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FORGIVING ROADSIDE DESIGN

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State and local governments, aided by Federal funds, have developed an extensive system of highways during the last half century. During the past 10 years, however, the Federal Government and many states have concentrated mostly on large metropolitan transportation problems which has led to a decline in the rate of major system improvements in rural areas. To counter this trend, Congress recently declared, as national policy, the need to emphasize the construction and reconstruction of all Federal-aid systems in order to reach reasonable standards, including those for safety. To assist in implementing this policy, Congress also provided specific categorical safety grants to eliminate many safety hazards both on and off the Federal-aid system. One grant area focuses attention on problems associated with making roadsides safe. Difficulties have arisen in identifying roadside obstacles, especially off the Federal-aid system. Apparent insufficient funds, uncertain effectiveness of roadside treatments, and lack of uniformly applied evaluation techniques further complicate the matter of establishing reasonable roadside safety standards.

Because of the above noted problems, the Transportation Research Board Committee on Operational Effects of Geometrics (A3A08) held a workshop in Denver, Colorado, on August 3-4, 1976. The goal of this workshop was to bring people together who were involved with roadside safety in an effort to find more effective ways of determining how available safety dollars could produce safe roadsides. Attendees, as shown in Table 1, ranged from those who were directly concerned with implementing highway safety programs on roadside obstacles to those who were performing or concerned with research on roadside geometrics and techniques for establishing where best to employ available safety dollars.

The workshop consisted of three separate, but related, sessions which dealt with 1) identifying roadside hazardous locations and selecting alternative safety improvements, 2) evaluating the alternative improvements and programming and implementing those selected, and 3) postevaluation of implemented improvements. Within each session, respectively labled as Problem, Funding, and Evaluation, background material was initially supplied by a moderator who also challenged workshop attendees by raising several questions pertaining to the subject of his session. Following the background presentation, attendees were split into groups of 8-9 people to seek answers to the questions raised by the moderator. In the next 3 sections are summaries of each session, including the background material provided, questions raised, and a synthesis of the major points made and conclusions drawn by the workshop attendees. As part of the workshop, attendees were asked to answer a questionnaire on roadside hazard ratings, which had been earlier developed by the Texas Transportation Institute and administered in Texas. A comparison of the Texas and workshop responses is discussed after the session summaries. The article concludes with a summary of major workshop outputs and a reference list of publications pertaining to roadside safety.

PROBLEM SESSION

This session was moderated by Dr. Thomas E. Mulinazzi, P.E., Assistant Professor, Department of Civil Engineering, University of Maryland.

Background

The Blatnick Committee concluded in 1968 that "regardless of the reasons why a driver may leave a portion of a high speed highway, roadside areas should be sufficiently clear of obstructions to give him an opportunity to allow both himself and his passengers to be given a reasonable chance of survival and not be faced with a death penalty for a comparatively minor error."(1) This statement forms the basis for the following philosophy to be used in designing forgiving highways:

1. Remove the object, if possible,

2. If it cannot be removed, make it breakaway, and

3. If one or two cannot be done, protect the driver from the object.

That is the last alternative.

The modern highway is marked by scars where vehicles have left the roadway - skid marks, upturned sod, broken sign supports, twisted delineators, and bent fences. As long as man is driving a machine, vehicles will be leaving the roadway. Past research projects have linked alcohol, drugs, fatigue, and even suicide with vehicle departures from the roadway. Engineers have little or no control over these factors. The engineer can only make the roadside as safe as possible.

With this realization, how can roadsides be made safer? An adequate job has been done on making roadsides safer on controlled access facilities. Freeway design elements have been researched and improvements in design have been implemented. The main reason why roadsides can be made safer on controlled access roads are the wider rights-of-way associated with such facilities. Emphasis should now be placed on improving the safety of roadsides on nonaccess controlled roads. There is a definite void of research findings in this area.

In attempting to make roadsides safer, the highway engineering profession is faced with a situation where the probability of leaving the roadway and hitting a fixed object is very small, but the severity of the potential accident is very great. How can the engineer decide which roadside safety problems should be addressed and how such selected problems should be treated?

In seeking answers to this two-part question, each workshop team was asked to discuss the following two major questions and at least one of the other listed questions.

Major Questions:

1. What are the most prevalent roadside safety problems?

2. If you had to design a state's roadside safety program, which types of projects would you include and why?

Other Questions:

1. Do we need a 30 foot clear zone? How much do we need and what justification do we have to use this distance?

2. Does the Federal-Aid Highway Act of 1976 make it easier or more difficult to implement Section 210 (Elimination of Roadside Obstacles) programs?

3. What type of inventories, records and reference systems should be used to help identify problem areas?

4. What should future plans be in the area of forgiving roadside design for different classes of highways?

Major Points and Conclusions

In attempting to answer these questions, workshop teams centered their discussions around rural non-access controlled highways rather than on urban highways or access controlled rural highways. It was generally felt that major roadside safety problems on the latter type highways have been researched and the results implemented. Because of lower operating speeds in urban areas and a completely different cross-sectional approach, workshop participants also felt that urban highways do not have the same magnitude of roadside safety problems as rural roads. Figure 1, which shows the number of roadside obstacle projects funded by highway system, supports this point of view.

