Highway-Related Tort Claims to Iowa Counties

R.L. CARSTENS

Tort claims that result from alleged highway defects have introduced an additional element in the planning, design, construction, and maintenance of highways. A survey of county governments in Iowa was undertaken in order to quantify the magnitude and determine the nature of this problem. This survey included the use of mailed questionnaires and personal interviews with county engineers. Highway-related claims filed against counties in Iowa amounted to about $52 million during the period 1973 through 1978. More than $30 million in claims were pending at the end of 1978. Settlements of judgments were made at a cost of 12.2 percent of the amount claimed for those claims that had been disposed of, not including costs for handling claims, attorney fees, or court costs. Problems that resulted in claims for damages from counties have generally related to alleged omissions in the use of traffic control devices or defects (often temporary) that result from alleged inadequacies in highway maintenance. The absence of stop signs or warning signs often has been the central issue in highway-related tort claims. Most frequently alleged maintenance problems have included inadequate shoulders, surface roughness, ice or snow conditions, and loose gravel. Eight recommendations resulted from this research. These are directed toward reducing the potential exposure of counties to tort liability.

The 99 counties in Iowa are responsible for a system of approximately 90 000 miles of collector and local service highways. Nearly 3.5 billion vehicle miles of travel occur on this system annually. This travel results in about 200 fatalities from traffic accidents.

Each accident on a county highway, and especially each serious accident, introduces the potential for a damage claim against a county. Since any highway segment is imperfect in some respect, the basis for a claim can grow out of any traffic accident.

BACKGROUND

The goal of this research was to improve highway safety and reduce the potential liability of counties from accidents related to alleged imperfections in highway facilities or in connection with essential highway-related activities. This goal was addressed by focusing on those safety problems that have resulted in highway-related tort claims against counties.

The Code of Iowa was amended in 1967 to permit claims and suits against cities and counties for tort damages. Liability is imposed whether it arose out of a governmental or proprietary function. Hence, virtually no highway-related activities are carried out by counties in Iowa that are barred from tort claims.

Various chapters of the code charge the county supervisors and engineers to keep secondary roads in the best condition practicable, provide details on the performance of certain maintenance tasks, mandate that local traffic control devices conform to the state manual, direct local authorities to place such traffic control devices as they may deem necessary, and have specific provisions to deal with stop and yield signs--stop signs at particularly dangerous highway grade crossings of railways and additional warning signs at unusually dangerous places. Collectively, these sections of the code afford ample basis for highway-related tort claims against counties in Iowa.

Typical low-volume roads found on county systems are constructed to lesser standards than high-volume facilities. Although the logic of this approach is inescapable, none of the seemingly valid reasons for adhering to lesser standards on a low-volume highway affords a suitable defense in litigation. A seriously injured plantiff, or relatives who represent the estate of a person killed in a highway accident, will exploit any discrepancy between an ideal standard and the imperfect highway segment where an accident occurred.

This research was undertaken to quantify the problem of highway-related tort claims against counties and to seek solutions that would make travel on county highways safer and reduce the frequency and magnitude of claims. The solutions sought were assumed to be constrained by realistic fiscal limitations and were intended to render an existing system, without significant modification, safer for travel. Their adoption could be expected to free a greater proportion of available funds for the construction and maintenance of county highways if a decreased proportion were required to satisfy tort claims or for liability insurance.

IDENTIFICATION OF THE PROBLEM

A survey of the counties in Iowa was undertaken in order to ascertain their experience with highway-related tort claims. This was accomplished in part by mailed questionnaires that solicited information from each county concerning any tort claims that resulted directly from the responsibility for construction and maintenance of highways, including the installation of traffic control devices.

Information was requested concerning any claims initiated during the period from January 1, 1973, to December 31, 1978. The questionnaires were directed to county engineers.

Magnitude

Eighty-five completed questionnaires were received. Sixteen respondents indicated that no highway-related tort claims had been submitted during the period 1973 through 1978. The 14 counties that did not respond included four of the five most populous counties in Iowa.

