

Carstens (3) performed one of the few quantitative studies of liability relative to traffic engineers. He used a questionnaire and personal interviews with county engineers to determine the magnitude and type of highway-related tort claims that were filed against counties in Iowa. Carstens pointed out those features of the road system that

were frequently involved in tort claims; these included inadequate shoulders, improper signing of curves, railroad grade-crossing signs, T-intersections, roadway geometric deficiencies, snow or ice on the road, and improper sign placement.

Baldwin (4) noted that the collection of aggregate claims data from published cases could assist in identifying safety risks; however, he did not report any actual data. Baldwin indicated that although Michigan law provided only one standard (that the road be "reasonably safe") relative to highway design, construction, maintenance, and traffic control, there were many specific applications. Some of these have been expressed in statutes but most were expressed in court decisions. Published decisions of the Michigan Supreme Court and Court of Appeals could provide useful information on how the concept of a reasonably safe road had been applied. For example, some cases gave insight about the importance of published engineering standards and how they related to the exercise of engineering judgment in highway safety engineering decisionmaking. The research to be described here expands on the work of Carstens and Baldwin by examining both claims data and published cases.

DATA COLLECTION

Two types of data were collected and analyzed to evaluate the frequency, magnitude, and characteristics of claims against highway agencies. These two sources were the West Virginia Court of Claims Reports and the South Eastern Reporter. The South Eastern Reporter consists of published accounts of appellate court decisions in the states of Virginia, West Virginia, South Carolina, North Carolina, and Georgia. The two sources of data are distinctly different since the data collected from the West Virginia Court of Claims Reports consist of claims that were filed against the West Virginia Department of Highways (WVDOH). These records do not contain discussions of laws that were applied to each claim. The South Eastern Reporter contains cases (in the legal sense) that were heard previously by at least one court but for certain reasons were appealed to a higher court. These cases present certain details not present in Court of Claims data about the original accident, including a discussion of laws that were applicable to the case.

Most of the claims were for relatively small amounts of money as opposed to the cases where relatively large sums were involved. This is due to the differing natures of each type of court. There are a large number of small claims in the Court of Claims. Because there are no attorney or court fees involved, injured motorists may bring claims for small-damage awards since they have essentially nothing to lose. Cases tried by jury, especially those that continue to an appellate court, require a relatively large financial investment for attorney fees and other costs. Such an investment is justified only when the award will be large. Thus, one tends to find claims for damaged tires, axles, and other problems of this nature in the Court of Claims, whereas the larger claims for personal injury or death tend to appear in reported cases. It was felt that examining both sources would provide a relatively complete record of the liability experience of low-volume roads.

Court of Claims Reports

The Court of Claims of West Virginia has been in existence and engaged in hearing and determining claims against various state agencies since 1941. All claims that have been heard by the Court since that time are published in the West Virginia Court of Claims Reports. In this study, the investigators searched the Reports for claims filed against WVDOH.

WVDOH was subject to the greatest number of claims among all state agencies: About 50 percent of all claims since 1941 had been filed against them. Not all claims against WVDOH were considered in this study. Only claims resulting from a defect or problem that led to a motor vehicle accident on or near the roadway were considered.

Data collected covered a seven-year period from 1973 to 1979. Time and funding constraints prevented the researchers from examining claims prior to 1973. However, this was not felt to be a serious limitation due to the relatively small number of claims against WVDOH before that time. In all, 198 cases were identified.

A data-collection form was developed for Court of Claims data. The form contained space for the monetary amount claimed and the amount awarded; these were included to provide insight about the magnitude and characteristics of claims against the highway agency. Also included on the form was space for a brief statement of the case in which a short summary of the claim was presented. Where available, traffic engineering details such as vehicle speed, condition of roadway, and traffic-control devices at the accident site were noted. Route number, i.e., the number of the U.S., state, or county route on which the accident occurred, was noted so that insight could be gained as to which class of road gave rise to the highest number of claims and so that characteristics of these claims could be identified and compared. The West Virginia Functional Classification State Highway System map was used to classify the routes identified. In West Virginia, routes are classified into five functional groups: Interstate highways, expressways, trunklines, feeder routes, and state local-service roads.

Interest in this study focused on the state local-service roads. This category includes local arterial and spur routes providing land access to abutting properties. West Virginia is different from most states in that WVDOH has responsibility for local roads as well as state roads. This fact facilitated analysis of the Court of Claims data. According to WVDOH data, 87.5 percent of local-service roads carry less than 500 vehicles per day and can be considered low-volume roads. Thus, it is reasonable to say that the characteristics and patterns found in this study can be inferred to be representative of low-volume roads in West Virginia.