The participants came to an early conclusion that it would be impossible to solve all roadside safety problems. They concluded that what is needed is the establishment of a priority program in order to schedule roadside safety improvements. To do this, a system is needed which identifies and analyzes roadside safety problems, including the correlation of accident data and highway geometrics. A noted serious problem is the inability to define criteria for the design of safe roadsides; e.g., what are the safety benefits of various "clear roadway widths"? The inaccuracy found in state accident reporting systems was noted as a major problem in establishing and evaluating any roadside safety program.

Most of the recommended solutions to the roadside safety problem can be grouped into the following 4R's:

1. Remove obstacle
2. Relocate obstacle
3. Redesign obstacle
4. Redirect vehicle

There was a strong feeling that a "safety management system" is needed. In such a system there would be persons responsible for the safety programs in each jurisdiction; each jurisdiction would identify its safety problems, prioritize them, search for funds for upgrading the existing safety problem locations, and assist in safety program implementation.

Many specific roadside safety problems associated with utility poles, guardrails, medians, unstabilized shoulders, and curbs were discussed. However, the participants felt that many of these problems would continue to exist for the following reasons:

1. Lack of training for maintenance personnel and state police.

2. Geometric features are designed separately and are not coordinated.

3. National standards are not enforced because of social, economic, and/or political constraints.

4. The present roadside safety improvement program is more of a reactive action rather than an active approach. (After the fact rather than preventive.)

The question of attacking the roadside safety problem on a specific high accident location approach or on a broad systemwide approach was discussed in detail. The participants felt that it would be ideal to solve some of the roadside safety problems on a system basis, but that improvements could only be economically justified when approached on a location-by-location basis. With the highway agencies currently under a tight money situation, this latter approach seemed to be the only economical way to implement a roadside safety program.

In summary, it was concluded that there is still a serious roadside safety problem on our nation's highways. The technology exists to solve many of these problems, but the data base upon which to develop a priority system is weak at best and the money to implement the improvements is scarce and in tough competition from other highway projects.

FUNDING SESSION

This session was moderated by Mr. Stanley R. Byington, Chief, Systems Requirements and Evaluation Group, Federal Highway Administration.

Background

Roadside safety improvement programs are carried on in an environment where there are apparently insufficient funds even though funding can be obtained from several safety categorical programs; dollar values for savings from reduced accidents, injuries, and fatalities are not treated uniformly; costs for the same type improvement change drastically from project to project; and benefit-cost ratios vary considerably.

One example can be cited which clearly demonstrates that there are insuffiсent funds available to tackle all roadside safety problems. The State of North Carolina has estimated that to take care of all their roadside safety problems would require from \$384 to \$1,384 million, yet total Federal funds available for specifically eliminating roadside obstacles was only \$169 million in the three year period, FY 1974 through FY 1976. It should be noted that there are several types of Federal funds available for correcting roadside hazards, including both construction and special safety categorical programs. The 1973 Highway Safety Act included special categories for five safety areas, the following three of which have been used to some extent to make roadsides safe:

1. Program for Elimination of Roadside Obstacles - For use on any Federal-aid highway system except interstate. As shown in Figure 2, over half of the obligated \$61 million under this program during FY 1974 and FY 1975 have been used for guardrail and crash cushions. (Since the workshop was held, an additional \$52 million has been obligated as of June 30, 1976 under this program. Guardrail and crash cushions still account for 53 percent of the obligations.)
2. Projects for High-Hazard Locations - For use on <u>any</u> Federal-aid highway system except interstate. Projects have included widening of lanes; dividing a highway and adding a median barrier; improving shoulders; flattening and/or clearing sideslopes; and installation of road edge guardrail, median barriers, and impact attenuators. About 10 percent of the \$76.5 million obligated high-hazard location funds in 1974 and 1975 were for roadside appurtenances.
3. Federal-Aid Safer Roads Demonstration Program - For use in correcting hazards on all roads <u>not on</u> the Federal-aid system, including installation of guardrails and crash cushions and removal of trees and other obstacles. Only 35 percent of the available funds for this program were obligated in 1974 and 1975 which was felt to be due in large part to the lack of an effective way of getting funds down to the local level for use off the Federal-aid system. Other possible factors were the lack of local manpower resources and sufficient accident and traffic records systems for prioritizing where available funds would provide the most return on the dollar. (Since the workshop, the percent of apportioned funds available in this program as of June 30, 1976 has risen to 51 percent. \$246 million has been obligated.)

Answering the question of where to spend the limited roadside safety dollars involves three steps. First, one must evaluate alternative improvements in terms of cost and potential improvement (reduction of accidents). Second, funds must be programmed according to certain established goals, ranking methods, political constraints, and available resources. Finally, selected projects must be "sold" and implemented.

In evaluating alternative roadside safety improvements, there are several factors that must be considered, many of which are treated differently from state to state. Various interpretations are placed upon what constitutes a "preventable" accident, how many accidents may be saved, and what severity damage reduction will occur with the implementation of specific roadside safety improvements. Decisions must also be made as to what cost values should be placed on fatalities, injuries and property damage; what are the capital and maintenance costs for various types of improvements and what interest rates and service lives should be employed in economic tradeoffs of alternative improvements. Many different accident cost values are used by various jurisdictions, as reflected in Figure 3; and these same jurisdictions experience a wide range of costs in implementing improvements as shown in Figure 4.