Total highway-related tort claims reported by 85 counties amounted to $44 652 728 for the six-year reporting period. Annual totals are shown in Table 1. Note that the amounts claimed were relatively constant for the first five years of the reporting period. However, claims submitted during 1978 amounted to more than twice the annual average for the preceding five-year period. It is not apparent whether the 1978 claims experience is indicative of an increasing trend, although this appears to be the case, since the time series otherwise is relatively flat.

Of this total, claims of $26 339 108 (59.0 percent of the amount claimed during the six-year period) were pending at the end of 1978. A breakdown by category of claims submitted and pending is displayed in Table 2.

The total amount claimed resulted from 366 claims that were reported, an average of $122 002/claim. Most smaller claims tend to be settled quickly, so the average amount claimed for the 81 claims still pending at the end of 1978 was $325 174.

Payments on the 285 claims that had been settled by the end of 1978 amounted to $2 232 890. This was 12.2 percent of the $18 313 620 that had been claimed. Methods of settlement included denial of a claim in its entirety, full or part payment of the

amount claimed, and, for most larger claims, by court-imposed judgment. Settlements by claims category are shown in Table 3.

By using the average amount claimed of more than $525 000 for the 85 counties that responded to the survey, the projected statewide total for 99 counties would exceed $52 million in total claims for the six-year period. A similar calculation for pending claims indicates that more than $30 million in claims was pending for all 99 counties at the end of 1978.

Claims Categories

A description of typical incidents that were included in each claims category follows. However, note that an attorney for a plaintiff typically will employ a shotgun approach in the preparation of a case against a county defendent. The allegations often will include a wide variety of imperfections in signing and roadway geometrics. In such cases, the category was selected that appeared to be most relevant to the particular incident that gave rise to a claim.

Table 1. Annual amounts of tort claims in 85 Iowa counties.

Year	Total Amount ($)	Proportion of 1973-1977 Average
1973	6 342 008	1.007
1974	3 910 961	0.621
1975	8 338 906	1.324
1976	7 934 128	1.259
1977	4 973 057	0.789
1978	13 153 668	2.088
Total	44 652 728	

Inadequate Shoulder

Shoulder inadequacies reported by the counties as leading to tort claims were about equally divided between dropoffs at a pavement edge and other deficiencies. Dropoffs involved in such cases allegedly ranged from 3 to 12 in. Other problems included locations where the shoulder allegedly was soft, some material had eroded, or the shoulder otherwise was deficient in an unspecified manner.

Improper Signing of Curve

Allegations of improper signing of curves tended to be general in nature, and simply charged a failure to provide adequate warning. In many instances, allegations were made of deficiencies in the design of a roadway as well as imperfections in signing.

Claimants generally referred to the Manual on Uniform Traffic Control Devices (MUTCD) (1) as the appropriate authority for signing practices. Depending on the signing actually in place, the alleged negligence might involve failure to use an advisory speed plate, a large arrow (or chevron) sign, or both.

Railroad Crossing Sign

The usual allegation for claims against railroad crossing signs was that a county was negligent in failing to erect a stop sign or automatic signals at a railroad grade crossing. Impetus for these claims was afforded by the section of the Code of Iowa that suggests the appropriateness of stop signs at particularly dangerous crossings. However, a different basis was stated for the largest claim reported (for $3.5 million). Failure to install lights at the crossing was cited in this case to support an allegation of negligence by the county.

Table 2. Total and pending claims.

Category	Total Claims ($)	No. of Claims	Claims Pending at End of 1978 ($)	No. of Claims Pending
Inadequate shoulder	7 966 540	17	2 686 500	8
Improper signing of curve	7 622 843	12	3 930 546	4
Railroad crossing sign	5 780 607	12	4 225 000	4
Uncontrolled intersection	4 930 251	10	4 926 051	9
T-intersection	3 822 165	17	3 532 776	10
Rough road	2 825 275	39	2 399 003	11
Roadway geometric deficiency	2 120 568	4	900 000	1
Snow or ice on road	1 462 000	10	768 500	5
Improper signing for road closure	1 375 661	8	375 000	1
Mud on road	1 350 000	4	0	0
Bridge	974 391	19	720 000	3
Other	4 422 427	214	1 875 732	25
Total	44 652 728	366	26 339 108	81

Table 3. Ranking of categories by total amount of settlement.