South Eastern Reporter

The South Eastern Reporter contains cases that were originally tried by jury at the local level but, for various reasons, were appealed. For these cases, information about applicable laws and incidents that led to accidents are presented in more detail than in the Court of Claims Reports. Law encyclopedias and digests were used to locate relevant cases. In these sources, cases are classified by topic. Cases were located under such topics as automobiles, bridges, defects, negligence, and highways and streets. Cases of interest were those that resulted from a motor vehicle accident allegedly caused by a roadway or traffic-control defect and that was decided between 1900 and 1979. None of the cases in the South Eastern Reporter was against WVDOH. In West Virginia, with its modified sovereign immunity, any civil action that might be brought against state agencies can be heard only through the Court of Claims. However, it was felt that the topographical, geological, and cultural characteristics of surrounding states had enough similarity to West

Virginia to make the results transferable. In all, 107 cases were found to be relevant and they were used for analysis purposes. A data-collection form similar to that used for the West Virginia Court of Claims Reports was developed.

RESULTS

Court of Claims Reports

The proportion of claims in each road functional classification was tabulated. As shown in Figure 1, local-service roads, feeder roads, and trunkline highways were similar in that they had significantly more claims compared with expressways and Interstate highways. For comparison purposes, the proportion of West Virginia statewide highway mileage and vehicle miles of travel (VMT) in each functional category are presented below:

Functional Class	Miles of Highway	VMT
Interstate and expressway	3.4	30.6
Trunkline	4.6	16.8
Feeder	9.9	24.3
Local-service roads	82.1	28.3

Claims on low-volume roads occurred roughly in proportion to the exposure on such roads. Trunkline highways experienced significantly more claims than would be expected based on exposure, whereas Interstates and expressways experienced less claims than expected.

A breakdown of the severity [property damage only (PDO), injury, and fatal] of accidents leading to claims as a percentage of all accidents for each type of road functional classification was made. As shown below, feeder roads had the highest percentage of PDO accidents, whereas expressways had the highest percentage of both injury and fatal accidents. Almost 70 percent of the claims on low-volume roads were for property-damage accidents; there were no claims for fatal accidents.

	Percentage of Accidents in Each Category		
Functional Class	PDO	Injury	Fatal
Interstate	56	38	6
Expressway	36	50	14
Trunkline	71	29	--
Feeder	77	17	6
Local-service road	69	31	--
Overall	61	36	3

Results of this analysis were similar to the accident-severity distribution for West Virginia, as compiled by WVDOH, during the same time period. According to the WVDOH data, 59 percent of all accidents were PDO, 40 percent were injury, and 1 percent were fatal.

Examination of the amounts claimed and awarded for each road functional classification was accomplished by classifying the amount claimed or awarded into convenient categories for all roadway classes and for each individual road class. Figure 2 presents a frequency tabulation of the amount claimed and awarded in each category aggregated for all road functional classifications. The frequency tabulation of amount claimed or awarded for the low-volume-roads category is shown in Figure 3. Note that the frequency distribution for low-volume roads is similar to the distribution for other classes of highways. In both cases, the highest percentage of claims was in the $0-$200 category. This was expected, since an individual has essentially nothing to lose by asking for compensation when a vehicle is slightly damaged by a highway defect. In both cases, the $0-award category had the highest percentage (about 40 percent); i.e., 40 percent of the claims were disallowed.

To provide insight about the nature of accidents on low-volume roads and how this compared with accidents on other road classes, claims were categorized on the basis of contributing factors. Categories used were construction zones, traffic-control devices, holes in roadways or bridges, wet and slippery roads, bridges, impassable roads, and maintenance activities. Categories were selected primarily from those listed as contributing factors on accident reports and modified based on the number of claims in each category. Details of the types of claims in each category are presented in the original study report (5).