Many decisions are also faced by state personnel in programming funds to improve roadside safety. They must establish achievable goals, determine how much must be spent to obtain measurable improvements, decide whether improvements should be made on a spot or blanket coverage (e.g., all gore areas on an entire route) basis, and select a priority ranking measure (e.g., accidents, accident rates, severity rates). And, while wrestling with all these decisions, state personnel must also consider 1) environmental questions, like those dealing with tree removal, 2) the geographic distribution of funds, and 3) how to get funds down to, and used at, the local level.

The preceding considerations involve, to a great extent, communication with decision makers and the public. To aid in this communication, a new graphic tool called LI-FE (<u>L</u>owest <u>I</u>nvestment with <u>F</u>orgiving <u>E</u>nvironment) has been developed by the Iowa Department of Transportation. LI-FE, which is described in more detail below, attempts to convey the basic meaning of highway design to the general public. (The workshop presentation on

Table 1. Attendees at Forgivable Roadside Design Workshop.

Employer	Attendees
Government	
Federal	18
State	36
County/City	6
Other	
Consultants/Manufacturers	6
University	4
Professional Groups	5
Toll Authorities	2
	77

Figure 1. Number of roadside obstacle projects funded in 1974 and 1975 by highway system (6).

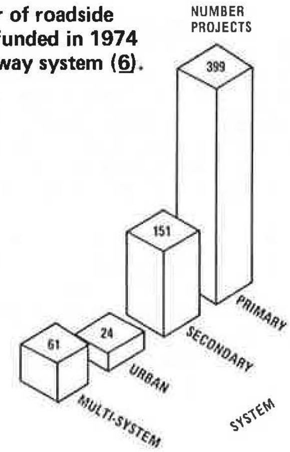


Figure 2. Distribution of funds obligated under the roadside obstacles program (FY 1974-FY 1975) (6).

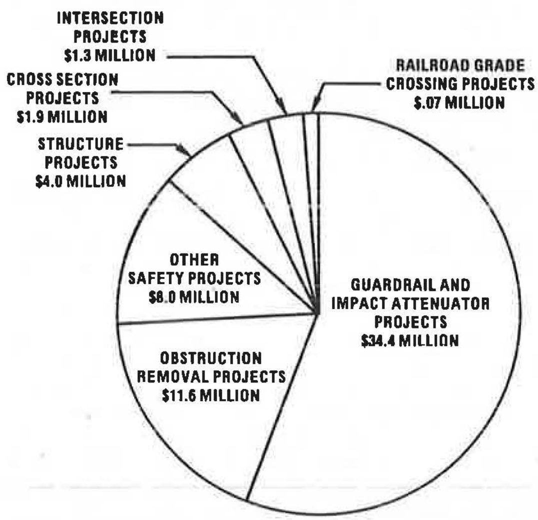
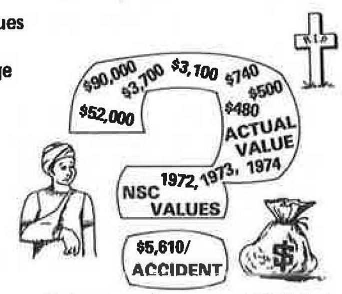
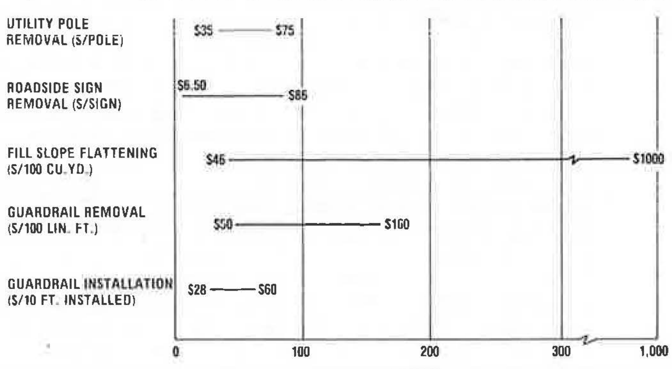


Figure 3. Various dollar values assigned to traffic fatalities, injuries, and property damage accidents.



Values came from several 1976 State Safety Improvement Reports covering safety improvement projects authorized by the 1973 Highway Safety Act.

Figure 4. Range of costs for various roadside safety improvements (7).



LI-FE was made by Mr. Patrick R. Caine, P.E., Iowa Department of Transportation.) To show the public the value of good highway design, LI-FE was conceived to simulate both sides of the design equation - costs vs. effects - and hence measure the cost-effectiveness of capital improvements. LI-FE uses a numerical profile to compare existing road sections to design alternatives. By assigning points to features of the roadway environment (see Table 2), a LI-FE profile can be plotted to pictorially demonstrate the cost effectiveness of various investment levels for highway improvements. The primary yardstick used to measure effectiveness is the potential for reducing the frequency or severity of accidents.