Category	Total Settlement ($)	No. of Settlements	Amount of Original Claims ($)	Settlement Cost as Percentage of Claims
Improper signing of curve	997 418	8	3 692 297	27
Inadequate shoulder	610 700	9	5 280 040	12
Railroad crossing sign	236 000	8	1 555 607	15
Improper signing for road closure	116 683	7	1 000 661	12
Rough road	58 842	28	426 272	14
T-intersection	50 264	7	289 389	17
County vehicle accidents	45 798	108	442 481	10
Snow or ice on road	45 000	5	693 500	6
Gravel windrow and loose gravel	30 588	28	669 480	5
Construction signing	10 439	8	61 048	17
Road washout	6 600	4	110 023	6
Improper sign placement	6 244	5	359 261	2
Other	18 314	60	3 733 561	0
Total	2 232 890	285	18 313 620	12

Uncontrolled Intersections

Claims that involved uncontrolled intersections involved allegations that counties were negligent in failing to provide stop controls at intersections. If two-way stop control had been provided, a need for four-way stop control was alleged. Such claims may also be accompanied by assertions that other problems existed, such as deficiencies in the designs of the intersecting roadways. On paved highways, some claims also alleged a need for rumble strips.

T-Intersection

Most of the claims against T-intersections involved alleged deficiencies in the signing needed to provide sufficient warning at T-intersections. An advance warning sign, a large arrow sign on the far side of an intersection, or both most frequently were at issue. However, both of the claims in this category for more than $1 million resulted from accidents at stop-controlled T-intersections. The reflective quality of the stop sign was at issue in both cases.

Rough Road

Many of the claims due to rough roads merely stated that the road was rough. Other allegations included frost boils, potholes, or blowups on portland cement concrete pavement.

Roadway Geometric Deficiency

Roadway geometric deficiencies include four claims that alleged an excessively steep grade or inadequate sight distance on a curve or excessive crown on a road. Note that allegations that involved the width of a roadway have been included in a separate category on narrow roads.

Snow or Ice on Road

Claims due to snow or ice on the road resulted from accidents allegedly caused because snow or ice was on the roadway. Counties in these cases allegedly were negligent either for failure to remove snowdrifts or by failing to correct slippery conditions caused by ice or packed snow.

Most of these claims arose due to snow or ice accumulations from precipitation. All of the claims of this nature that had been settled resulted in no payment to the claimants. The one case that resulted in payment to several claimants came about because ice accumulated on the roadway due to runoff from adjacent land.

Improper Signing for Road Closure

Of eight claims due to improper signing for road closure, four were for minor damage that occurred when automobiles or light trucks struck part of the signing or barricades used to close a road. One large claim arose when a motorcycle struck a barricade that was used to close a road. The barricade allegedly did not conform with standards. The other three cases alleged that a road should have been closed but was not. In two instances, a bridge had washed out and in the other case some construction activity was taking place.

Mud on Road

The four claims due to mud on the road resulted from the same incident. A vehicle on a paved county highway encountered a road section that was slippery due to the presence of mud and skidded out of control. A jury trial resulted in a verdict in favor of the defendent county.

Bridges

Most claims against bridges have been small demands to cover vehicle damage. They generally resulted from roughness of deck, often a timber deck. However, four claims, as follows, have been for substantial amounts:

1. Bridge deck allegedly slick from frost,
2. Collapse under the load of a truck,
3. Accident allegedly resulted from loss of control due to dip in the bridge approach, and
4. Approach fill undermined and gave way beneath a vehicle.

Improper Sign Placement

Improper sign placement was included to encompass alleged signing deficiencies not included in the categories of curves, railroad crossings, T-intersections, road closures, or construction activities. Most such claims involved stop signs that either were obstructed or were missing as a result of vandalism.

Among other claims, the largest alleged failure to install a pedestrian crossing sign. One claim resulted because no advance-warning sign was used before a stop. Another alleged that a county was negligent because a no-passing zone had not been established.