Characteristics of each of the claims categories, aggregated for all road classes, are presented in Table 1. The total amount claimed against WVDOH due to roadway defects during the period 1973-1979 totaled close to $1.7 million from 198 claims. However, only 59 percent of the claims received any award. In 46 percent of the claims awarded, the claimant was awarded the amount originally requested. The total amount actually awarded was

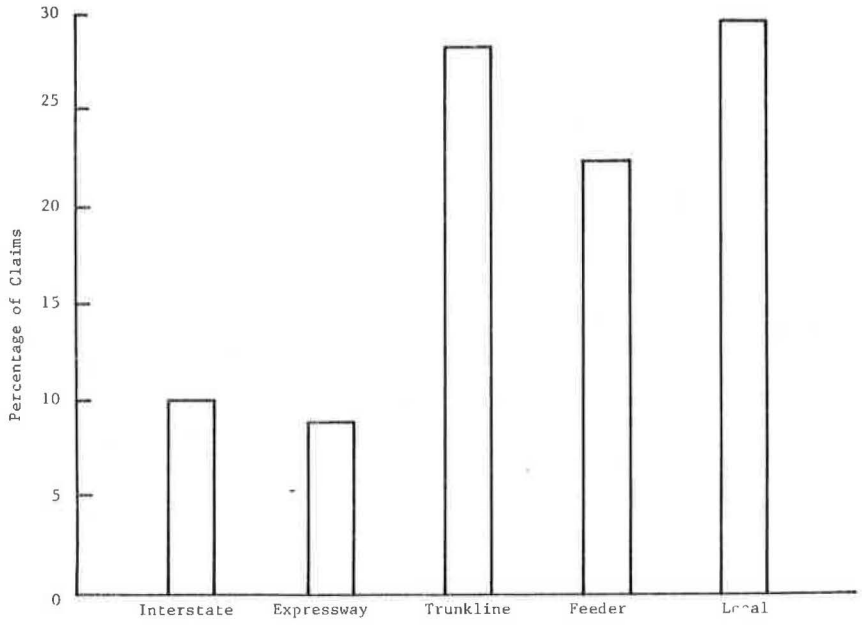

Figure 1. Claims by road functional classification (West Virginia Court of Claims, 1973-1979).

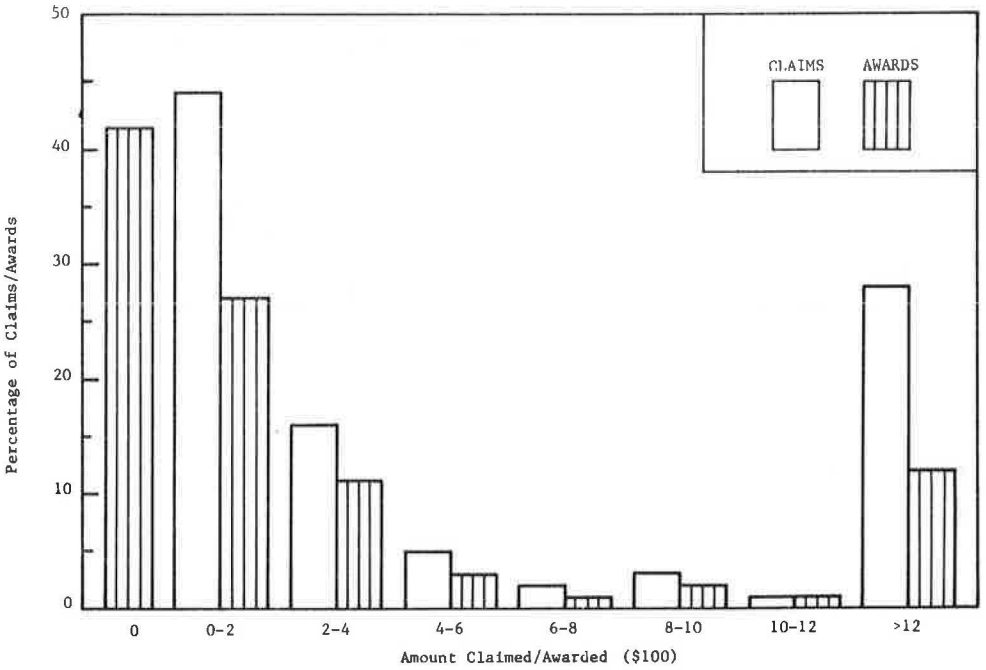

Figure 2. Amounts claimed or awarded for all functional classes (West Virginia Court of Claims, 1973-1979).