A road section receives points, up to a maximum of 70, based on how well each item listed in Table 2 measures up to predetermined standards. Points received for a given condition depend on the road's functional classification, average daily traffic, and terrain. Point assignment tables have been developed by the Iowa Department of Transportation to insure a uniform assignment of points for similar conditions.

By applying the point assignment ratings on short segments of a study route, one can create a profile of a roadway's environment like that shown in Figure 5. This figure shows the profile lines for an existing roadway and two alternative improvements. The existing roadway is an 18-foot section of pavemnt with inadequate shoulders, poor sideslopes, and a high accident rate. Alternate 2, which would cost $236,000 per mile, is reconstruction and would include: pavement widening to 24', 6:1 sideslopes, and improved vertical alignments. Alternate 1, which would cost $454,000 per mile, is relocation and reconstruction, including all the work outlined for Alternate 2 and eliminating the horizontal alignment problems still found in Alternate 2. In a public hearing process, the example LI-FE numerical profile could be used to illustrate what the various levels of design specifications would produce in terms of a safe forgiving environment; namely, that selection of Alternative 2 could free needed funding for other projects and produce a profile line nearly equal to Alternate 1.

Having presented several problems (and some suggested solutions) for evaluating, programming and implementing road safety improvements, workshop teams were then challenged to address two of the following three major questions and at least one of the "other" questions:

Major Questions:

1. Should national figures be adopted for the cost of fatalities, injuries, and property damage for use in all roadway safety evaluations?

2. Should roadside hazards be attacked on a blanket basis (i.e., complete road section) or on a spot improvement basis (i.e., at identified high hazard)?

3. Does the LI-FE concept as a communication tool appear to have sufficient merit to warrant further development?

Other Questions:

1. Should roadside safety goals be established, (i.e., shoot for some percent reduction in roadside accidents) and, if so, what should the goals be?

2. Are there certain type roadside hazards which we can't do much about (i.e., improvements are not likely to be cost effective)?

3. Should other benefits (other than savings in accident costs) be used in analyzing the effectiveness of potential roadside safety improvements?

4. What is the best way to forecast potential accident reductions for various roadside safety improvements?

5. What interest and inflation rates and service lives should be used in analyzing whether to program a roadside safety improvement?

6. Should expenditure of roadside safety funds be in direct proportion to traffic carried on various routes (i.e., should some attempt be made to classify potential hazard on a probabilistic basis of a vehicle running off the road - rather than relying on accident records entirely or at all? If so, how?)?

7. Should one attempt to recover damages from those who destroy lampposts, signs, protective features, etc. (i.e., is the amount to be recovered worth the cost of obtaining the recovered damages)?

8. What is the best way to estimate how much a roadside improvement will cost (in some states the estimate has been off by 100%)?

Major Points and Conclusions

No complete agreement was reached on whether national dollar figures should be adopted for fatality, injury, and property damage only accidents. Those opposed to adopting national figures cited problems with including indirect (unquantifiable) costs, particularly societal costs which some workshop attendees felt state officials must consider. Some opponents also argued that roadside accidents at any single location occur on a random basis in small quantity and assignment of dollar values to random occurring, rare events lacks merit. They also note that the goals of roadside safety improvement programs are to reduce accidents, injuries and fatalities, not money, and that decisions on where to spend available dollars within a single safety program like roadside obstacles are insensitive to dollar values placed on accidents, injuries and fatalities. A final point made was that we should be concerned with determining how much we need to spend to save a life, not on how much a life is worth.

Those in favor of employing national dollar figures countered the preceding arguments by stating that all improvements cost money and tradeoffs must be made on alternative improvements and safety projects. It was further argued that, in making decisions on where to spend available roadside safety dollars, decision makers either directly or indirectly (through value judgments) are placing dollar values on accidents, injuries, and fatalities. Otherwise, how does one equate improvements to reduce property damage type accidents at various locations (moderate sideslopes with few small fixed objects) with improvements to reduce fatality type accidents at other locations (steep embankments or several large fixed objects)?

There was also disagreement among those in favor of using dollar values for accidents, injuries and fatalities. Some favored use of National Safety Council figures because they come from an organization which has no axe to grind, except for safety. Others felt costs should be determined on a regional or state basis so they could be adjusted to reflect costs awarded by the courts or affected by varying cost indexes. One workshop team also believed that the following elements should be considered in establishing dollar values to assign to accidents, injuries, and fatalities:

1. Future productivity of the person injured or killed,
2. Damage to family units,
3. Mental problems to either the injured or relatives, and
4. Direct costs (property damage repair, hospital costs, insurance costs, etc.).

Another team wanted to exclude societal costs, however, because of the large variations from state to state and area to area.

In discussing whether roadside hazards should be attacked on a blanket or spot improvement basis, workshop teams had a definition "problem" with the term blanket and how the roadside obstacle and high-hazard location safety programs differ. Even with these difficulties, there was general agreement among workshop attendees that both spot and blanket type improvements are needed. Spot improvements should be employed to meet immediate needs and where adequate accident data are available to identify high-hazard locations. This was felt to be the most cost effective approach. Still, blanket improvements were deemed necessary if there were insufficient accident data available to determine precise safety needs or if high accident locations were closely spaced (one workshop team coined the phrase "spot-blanket" to describe this combination approach). The blanket approach was deemed to be especially suited for roadside obstacle safety programs because to remove only certain fixed objects within a given distance of the roadway does not "do much for safety" when considering the aforementioned random occurrence of accidents.