Gravel Windrow and Loose Gravel

Most of the claims due to gravel windrow and loose gravel involved vehicle damage only, although a few involved accidents that had personal injuries. They resulted when a vehicle either struck the gravel windrow that occurred during blading of a loose-surfaced road or encountered loose gravel that allegedly had not been sufficiently spread or hit a large stone lying on the road. One claim of a different nature arose when crushed stone from the shoulder had encroached onto the edge of the pavement and caused loss of control of a vehicle on a curve.

County Vehicle Accidents

Claims resulting from motor vehicle accidents were not included in the responses to the survey unless they occurred when a county vehicle was actually engaged in a construction or maintenance activity. Consequently, most of the claims in this category resulted from accidents that involved graders or snow plows. Fewer of the accidents that gave rise to these claims involved trucks, mowers, or heavy equipment. Included are accidents that resulted in damage to other vehicles as well as to other types of property.

Construction Signing

Construction signing includes claims that resulted from alleged deficiencies in warning of construction or maintenance (other than routine blading) activities on the road other than those that involved signing for road closure.

The largest claim resulted when a worker sealing cracks on a resurfacing project was struck by a passing automobile. Three claims involved vehicles running into excavations. Other claims resulted from accidents that involved an automobile that

Table 4. Description of dependent and independent variables.

Variable	Definition	Mean Value	Simple Correlation with Y
Y	Total dollar amount of claims for a county from 1973 through 1978	525 326	1.000
X_1	Latitude of the county seat of a county, minus 40°	2.04	0.215
X_2	Longitude of the county seat of a county, minus 90°	3.46	-0.153
X_3	County population based on the 1970 census	22 250	0.244
X_4	Miles of loose-surfaced and unsurfaced roads in a county's secondary road system in 1977	752	-0.034
X_5	Miles of hard-surface roads in a county's secondary road system in 1977	136	0.093
X_6	Total road mileage in a county's secondary road system in 1977	888	0.002
X_7	Number of attorneys in a county that are members of the Iowa State Bar Association in 1978	27.5	0.195
X_8	Vehicle miles traveled per day on a county's secondary road system in 1977	87 515	0.206
X_9	Average value in dollars per acre of agricultural land in a county in 1978	1634	0.091
X_{10}	Population in county that resides in communities of at least 1500 in 1970	12 587	0.214
X_{11}	Population in county that resides outside communities of 1500 or more in 1970	9663	0.317

struck a bituminous paving machine, a motorcycle that skidded on a bridge deck after it was treated with linseed oil, and an automobile that struck the end of culvert pipe lying on the shoulder.

Narrow Road

Four claims were placed due to narrow roads. Two claims resulted from accidents on roads that allegedly had become too narrow due to erosion of one edge of the road. One of these was occasioned when a farm tractor rolled into the ditch and killed the operator.

The other two cases apparently involved roads that had retained their design widths. One was occasioned by an accident on a bridge that was 20 ft wide. The other claim followed an accident on a dirt road that allegedly was too narrow for two vehicles to meet safely.

Water Backup or Right-of-Way Encroachment

Water backup or right-of-way encroachment includes claims that arose from highway construction or maintenance activities that in some manner interferred with the property right of adjacent land owners. In four cases, construction of a drainage facility allegedly caused water to back up on adjacent land. In two cases, trees on private property were cut down without the owner's consent. The other two cases involved encroachment of a roadway onto private property.

Road Washouts

In each of four claims, a road allegedly had washed out to cause an accident that gave rise to the claim. Note that some of the claims that involved shoulder deficiencies, road closure signing problems, and narrow roads also involved erosion of some part of a roadway. Claims in this category differ, in that each incident affected the traveled portion of the road and the principal allegations concerned warning of a hazard rather than road closure.

Unclassified

Three sizable claims could not be included in other claims categories. These included a work area accident that involved a fatal injury to a contractor's employee, a claim after a house fire to which access by fire equipment was hampered because the county had a bridge under repair, and a claim that arose from a collision between an automobile and a post placed on the road shoulder to support a box used for newspaper delivery.