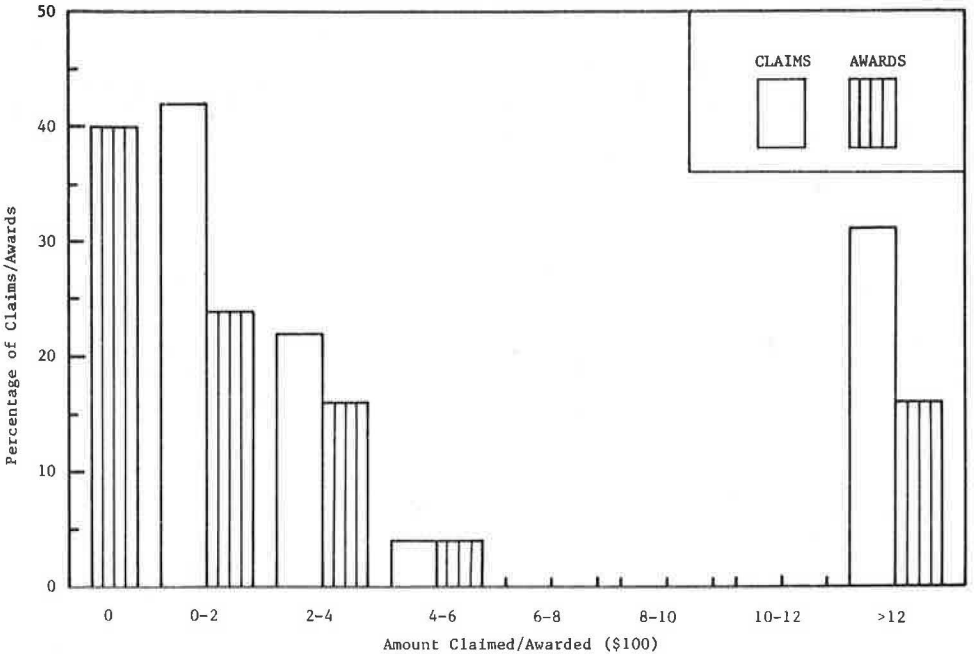

Figure 3. Amounts claimed or awarded for low-volume roads (West Virginia Court of Claims, 1973-1979).

Table 1. Monetary aspects of claims categories for all West Virginia road functional classes (1973-1979).

Claim Category	Claims (%)	Total Claims ($)	Total Awards ($)	Claims Awarded (%)	Dollar Award per Claim
Construction signs	9	214 155	67 020	67	3723
Traffic-control devices	6	117 527	24 322	58	2027
Holes in roadways or bridges	37	620 018	111 369	45	1505
Wet and slippery roads	7	361 251	16 625	13	1188
Bridges	17	263 295	34 684	97	1051
Impassable roadways	20	112 615	7 274	44	187
Maintenance activities	4	1 320	1 270	75	159
Total		1 690 181	262 564	59	1326

close to $263 000, or only 15 percent of the original claims. This compares closely with the 12 percent ratio found by Carstens for the State of Iowa.

Although claims related to construction signing made up only 9 percent of claims, they received the highest dollar award per claim. Similarly, accidents attributable to traffic-control devices were small in terms of relative frequency but were characterized by a large award per claim.

As might be expected, holes in roadways or bridges gave rise to the highest number of claims. Slightly less than half of these claims received an award. The second most common claim category was impassable roadways. As with holes in roadways, just less than half of these claims received any award. Note that the dollar amount awarded per claim was an order of magnitude less than the award for the pothole category. It is hypothesized that the court viewed the washouts and rockslides that make roadways impassable as "acts of God" rather than negligence on the part of the highway agency and therefore were reluctant to award significant amounts of money.

Almost all claims resulting from accidents on bridges received awards. Incidents in this category resulted primarily from nails protruding out of timber deck surfaces, loose steel plates on bridge decks, and decayed condition of timber decks. None of the claims filed involved vehicles striking railings or other structural elements of narrow bridges.

At the other extreme, only 13 percent of the claims in the category of wet and slippery roads were awarded; 57 percent of claims in this category involved snow or ice on the roadway. The courts may have felt that motorists were traveling too fast for conditions in many of these instances and thus did not feel an award was justified.

Analyses relating contributing categories of claims to road functional classification were also made. Results of the analyses are presented in Table 2. In general, low-volume roads had a high percentage of claims in each of the contributing categories. One-third of all claims attributable to traffic-control devices involved low-volume roads.

Almost 30 percent of the claims attributable to wet and slippery roads occurred on low-volume roads. Note that feeder and low-volume roads combined accounted for 65 percent of these claims. This is understandable when one considers that low-volume roads generally rank lowest in maintenance priority. As noted earlier, more than half of these claims involved ice- or snow-covered roads. Low-volume roads are treated or plowed only after the higher functional classes of highways have been adequately handled. Since only 13 percent of these claims were awarded, it appears that the courts recognized the limitations under which the highway agency operated.