In considering what programming approach to use, decision makers must remember that roadside hazards are defined by the probability of a vehicle leaving the road and the severity associated with an obstacle that may be struck. (See later section on ratings of roadside safety hazards). At least one team felt there was a need to establish a level of safety standard for various classes of roads; i.e., a concept similar to level of service should be specified to establish appropriate lateral clearance distances, sideslope ratios, fixed object breakaway features, etc., for roadways carrying different volumes of traffic.

On other questions addressed, but not discussed in much depth, the following major points were made by workshop attendees:

1. The LI-FE concept appears to have sufficient merit for further use.
2. Attempts should be made to recover damage costs from those who destroy lampposts, signs, protective roadside features, etc. Attempts should be a function of how much it would cost to recover any damages and the extent of the damages.
3. Data is needed on the frequency of off-road encroachments. The amount of effort devoted to this task should be related to the amount of authorized funds for making such encroachments safer.
4. Roadside safety efforts should be concentrated on high volume roadways.

EVALUATION SESSION

This session was moderated by Mr. John C. Glennon, Transportation Engineering Consultant.

Background

Over the last ten tears, considerable technology has been developed in the area of roadside safety. However, when driving along the highway, one may observe that we have only begun to scratch the surface in terms of effective implementation of such technology. A more critical evaluation is needed to demonstrate the effectiveness of specific improvements and to draw clear focus on the ways to gain headway on this pervasive problem.

Why is there still a preponderance of hazardous objects on even our major highways? Four observations can be made in this regard. First, it does not appear that the latest roadside safety technology has filtered down to people on the firing line (design squads, resident engineers, etc.); consequently, roadside hazards are still being built into highways.

A second observation is that because of the lack of general knowledge on certain basic principles, some roadside safety improvements are poorly implemented. For example, it is well documented (2) that, with roadside obstacles, a primary problem is the "snag" potential. Hitting the side of a smooth concrete wall is usually not too severe, but hitting the end of that same wall is often fatal. Even though eliminating the snag potential, or end condition, is a basic objective, it is easy to find recent guardrail installations where several short sections are placed very close together (each with their own end conditions) when one continuous guardrail section could have been installed.

A third observation is that we still see many roadside hazards because some highway agencies are still taking the easy way out by installing only those improvements that are easy to implement, popular, or highly visible -- improvements such as guardrails, breakaway posts, and particularly impact attenuators.

The final observation is related to the third in that highly visible improvements are being implemented regardless of their relative cost and, in the process, highway agencies do not have remaining funds to implement some of the other, more cost-effective, kinds of roadside safety improvements.

The point of these four observations is that the lack of proper evaluation has prevented both adequate attention to roadside safety design and a clear focus on the cost-effective application of available funds. "Must" reading in the area of safety program evaluation is the University of North Carolina's report "Impediments to the Evaluation of Highway Safety Programs."(3) This report sheds considerable light in the area of effective safety evaluations by distilling the problems and solutions. Following are the major points covered in the report.

Why is evaluation important? Evaluation is important to determine if program goals are being reached and this evidence is often needed to support program continuance. Evaluation is also important to analyze program efficiency. This analysis can help in the realignment of priorities. In addition, evaluation is important to identify results that are contrary to program goals. This can help in redefining program goals and to streamline program elements.

The basic function of evaluation is to make judgments of worth. These judgments can result from studies ranging from those that use the most rigorous, quantitative experimental designs to those that involve capricious or subjective evaluations.

What are the basic types of evaluation? Since evaluation is an ambiguous concept for most people, it is important to explain exactly what the term means. Basically, three kinds of evaluation exist. The first type of evaluation is called "subjective or clinical assessment" in the North Carolina report. These type evaluations are reflected in the impressions of so-called experts, are usually devoid of numerical data, and are necessarily filled with subjective dramatizations. In the highway safety field, judges, police officers, and physicians frequently serve as expert evaluators. Unfortunately, in the area of roadside safety, many decisions are still made using this type of evaluation.

The second type of evaluation is called "process evaluation." These evaluations are numerical, but devoid of independent variables. They are used to determine if, and to what degree, the treatments advocated at the initiation of the program have been carried out. This type of evaluation is seen most clearly in state reports submitted to the Federal government on traffic safety programs. These reports generally give a very gross evaluation of the total program and very little detail about program elements and how those elements might be improved.

The third type of evaluation is called "outcome or effectiveness evaluation." These evaluations are characterized by the measurement of a dependent variable. When a program intended to influence one or more variables is instituted, then measurement of change in those variables constitutes an effectiveness evaluation. This is the type of evaluation needed in order to do a more effective job with roadside safety programs. It provides the data necessary to improve program priorities and implementation efficiency.