Other Maintenance Activities

Other maintenance activities involved only comparatively small claims, including damages from weed spraying or tree trimming and from gravel that blew from trucks and damaged passing or following vehicles.

Analysis of Claims Experience

A multiple-regression analysis was undertaken in order to identify any demographic or geographic factors that tended significantly to explain the variation in claims experience among counties. Two different dependent variables were tested--the total amount of claims reported for a county during the period 1973 through 1978 and the claims per capita for this period.

No useful insight into the occurrence of tort claims in a specific county was afforded by this statistical analysis. None of the correlations of explanatory variables with the amount of claims was sufficiently high to indicate that any of these variables was useful for predicting claims experience. Equations developed by using multiple-regression techniques also lacked significant explanatory capability. These findings suggest either that the occurrence of tort claims is almost completely random or that factors to explain their occurrence remain to be identified.

A list of the independent variables tested is given in Table 4. Also shown in Table 4 are the mean values for each variable and the simple correlation between that variable and the total claims during the six-year study period.

An additional analysis, by using a sample of only 11 counties, used as an independent variable a subjective rating that was based on the extent to which a county's signing practices appeared to go beyond the minimum requirements set forth in MUTCD. A significant inverse relation was shown between claims experience and the extent to which use of warning signs apparently exceeds the requirements of MUTCD. Because of the small sample size and the highly subjective nature of the rating variable, caution is necessary in the interpretation of this finding. Also note that this research did not demonstrate a relation between the degree of safety afforded the traveling public and either signing practices or the amount of claims. It is quite possible that safer highways may attract more claims than will older, less safe highways.

INTERVIEWS WITH COUNTY ENGINEERS

Information to supplement that afforded by the questionnaires was obtained by interviews in varying depth with 40 county engineers. Fifteen of these interviews were in sufficient depth to cover most or all of the following topics:

1. Claims reported on the questionnaire responses,
2. Procedures for maintaining loose-surfaced and unsurfaced roads,
3. Policies regarding coordination of efforts on county line roads,
4. Policies about use of stop control,
5. Use of speed limits outside cities,
6. Use of lighting at rural intersections,
7. Practice with respect to accident reporting,
8. Sign inventory,
9. Practice with respect to use of warning signs, and
10. Use of advisory speed plates.

Counties in Iowa are divided into maintenance districts for routine blading and snow removal on loose-surfaced and unsurfaced roads. A grader with operator is assigned to each district. Data from 14 counties indicated a range of from 7 to 21; the average was 11.4 graders per county. Graders normally worked singly and covered most roads in their districts in four- or five-day cycles. It was not uncommon for a grader to work in a lane in the direction opposite to the normal flow of traffic.

Approaches to coordination of maintenance activities on county line roads varied widely among the counties in which interviews were conducted. Similar problems were also reported at state lines and municipal corporation boundaries. Formal agreements that were legally approved by resolutions were much less common than were informal agreements among county engineers. Agreements always covered routine maintenance operations such as blading, snow removal, and mowing but infrequently spelled out responsibility for signing. Several examples were noted of potentially serious discrepancies or omissions in traffic control on county line roads. Most of these involved different policies among counties that occasioned incónsistencies with respect to stop control.

Counties most frequently used stop control to afford preferential treatment to through highways, generally paved roads on the trunk system. Other installations of stop signs were based on studies by county engineers, usually rather informal, that considered traffic volumes, sight distances, accident experience, composition of the traffic streams, and other factors as appropriate. Many such studies were initiated in response to suggestions from private citizens.

The only instances of speed limits on county roads reported by the county engineers who were interviewed were in built-up areas. These included roads in incorporated communities, unincorporated communities, and rural subdivisions. Speed limits were implemented on the basis of traffic engineering studies carried out by personnel of the Iowa Department of Transportation.

Practices among counties varied widely with respect to the use of roadway lighting. Lighting was not used on county road systems in a majority of the counties visited. Usage in four counties that had installed lights varied from 6 to 27 locations. Most installations consisted of a single luminaire at an intersection. Two lights were used at a few locations. Economic constraints and the threat of vandalism were the reasons most frequently given for not using more lights at county road intersections.