Low-volume roads ranked highest in claims in the construction-sign category, which had 22 percent of all claims. Although data were not available on the amount of construction activity on low-volume roads during the study period, one would intuitively expect the proportion to be low relative to that on other road classes. Thus, the percentage is significant since it may indicate a need for better traffic-control plans for construction activities on low-volume roads.

Frequency tabulations of claims in the contributing categories were made for each functional class of roadway. Aggregate results for all roadway classes are shown in Figure 4. Holes in the roadway and impassable roads were a common problem in all road functional classifications. Much of this can be attributed to the topography, geology, and climate of West Virginia. A large proportion of the road mileage in the state has been built on steep slopes and slide-susceptible soils that may allow rocks, water, etc., to be carried onto the road and where conditions are favorable for pothole formation.

The frequency tabulation of claims in contributing categories for low-volume roads is shown in Figure 5. The distribution of claims among contributing categories for low-volume roads is almost identical to the distribution for all other road classes combined. Thus, although the types of problems encountered by motorists on low-volume roads are no different from those encountered on other classes of roads, as shown in Table 2, low-volume roads are overrepresented in terms of claims frequency for certain contributing categories.

South Eastern Reporter

The analysis of data collected from the South Eastern Reporter was more qualitative than quantitative. There were several important differences between the South Eastern Reporter and the Court of Claims Reports. In the former, driver error was sometimes mentioned as a causal factor. Accidents included in the driver-error category were those that were caused by drivers who did not respond to signs, drove at high speed, or fell asleep while driving. All cases in this category were decided in favor of highway agencies since courts held that negligence of the driver was the proximate cause of the accident. Thus, this factor was added to the list of contributing factors prepared previously. Another difference between the two sources was that in the South Eastern Reporter it was not possible to identify the functional class of highway involved. This was not felt to be a serious limitation since the Court of Claims data had indicated that the claims pattern among contributing categories was similar for all functional classes of highway.

The frequency distribution of reported cases by contributing category is shown in Figure 6. As expected, the distribution is different from that of the Court of Claims data. Holes in the roadway have been replaced by traffic-control devices as the leading factor. This is understandable since holes in the roadway usually result in relatively minor

Table 2. Percentage of claims by contributing category for each road functional class in West Virginia (1973-1979).

	Functional Class					
Claim Category	Interstate	Expressway	Trunkline	Feeder	Local-Service Road	Unknown
Construction signs	6	11	17	11	22	33
Traffic-control devices	17	0	25	8	33	17
Holes in roadways or bridges	8	4	30	18	24	16
Wet and slippery roads	0	14	7	36	29	14
Bridges	6	6	21	9	19	39
Impassable roadways	10	13	10	26	23	18
Maintenance activities	12	0	25	13	0	50

damage that does not warrant pursuing a case through the appeals courts to gain compensation. On the other hand, accidents involving traffic-control devices may be severe (e.g., those occurring at stop-controlled or signalized intersections) and there could be legitimate differences of opinion concerning the details of the installation. For these reasons, such cases are more likely to proceed to an appellate court.

The bridge category also ranked high in terms of claims. Most of these cases resulted from a hidden or unknown defect on the bridge such as a deteriorated deck.

The South Eastern Reporter data were classified on the basis of accident severity: 14 percent of the cases involved property damage only; injury and fatal accidents accounted for 59 percent and 27 percent of the cases, respectively. These results are distinctly different from those for the Court of Claims shown earlier. The explanation for this lies in the different nature of the courts involved. In the appeals court cases from the South Eastern Reporter, the plaintiffs had to spend money for legal and court fees. Unless the damage that resulted from an accident involved a significant amount of money, it would not be worth the expense to bring the case into court.

It was originally hoped that the detailed descriptions of cases in the South Eastern Reporter would provide specific information that would be of value to traffic enginers in defining a standard of care. For example, by knowing the details about a