The North Carolina report lists four major impediments of effective safety program evaluation: naive ignorance, administrator wisdom, technical ignorance, and inadequate tools, procedures and data bases. Naive ignorance is the lack of awareness of what effective evaluation is and what its strengths are. This is not uncommon. The second impediment, called administrative wisdom, is the reluctance to initiate program evaluation because of the fear of a negative result like that shown in the left part of Figure 6. In this case, administrators feel that a "no effect" verdict (like low or negative benefit-cost ratios) might result in the curtailment of funds. Technical ignorance is the term used to indicate the lack of adequate training in experimental design, experimental control, data collection procedures, and statistical analysis. That is not uncommon. The fourth impediment is inadequate tools, procedures and data bases. Even with the decision to proceed with a rigorous evaluation, the most competent evaluator will fall short if he has inadequate authority to gain cooperation, if he has insufficient funds to properly carry out the evaluation, and if the primary data sources do not meet program requirements. These are all very distinct problems.

The preceding described problems prompted the moderator to challenge workshop attendees with the following questions:

Major Questions:

1. What are the major impediments to effective evaluations within individual agencies and how can they be overcome?

2. Is there a problem in program evaluations because program goals are generally too broadly defined? What can be done?

Other Questions:

1. What special procedures, forms, etc., are needed to identify hazardous locations and to record data for evaluation purposes?

2. How can we interest administrators in committing themselves to effective evaluation?

3. How can we train and motivate the working staff to undertake effective evaluations?

4. How can the process be speeded up between identifying hazards, getting improvements implemented, and obtaining evaluation results?

5. How can we improve the impact of program evaluations? Who should obtain results? In what form? How should results be interpreted? How can past imperfections be corrected?

6. What is the most practical method of roadside safety evaluation?

   a. What measures should be used (percent change in accidents, accident rate, severity rate, or what)?

   b. What length of evaluation period should be used?

   c. What experimental designs should be considered (i.e., control sections)?

Table 2. LI-FE design concept safety points.

Item	LI-FE Points
Surface Width	22
Shoulder Type & Width	5
Stopping Sight Restrictions	5
Horizontal Alignment	5
Passing Sight Distance	5
Vertical Alignment	3
Accident Experience	5
Problem Intersections	10
Roadside Clearance	5
Side Slopes	5
	70

Figure 5. Example of a LI-FE profile (8).

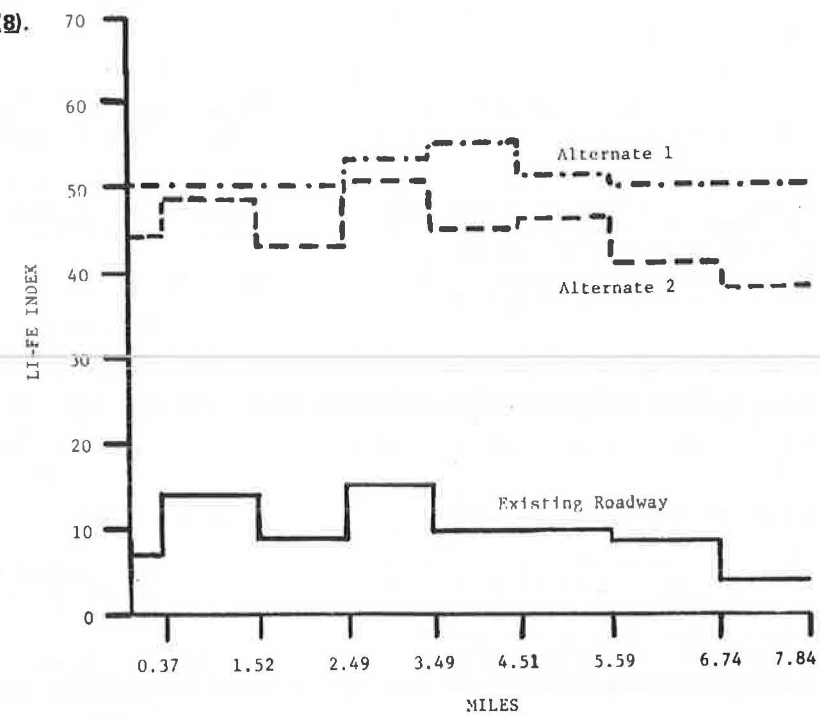
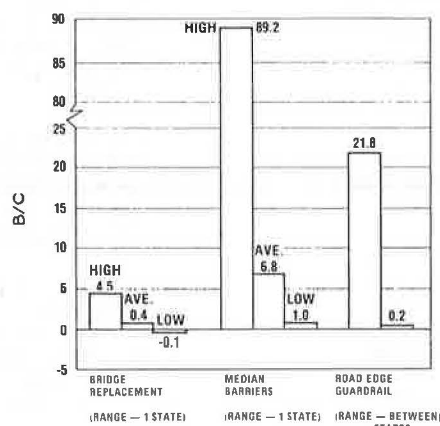


Figure 6. Ranges of benefit/cost ratios for various roadside improvements.



d. What accidents should be considered (all those directly related to improvement, certain types of accidents, or what)?

Major Points and Conclusions

Workshop teams concluded after their examination and discussion of several of the preceding questions that:

1. Program managers need to state specific objectives at the beginning of their programs. This will lead to the specific evaluation procedures and will preclude a last minute evaluation effort.

2. There is a lack of personnel with adequate training in scientific evaluation methodology and also a lack of simplified evaluation procedures.