Eight of the 14 county engineers with whom this topic was discussed indicated that they seldom or never were notified of an accident on a county road that was investigated by the sheriff's office. Four others stated that they were usually notified and two thought that they were made aware of virtually all accidents investigated by the sheriff. In no case could a county engineer anticipate notification of an accident if the investigating officer was from the state patrol. No other mechanism exists for timely notification to county engineers of accidents that may result in tort claims against counties.

Each county engineer interviewed reported the existence of some form of sign inventory for the county. These varied widely in complexity and format. Most inventories consisted of a series of maps, each usually covered a single township, on which signs were located. Some detail as to sign type and condition was afforded by a symbol, number, or series of numbers on the maps. Other inventories were on cards or forms prepared for this purpose. One county was in the process of implementing a computerized sign inventory. The most common procedure for updating an inventory was a semiannual or annual visual inspection of signs on the entire county highway system by a person designated to have primary responsibility for signing.

Philosophies regarding the use of signs varied widely among the county engineers who were interviewed. These differences were manifested most clearly with respect to the use of warning signs. About half of these engineers favored adherence to the minimum requirements set forth in MUTCD. The others clearly went beyond these minimum requirements in varying degrees by using more warning signs than strict adherence to MUTCD would suggest. There generally were pronounced differences in the elaborateness of signing, depending on the highway type. Advance warning signs of all types tended to be used much more frequently on paved roads that had high volumes than on unpaved roads that carried very low traffic volumes.

Similarly, advisory speed signs were rarely used on unpaved roads by the interview responses. Use of these signs was much more common on paved highways. The appropriate advisory speed generally was determined by trial runs to determine a speed that precludes sliding and feels comfortable. A ball bank indicator reportedly was used to assist in this process by only two of the county engineers who were interviewed.

A critical concern for vandalism of traffic signs and hazard markers was expressed by all of the county engineers who were interviewed. Loss of these devices not only has caused a substantial expense to the counties for replacement but also has been the cause of a number of accidents and led to several tort claims.

An appropriate response to the destruction of traffic signs has been difficult to formulate, according to the county engineers who were interviewed. Some county engineers reported success with information campaigns that made an appeal to the public and pointed out the hazards and expense occasioned by vandalism of signs. Others found such campaigns counterproductive. The directing of attention to the problem apparently attracted more imitators than it deterred. Similar experience was reported regarding vigorous prosecution and punishment of those apprehended after destroying traffic signs. The rather nominal fines received by offenders and the resultant publicity was often believed to lead to more sign destruction and to have no deterrent effect.

Unfortunately, the problem of vandalism appeared clearly to inhibit the more extensive use of warning signs. County engineers, in general, wanted to minimize their exposure to vandalism by reducing the number of signs.

Most of the county engineers who were interviewed regularly investigated accidents that occurred on county roads and were reported to them. They documented the facts related to possible causes of the

accidents, including measurements of marks left by the vehicle or vehicles involved. They also took photographs of road conditions and control devices. In several instances these photographs were the critical items of evidence in sustaining the denial of a tort claim that had been based on erroneous facts.

SUMMARY AND CONCLUSIONS

The threat of tort claims that result from alleged highway defects introduces an additional concern to those charged with providing highway service. Any decision related to highway design, construction, or maintenance made by a jurisdiction that does not enjoy sovereign immunity is subject to possible review in court. There, the good faith and competence of the decision maker will be carefully scrutinized and challenged.

The results of this research suggest that the possibility of such a review may induce responses that are entirely defensive in nature and may even exert an adverse effect on the safety and efficiency of highway travel. At least this seems to be the case with county governments in Iowa. The installation of stop signs at low-volume rural intersections or railway grade crossings is an example of a response that has introduced inefficiencies in travel and with little or no beneficial effects on safety.

Given the fiscal constraints within which county highway systems are constructed and maintained, their more consequential imperfections cannot be corrected. Moreover, considerable evidence shows that current levels of expenditures for highways reflect the viewpoint of a majority of citizens regarding the value of highway safety. The public has demonstrated little willingness to support substantially increased outlays for safety measures on local highway systems. Instead, low-cost responses, such as improvements in highway signing, need to be sought out and implemented. An additional element of risk analysis, which results from tort claims, must be entered as a variable in making a choice among alternatives to establish priorities for highway improvements.