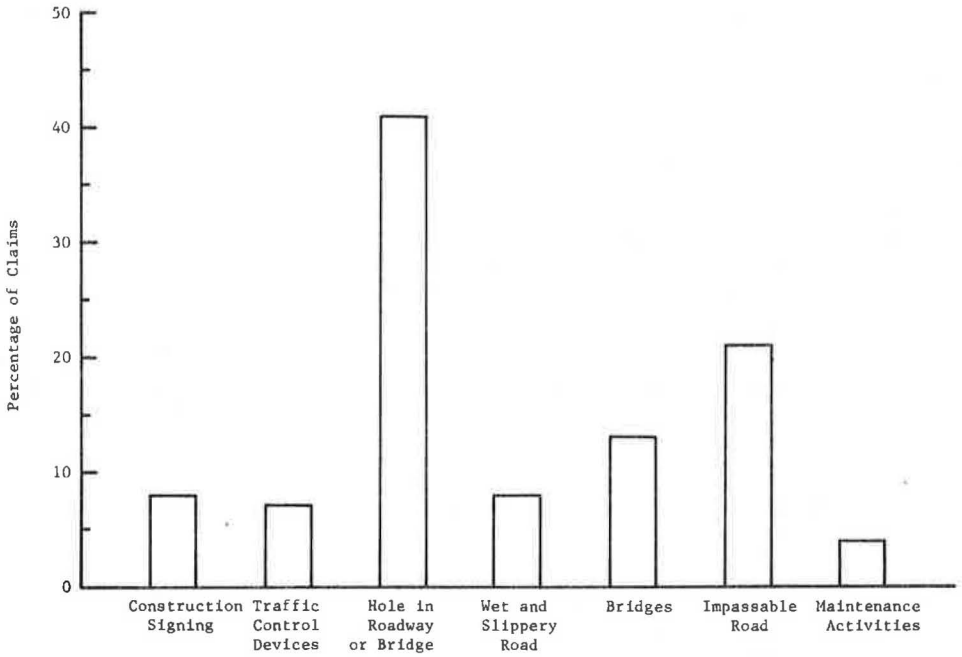

Figure 4. Claims in contributing categories for all West Virginia road functional classes (1973-1979).

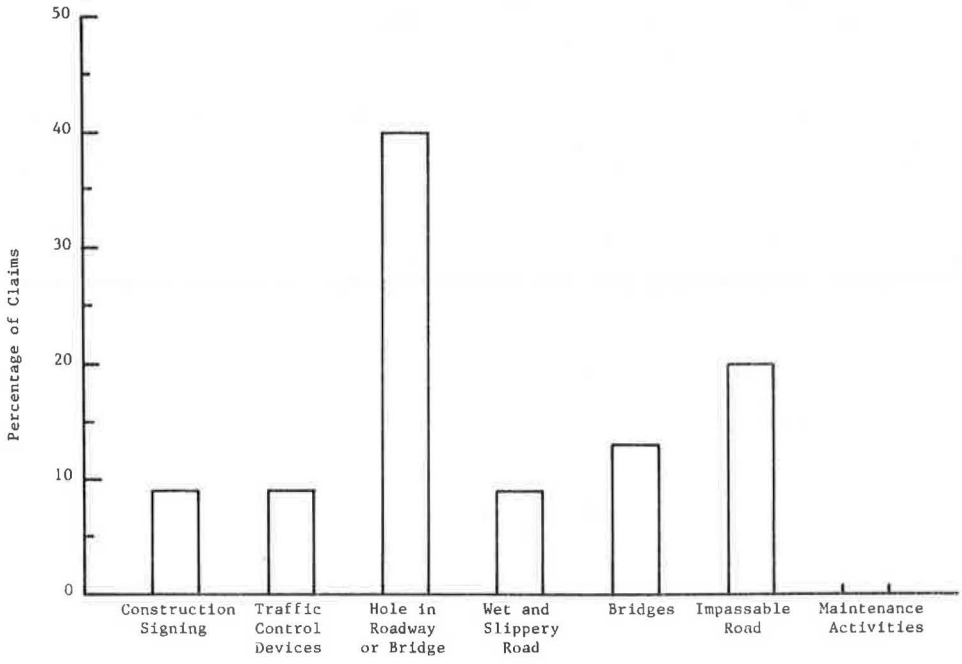

Figure 5. Claims in contributing categories for West Virginia low-volume roads (1973-1979).