3. There is a lack of management support and interest in highway safety programs and their evaluation.

4. We need a broader evaluation of each particular roadside safety improvement technique than can be provided by a single application of each technique.

5. Better overall control of evaluation requirements, results, correlations, and reporting could best be done at the Federal level. For example, we do not have large enough accident samples in connection with any specific application to allow sufficient confidence in results. Furthermore, we do not have a crash severity data base, an encroachment expectancy data base, or a weather effects data base.

6. The length of evaluation periods should be 2 years minimum, and 3 years preferable, for all corrective actions taken.

7. Attitudes and personnel capabilities within the highway departments are such as to block any rapid changeover to provide for adequate evaluation, and it is regretful that Federal legislation may be required to overcome these problems. A problem exists in the "vacuum" between Federal legislation requiring evaluation and what actually materializes in the states.

8. Accident research has been poor and accident data bases are weak. Severity resulting from striking a fixed object is relatively easy to evaluate; the probability of striking a fixed object is low.

9. To produce more effective roadside safety evaluations.

   a. Maintenance records generated by trained field and maintenance personnel should be used as a source of unreported accident data,

   b. Complete before-after studies should be employed,

   c. Longer evaluation periods, 5 years, should be used,

   d. Speed/volume studies should be made,

   e. Highway sections with good inventory data (traffic volume, accident and other required data) should be used in experiments, and

   f. Evaluations should use severity improvement criteria.

ROADSIDE HAZARD RATINGS

A few years ago, the Texas Transportation Institute designed a two part questionnaire to determine relative hazard indexes for various roadside obstacles. Part A sought a comparison rating of two hazards and Part B a direct numerical rating, on a relative basis, of the hazard index. Portions of each of these questionnaire parts are shown in Figure 7. Since the original questionnaire was administered only to State of Texas personnel involved with safety, design, operations, maintenance, enforcement, and demonstration, workshop attendees were asked to complete the same questionnaire in order to determine whether people from different regions of the country would respond similarly. Twenty-four workshop attendees completed the questionnaire. Respondents were distributed by employer in approximately the same proportion as the total attendees shown in Table 1. In terms of work experience: ten of the respondents dealt with design; eight with operations; two with maintenance; and three with either research, teaching, or administration. The final respondent was a contractor.

Since response data by Texas personnel were only readily available for Part B of the questionnaire, comparisons between workshop and Texas responses were limited to that part of the questionnaire. Table 3 reflects these comparisons. Two major types of comparisons were made for each roadside hazard shown in Table 3; one based upon the linear severity numerical scores (0-10) recorded by the two sets of respondents and a second based upon non-linear adjusted numerical scores to better reflect differences in cost between the six different accident severity levels shown under Part B of Figure 7. A comparison of the linear and non-linear hazard indexes is shown in Table 4. Details on how the non-linear scale was established can be found in a document entitled "Training Course on Highway Safety Improvement Programming."(4)

Table 3 compares both numerical scores and rankings (as defined by the scores) for each listed roadside hazard. Employing the Kruskal-Wallis One-Way Analysis of Variance by Ranks test (5) to the two sets of rank comparisons (survey severity and adjusted severity) shown in the table, it can be concluded that the two groups of respondents responded similarly in ranking roadside hazards.

SUMMARY

In the last session of the workshop, Dr. John W. Hutchinson, Professor of Civil Engineering, University of Kentucky summarized what he felt were the major points made during the workshop. His comments are abstracted in list form below:

1. Current research is aimed at getting some, but not all, the answer to questions (i.e., problems) that are researchable in roadside safety and design. For example, the question - where can design standards be cut without adversely affecting accident

Table 3. Comparison in severity rankings for various roadside hazards between Texas and workshop personnel.

Roadside Hazard	Adjusted Severity				Survey Severity			
	Workshop Scores	Rank	Texas Scores	Rank	Workshop Scores	Rank	Texas Scores	Rank
Bridge Abutment, Pier, or Column	88.2	1	82.5	1	9.4	1	9.3	1
Overhead Sign Bridge Support	67.7	2	52.5	3	8.4	2	8.1	3
Bridge Wingwall With No Protection	63.6	3	82.5	2	8.4	3	9.3	2
Cantilever Sign on T-mount Support	62.5	4	30.0	8	8.1	4	7.2	8
Open Gap Between Parallel Bridges	60.2	5	30.0	9	8.0	5	7.2	9
Rigid Base Luminaire Support	55.5	6	37.5	7	8.0	6	7.5	7
Multiple-Post Rigid Sign Support	54.1	7	30.0	10	7.8	7	7.2	10
Leaving Roadway and Striking Culvert Face Adjacent to Parallel Roadway	40.8	8	47.5	5	6.9	9	7.9	5
Utility Poles 8-inches in Diameter or Larger	40.5	9	27.5	11	7.2	8	7.1	11
Leaving Roadway and Crossing Over the Top of Culvert Adjacent to Lane - Airborne	30.9	10	42.5	6	6.6	10	7.7	6
3-inch Diameter Tree or Greater	26.1	11	50.0	4	5.1	13	8.0	4
Rock Rubble Riprap Sideslope 3:1 or Steeper	20.9	12	11.7	14	5.9	11	5.1	14
Concrete Riprap Sideslope 3:1 or Steeper	14.8	13	2.5	23	5.4	12	2.5	23
Gap Between Bridges Protected by Connected Gaurdrail Sections	13.4	14	14.5	13	4.3	15	5.5	13
Concrete Riprap Backslope 3:1 or Steeper	12.0	15	2.5	24	4.6	14	2.5	24
6-inch High Raised Drop Inlet (Tabletop)	10.2	16	15.9	12	3.9	17	5.7	12
6 to 10 Inch Curb	9.9	17	4.7	16	4.1	16	4.1	16
6-inch Depressed Drop Inlet with Grate	5.4	18	3.1	19	3.1	19	3.1	19
Standard Steel Beam Gaurdrail Face	4.5	19	3.3	17	3.2	18	3.3	17
Smooth Bridge Rail Face (Flex Beam, etc.)	4.2	20	3.0	20	2.8	20	3.0	20
Grassed Backslope	4.0	21	3.0	21	2.5	23	3.0	21
Curb Less than 6 Inches High	3.4	22	2.4	25	2.7	21	2.4	25
Median Barrier (Concrete Design or Equivalent)	3.2	23	5.4	15	2.6	22	4.7	15
Grassed Sideslope	3.1	24	3.0	22	2.2	25	3.0	22
Culvert Inlet with Flush Sloped Grate	3.0	25	3.3	18	2.3	24	3.3	18