A study of Tables 2 and 3 will provide some insight into the relative risk of tort claims for various problem areas. The data in Table 2 indicate that only five claims categories have accounted for 67 percent of the total amount of claims. However, as shown in Table 3, not all types of claims offer the same probability of recovery.

Approximately 56 percent of the highway-related claims submitted to 85 counties in Iowa during the period 1973 through 1978 related directly to traffic control and signing practices. An additional 40 percent related to roadway deficiencies of such nature that a lack of adequate warning could support an allegation of negligence against a county. Thus, proper signing practices could afford at least a partial defense for 96 percent of the amount of claims received.

As part of this research, two alternative methods were tested for routine blading operations on loose-surfaced and unsurfaced roads. In one method, two machines would work in tandem. In the other method, a grader would reverse direction at each intersection. The objective of each method is to minimize the length of exposed windrow. A simulation based on representative maintenance districts showed that both methods would increase machine working time by 15 percent or more and would introduce additional hazards sufficient to offset the safety advantage of shortened windrows.

The study also included a series of trial runs to test the suitability of using a ball bank indicator to establish advisory speeds on curves on loose-surfaced roads. Considerable variation in indicator readings was noted due to differences in vehicle suspensions, surface roughness, and the lack of uniformity in road cross sections. Although the ball bank indicator can assist in establishing advisory speeds on curves on loose-surfaced roads, this variation suggests that engineering judgment is essential for properly interpreting the results of such trial speed runs.

RECOMMENDATIONS

1. Follow strictly the provisions of MUTCD in the use of warning signs. A defense against many highway-related tort claims can be afforded by demonstrating that warning signs were used in a suitable manner to provide motorists with notice of an unusual or potentially hazardous condition. Although MUTCD contains relatively few mandatory requirements with respect to warning signs, the existence of such a mandate is often inferred in court when the failure to install a warning sign becomes the matter at issue. Consequently, adherence to the minimum requirements of the manual is essential to avoid a finding of negligence against a highway authority. Moreover, courts often have held that even strict adherence to MUTCD is insufficient to demonstrate reasonable care in the provision of highway service.
2. Establish a coherent and carefully documented policy governing the use of stop signs. A policy should be adopted that sets forth specific circumstances that call for the installation of stop signs. Criteria governing their use should be consistent with those suggested in MUTCD, including accident experience, approach speeds, sight distance, and traffic volumes. An engineering study should be conducted and appropriately documented for each installation and for each instance where stop sign control is shown to be inappropriate.
3. Establish a continuing sign inventory process. A sign inventory is essential to provide evidence of the existence of a particular sign at a particular location at a specific time. It also provides a convenient mechanism for evaluating sign use for conformance with standards. The inventory process should be continuous with constant updating as signs are added, removed, or replaced.
4. Establish written agreements to cover roads on jurisdictional boundaries. Written agreements are necessary to establish responsibility for maintenance and for liability on roads at the boundaries of highway jurisdictions. The responsibility for signing should be spelled out in detail. Regulatory controls should be implemented by appropriate actions from both governing bodies.
5. Use a ball bank indicator to establish advisory curve speeds where needed. The appropriate advisory speed on a curve should be established by trial runs by using a ball bank indicator to demonstrate the combined effect of centrifugal force and superelevation. However, because of variations in vehicle suspensions and other factors, adherence to numerical limits must be tempered by judgment to ensure that the advisory speed does not closely approach the speed of incipient sliding or cause a feeling of discomfort to a driver within the curve.
6. Establish a road and sign inspection program. Many claims result from temporary conditions, such as roadway damage from a flash flood, surface irregularities, or accumulations of water from thawing or sign vandalism. A systematic method of notification of such conditions should be established by using assistance from the general public as well as highway department workers and other pub-

lic employees who travel regularly within the jurisdiction.