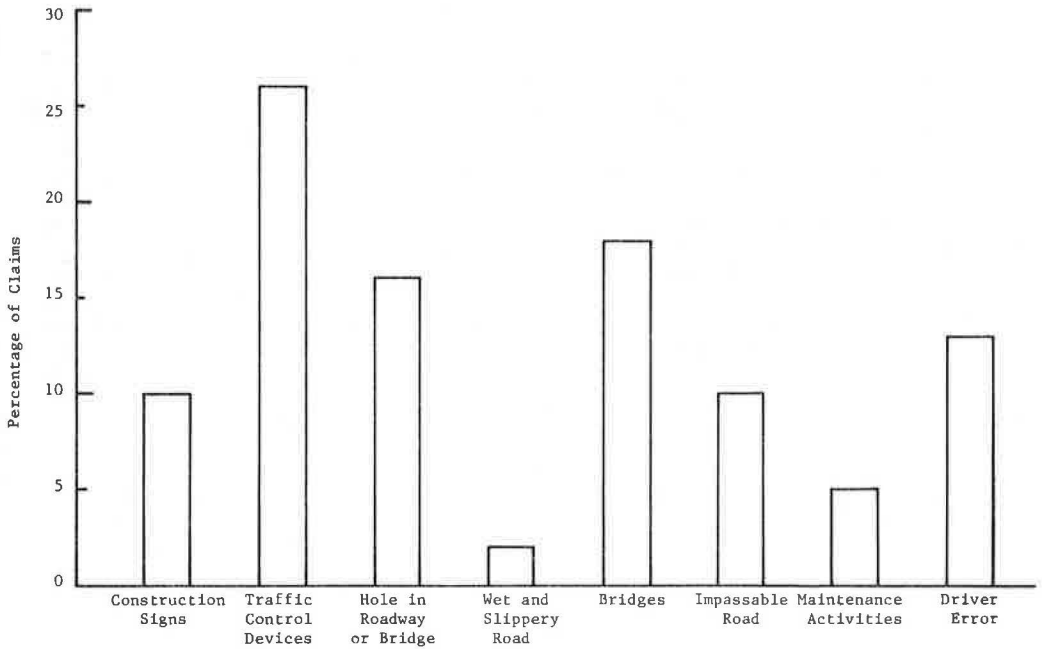

Figure 6. Claims by contributing category from South Eastern Reporter.

traffic-control device implicated in a lawsuit, the engineer could take this into account when designing or upgrading traffic-control devices. Similarly, by having a record of what the courts felt was a reasonable time period to repair roadway or traffic-control defects, engineers would be better able to set priorities for maintenance activities. Unfortunately, such detailed information was not available in published appellate cases. In order to acquire this information, it would be necessary to collect data from the original record of the case. This is usually available only from the court in which the trial was held.

For the South Eastern Reporter data, it was found that 55 percent of the 107 cases examined were originally decided in favor of highway agencies. However, after the injured party appealed, 27 percent of the cases (cases that were originally decided in favor of highway agencies) were decided against those agencies. Of the 45 percent of all cases that were originally decided against highway agencies, more than half (52 percent) were decided in favor of highway agencies after they were appealed. In sum, 64 percent of all cases were decided in favor of highway agencies.

CONCLUSIONS AND RECOMMENDATIONS

This study involved an analysis of published legal cases to try to identify common types of low-volume-road safety problems and where they are most likely to exist. Such information could be used to provide highway engineers and administrators with helpful guidelines in improving their decisionmaking relative to low-volume road design and operation. More informed decisionmaking should increase roadway safety and reduce liability potential. Because the published legal information was not so detailed as desired, it was not possible to develop specific guidelines. However, a study of case law can still provide valuable insight into the problems faced by engineers involved with low-volume roads. Conclusions drawn from the West Virginia data analyzed here will be presented below.

It was concluded that the pattern of liability experience of low-volume roads is no different from that of the other roadway functional classifications. The types of claims, in terms of traffic engineering categories, are similar for low-volume roads and for other classes of highway. Knowledge of this relationship should be useful to agencies lacking adequate data relative to claims on low-volume roads.

Although the types of problems encountered on low-volume roads may be the same as those on other roads, certain types of claims are overrepresented with respect to the amount of travel occurring on low-volume roads. This is probably attributable to the lower design standards used on low-volume roads and to the lower priority these roads receive in maintenance activities, e.g., snow removal and pothole patching. Although these problems will not likely be overcome without an infusion of large sums of money, engineers and decisionmakers can look to the other levels of the functional classification to give them an indication of the types of problems to be expected on low-volume roads. The limited funds that are available can be allocated accordingly.

A few specific types of problems were identified that can be resolved without expenditure of additional funds. As the examples below illustrate, there are many cases where a highway agency could reduce its liability risk through judicious use of existing case law in conjunction with standard procedures such as record-keeping and warning systems. Holes in roadways and bridges and impassable roads were the leading causes of claims on low-volume roads. This points out the importance of having a roadway inspection program and a system for receiving notification about changed conditions. A disproportionate number of claims on low-volume roads involved construction signing. Additional attention to the traffic-control plans for construction activities on low-volume roads appears warranted.