Figure 7. Portions of hazard rating evaluation form.

Part A--Comparison Rating of Roadside Hazards

INSTRUCTIONS: Circle "A" if you agree with the statement and "D" if you disagree. If you consider the two situations are essentially equal in severity, circle both "A" and "D." Impact conditions: 60 mph or greater, at 15 to 20 degrees exit-angle from roadway.

1. A D More damage and injury would occur from hitting a utility pole than a six (6) inch diameter tree

2. A D More damage and injury would occur from hitting a single post rigid sign support than a three (3) inch diameter tree

3. A D Less damage and injury would occur from striking a utility pole than hitting a twelve (12) inch diameter tree

Part B--Direct Rating of Roadside Hazards

INSTRUCTIONS: Circle the number associated with the condition that you would expect from running over or into the object or situation described (impact speed 60 mph or greater).

	No Vehicle Damage or Personal Injury		Minor Vehicle Damage, No Personal Injury		Substantial Vehicle Damage, Minor Personal Injury Likely		Major Vehicle Damage, Serious Personal Injury Likely		Vehicle Totaled, Fatal Injury Frequent		Solid Object Impact, Fatal Injuries Expected
	0	1	2	3	4	5	6	7	8	9	10
1. Turned down and anchored guardrail end	0	1	2	3	4	5	6	7	8	9	10
2. 6 inchi high raised drop inlet (tabletop)	0	1	2	3	4	5	6	7	8	9	10
3. Grassed backslope (steeper than 3:1)	0	1	2	3	4	5	6	7	8	9	10

Table 4. Comparison of linear and nonlinear hazard indexes.

Linear Severity Index	Non-Linear Severity Index Based on Cost
0	0
1	1
2	2
3	3
4	4
5	11
6	18
7	25
8	50
9	75
10	100

experience - has not been adequately addressed and deserves an answer.

2. There is currently wide variation in degree of application of available knowledge from state to state, from one highway department district office to the next within states, from county to county, from city to city, and even from one Federal Highway Administration region to the next, partially due to funding, partially due to program management, and largely due to a lack of understanding of (expressed or implied) or disagreement with (again expressed or implied) the mandate of extant research findings.

3. Little is being done to evaluate the true effects of safety efforts. Many important factors such as weather and demographic data are ignored in nearly all safety evaluations.

4. There are many socially expedient traffic fatalities on our 3,800,000 miles of roads and streets in the U.S. The fact that we cannot economically afford to try to prevent all traffic fatalities is not sufficiently recognized in workshops, and, therefore, tends to confuse many issues like "what are our problems," "how much funding is needed," and "how are the effects of problem solutions (safety programs) to be measured."

5. Preevaluated roadside improvement techniques are needed for low volume roadways. When improvements are applied to such roads on either a spot basis or at several locations along a greater stretch of roadway, there is insufficient before and after accident experience to draw rigorous conclusions about the improvements and advantages. Accordingly, roadside obstacle programs for low volume roadways need to be established based upon previously evaluated techniques.

6. High volume roadside improvement programs need to be based upon some systematic priority approach (not engineering judgment) to avoid litigations and to justify such programs to "our bosses."

7. Accident costs appear to be more desirable then accident indexes since comparisons need to be made with improvement costs. Although agreement was not reached on what accident costs to use, the advantages of using common figures, especially national crash severity figures, for comparing efforts across the country seem to outweigh any disadvantages cited.

8. Spot improvements are preferred because of their cost effectiveness but blanket improvements are needed if good data is not available to pinpoint hazardous locations. Any improvement though should be made on the basis of benefits versus cost.

9. Continuous effective evaluations are important for expenditures and programs <u>must be</u> justified on a highly competitive basis. They must be made on a more scientific basis and the results must be made available to program decision makers.

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