7. Establish a program to document conditions that surround highway accidents. The ability to defend a tort suit often depends on evidence that may be difficult to establish several years after a highway accident when a claim may reach the settlement stage. Evidence should be gathered immediately following an accident by a person knowledgeable about the highway facility. Such evidence, which should include photographs, should document the condition of the highway and traffic control devices as well as information that may be needed to reconstruct an accident.

8. Develop procedures to ensure timely notification of highway accidents. Immediate documentation of the conditions that surround an accident obviously is dependent on timely notification of accidents likely to result in tort claims. Arrangements should be made with the appropriate law enforcement agencies to ensure that the highway agency receives such timely notification.

ACKNOWLEDGMENT

This research was conducted by the Engineering Research Institute, Iowa State University, developed by the Iowa Highway Research Board, and sponsored by the Highway Division, Iowa Department of Transportation. However, the interpretation of factual input to the research, opinions, and conclusions are mine and are not necessarily those of the Iowa Department of Transportation or of members of the Iowa County Engineers Association.

REFERENCE

1. Manual on Uniform Traffic Control Devices. AASHTO, Washington, DC, 1978.

Publication of this paper sponsored by Committee on Traffic Safety in Maintenance and Construction Operations.

Procedure for Evaluating Efficiency of Power-Operated Cutting Tools in Localized Pavement Repair

H. RANDOLPH THOMAS AND DAVID A. ANDERSON

This paper describes a procedure for evaluating the cutting efficiency of air- and gasoline-operated pavement breakers. The procedure was developed as part of a comprehensive study of the pothole-repair procedures used by the Pennsylvania Department of Transportation. Cutting times and delay times are recorded by using the stopwatch study technique and time-lapse photography. A stepwise linear-regression-analysis procedure is used to determine the significant variables, and this information is subsequently used to compare cutting performance. Cutting times in minutes per cubic meter and most probable cutting time in minutes are used as the basis for further comparisons. Management delays are documented for duration and type for both cutting tools. These productivity efficiency factors are then used to show that the air-operated hammer is approximately 25 percent more productive than the gasoline-operated hammer. A procedure is demonstrated that applies the unit cutting rate and the productivity efficiency factor to establish a reasonable productivity goal or to verify an existing productivity or performance standard.

There is little doubt regarding the importance of proper equipment selection in the development of an efficient and productive construction or maintenance operation. All organizations that routinely deploy and use construction equipment are keenly interested in the selection of the right equipment to do the job. Examples of such organizations include contractors, owners who perform force-account construction and maintenance, and state departments of transportation.

Much has been written about the selection of heavy construction equipment, such as cranes, dozers, scrapers, and trucks (1-3). Typically, criteria are presented to help the user decide whether to rent or purchase, and the decision is largely one of economics. In determining the applicability of the equipment to perform the given task, the key reference source is often the manufacturer's specifications and performance characteristics (4).

The procedures noted above have two important shortcomings. First, they are applicable to high-cost, specialized pieces of equipment intended primarily for the earth-moving contractor. Little guidance is available for evaluating the more common pieces of construction equipment, such as an air compressor. Second, for hauling equipment, the production characteristics are reasonably well defined by the manufacturer. Thus, handbooks provide the contractor with the needed information for evaluating equipment based on an approximate productive output. Unfortunately, production rates for smaller pieces of construction equipment cannot be determined, except by trial evaluations, because productivity is primarily established by (a) the operator, (b) field conditions, and (c) the effectiveness of management. These factors are not addressed by the literature available from the equipment vendor. As pointed out in a recent Value Engineering study of bituminous patching operations, there is a need for further study and evalution of mechanical cutters, tampers, and compactors and a comparison with current methods (5).

OBJECTIVE AND SCOPE

The objective of this paper is to describe a systematic procedure for evaluating the cutting efficiency of air- and gasoline-operated pavement breakers. The important aspects related to cutting performance, field conditions, and management will be considered. A second objective is to assess the significance of the condition of the cutting bit relative to performance. This information is useful to the manager in planning a bit-sharpening program. The final objective is to demonstrate how field evaluation data can be used to establish a reasonable productivity goal or to verify an existing productivity or performance standard.