It is recommended that highway engineers and administrators consider using case law as a tool in their low-volume-road decisionmaking. Although not a panacea, case law may provide valuable information that may not be available from any other source. The data usually can be compiled relatively easily from published legal records. These documents are often available at the law libraries in county courthouses. We have prepared a guide to assist

traffic engineers in gaining access to these records (6).

Further research into this area is suggested. Studies similar to the one described here should be performed in other regions of the country. Differences in laws from state to state probably require that each state develop its own background data.

The findings of this study are based principally on the West Virginia Court of Claims Reports. Although an unknown number of dubious claims are probably made, the results are believed to be reasonably accurate for the less serious accidents. On the other hand, the cases found in the South Eastern Reporter may be unrepresentative in that they refer only to the cases appealed from at least one (lower) court. Because this group of cases covers a fuller range, including the more serious accidents, and since the records contain much more detail, it would appear desirable to use the original court cases as a data source. Thus, the feasibility of using original court cases as a data source should also be examined.

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Determination of Structural Equivalency Factors of Recycled Layers By Using Field Data

ADRIAAN VAN WYK, ELDON J. YODER, AND LEONARD E. WOOD

The recycling of pavement materials is an effective cost- and energy-efficient method of reconstruction. Good results can and have been obtained with recycling. Since more than 90 percent of all hard surface roads and streets in the United States are composed of asphalt mixes, the use of recycled asphalt layers in reconstructed pavements can be extensive. Cold recycling is especially suitable for use on low-volume roads due to the lower cost and usually assumed lower strength compared with hot recycling. A value for the strength of the recycled layer or the structural coefficient is important in order to design the pavement. Underdesign can lead to premature failure and corresponding high maintenance costs. Overdesign, on the other hand, can lead to the ineffective use of available funds. Asphalt cement and emulsified asphalt have traditionally been used as a binder in recycling. Another promising binder is foamed asphalt. The latter has the advantage that it can be mixed at lower temperatures than asphalt cement and it does not need curing like emulsified asphalt. During the summer of 1981, the Indiana Department of Highways built an experimental section of 9 miles (15 km) by using asphalt emulsion and foamed asphalt in cold recycling on a low-volume road. Before, during, and after construction, various tests were conducted to determine the properties of the pavement layer to be used in the determination of the structural equivalency factors of the recycled layers. These included in situ California-bearing-ratio tests, the testing of 4-in (102-mm) recycled base-course cores taken from the pavement, and Dynaflect deflection measurements. Based on layer properties obtained in these tests and pavement deflections, an elastic-layer computer program was used to determine the structural equivalency factors. The elastic moduli of the pavement layers were determined from Dynaflect deflection measurements taken at three different times. The pavement sections determined were used to calculate structural coefficients. Various criteria were used. The methodology used to determine the elastic moduli of the pavement layers and to calculate the structural coefficients is described in this paper. A wide range of coefficient values was determined with the different criteria. A range of values was selected that can be used in design.

The energy crisis in 1973 stimulated the search for alternatives to conventional pavement construction methods. Although used since the 1930s, the recycling of pavements, especially asphalt pavements, became a feasible alternative to rehabilitation and reconstruction. During the past few years, emphasis has shifted from the saving of energy to the more effective use of highway funds. The construction costs of highways have more than doubled since 1973 (1), whereas the motor fuel tax revenue declined from 63 percent in 1970 to 55 percent in 1980 (2). Emphasis has moved further, from the construction of new highways to the maintenance of existing highways. More than 90 percent of all paved roads in the United States used bituminous surfaces (3). A large percentage of all the paved roads need resurfacing or reconstruction.

Recycling has the potential to help solve the problem by saving expensive energy and pavement materials and by reducing costs, if it performs as expected. Studies (4-6) have shown that asphalt pavements can be recycled and reach a strength of equal to or better than the conventional mixture in some instances. These studies were based primarily on laboratory test results. The performance of recycled layers has not been verified beyond doubt through field applications. This is one of the reasons why recycling has not been used more outside the United States (7).

The problem is even more profound with cold recycling and for low-volume roads. The control of the mixing process and the compaction procedure is usually less stringent for cold recycling on low-volume roads than that on high-volume roads. It is difficult to simulate these conditions in the laboratory. The recycled layer on low-volume roads further contributes to the largest portion of the strength of the pavement. The base course on low-