Incremental Safety Improvements for Unpaved Rural Roads

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November 1997

Acknowledgements

This project was sponsored by the Department of Transportation, University Transportation Centers Program and the University of Wyoming. A number of state, regional and national rural road experts provided input to the research study. With their input the results of the project are extremely valuable in defining a concept of rural unpaved road safety improvements.

Disclaimer

EXECUTIVE SUMMARY

Safety on existing unpaved rural roads is enhanced by the implementation of an incremental improvement program. Many of the unpaved rural roads worldwide have geometric deficiencies that do not conform with recognized standards and guidelines. In many instances, roadway improvements are not being completed due to the inability to fund improvements that meet the standards and guidelines. Tort liability involving unsafe roadway conditions is an increasing concern to highway agencies. Incremental improvements for unpaved rural roads is potentially an important tool for local agencies. By making incremental improvements to certain rural roads, even though these improvements are not in conformance with acceptable minimum standards, the safety of the road is enhanced.

Reported here are the results of a project that used a national United States focus group to provide input into the use of incremental safety improvements on unpaved rural roads. The investigation targeted horizontal curvature as a site deficiency. The focus group was used to identify if, and what, incremental improvements should be considered. The results of this project demonstrate the need for functional sub-classifications of rural local roads, with design parameters that address the unique characteristics of these roads. Incremental improvements are an acceptable method to increase safety on unpaved rural roads and to minimize liability.

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CHAPTER I. INTRODUCTION

Background

Incremental improvements to unpaved rural roads provide a fundamental tool to enhance roadway safety. Many of the unpaved roads worldwide have geometric deficiencies that do not conform with acceptable design standards and guidelines. In the United States, local governments, i.e. counties and municipal governments, are typically responsible for a majority of these roads. Most local governments do not have available funds to upgrade all of the roads in their system to the minimum criterion. When comparing funding revenues to maintain and improve these roads, local governments have only 62 percent of the funding available to state governments. Based on mileage, yearly revenues available for state highways is on the average of $70,496 per mile or $43,805 per km as compared to $12,005 per mile or $7,460 per km for local government highways [20][1]. Limited funding often creates situations where safety improvements and installation of traffic control devices are delayed or not considered. Realizing that highway revenues will continue to be extremely limited, and safety considerations must be made, incremental improvements for these unpaved roads are an important tool for the local road manager.

The manager must be able to effectively prioritize safety improvements and implement a reasonable and cost effective safety improvement program (SIP). Models for SIPs specifically for unpaved rural roads have not been developed. Implementing SIPs that are traditionally used on paved rural roads often are beyond the economic means of local agencies for use on unpaved rural roads [4]. It may be more practical to provide incremental improvements to certain unpaved roads, even though

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[1] Number in parenthesis [ ] refers to selected reference list which begins on page 40.

these improvements do not bring the road into compliance with current design standards. However, by working towards the goal of compliance in an affordable and systematic approach, the safety of the road is enhanced.

Objectives

This project explored the concept of utilizing incremental improvements to increase the safety on existing unpaved local roads. The three main project goals were to determine the following:

1. whether or not incremental improvements are an acceptable method to enhance roadway safety on unpaved local roads,
2. if the functional classification of unpaved local roads into two or more categories based on the type of service, volume of traffic and other characteristics is warranted, and
3. if the functional sub-classification of unpaved rural local roads influences whether or not certain incremental improvements are acceptable.

Report Organization

In Chapter II, a summary of the background information on roadway improvement guidelines, functional classifications and tort liability relating to unpaved local roads has been provided. This includes a literature review and discussion on practices employed by transportation professionals and highway agencies. The procedures and methodology used in this project are discussed in Chapter III. The information provided in Chapter III formed the structure for which the information of this study was gathered. Presented in Chapter IV are the data analysis conducted to achieve the goals of this project.

Included are tables and figures that contain pertinent findings. The summary, conclusions, and recommendations are contained in Chapter V.

CHAPTER II. LITERATURE REVIEW

Improvement Guidelines

Most local highway agencies with jurisdiction over unpaved roads have established guidelines for the design of their roadways. These guidelines often have been adopted by modifying or referring to established guidelines that have been nationally accepted. Design guidelines have been typically adopted following the criterion developed by the American Association of State Highway and Transportation Officials (AASHTO) [1]. While considerable research has been completed in the establishment of the AASHTO guidelines, upgrading all existing roads to the guidelines may not be appropriate due to economic efficiency, different traffic characteristics of the roadway and varying cultural characteristics abutting the right-of-way. It is important to incorporate community values when designing improvements to local rural roads [19]. Various attributes to be considered to assure safe and efficient traffic operations on an unpaved road also include issues such as economy in construction and maintenance.

Traffic volumes and level of service are major criteria in determining the basis for the geometric design of local roads. In the AASHTO roadway width design guidelines for rural local roads, the lowest traffic volume category is for roads with the average daily traffic (ADT) of less than 400 vehicles. However, many local road managers state that for a road with less than 50 ADT, the roadway width is not as critical a safety issue as that for a road with 400 ADT. While geometric deficiencies on local roads are important safety issues, about half (977,567 miles - 1 573 199 km) [21] of the rural local roads have less than 50 ADT and adequate funding is not available to bring all the roads into compliance with established design guidelines. It is important to assess the individual characteristics of these low volume roads when developing funding priorities for improvement projects.

The National Research Council, the principal operating agency of the National Academy of Sciences and the National Academy of Engineering, assembled a committee to undertake the task to develop and apply cost-effective geometric safety design guidelines for resurfacing, restoration, and rehabilitation (RRR) projects on existing federal aid highways, except freeways. This was in response to a provision in the Surface Transportation Assistance Act of 1982 and a request by the Secretary of Transportation. A study was completed and recommendations were made on how to preserve and extend the service life of highways and to enhance highway safety. Results of the committee's work was published as Special Report 214, Designing Safer Roads, Practices for Resurfacing Restoration, and Rehabilitation by the Transportation Research Board, National Research Council.

The committee recognized that "in selected instances, federal, state, and local highway agencies can use the recommendations, along with published manuals, design aids, and local experience to *develop or modify minimum design standards* for RRR projects." [16] It was found that resurfacing, restoration, and rehabilitation projects enable highway agencies to improve highway safety by selectively upgrading existing highway and roadside features without the cost of full reconstruction. It also was found that RRR guidelines cannot be tailored to fit all possible, or even most, circumstances encountered at a specific site. As a result, the committee concluded that a variety of practices should be employed when developing a RRR project. These practices include assessment of site conditions, consideration of design guidelines for key highway features, and analysis of current and projected traffic loading.

In selecting an improvement project, highway agencies primarily base their decision on surface repair needs and seldom consider safety needs until preliminary design begins [16]. As an improvement project is developed, minimum design guidelines are often incorporated into the project without consideration of its effect on safety. Often, the cost of upgrading a local roadway to comply with the design guidelines becomes the primary cost of the improvement project. Given current budget constraints faced by local governments, road surface repair needs will continue to be the dominant factor in selecting improvement projects. Current policy and practice of many local agencies often discourage incremental roadway improvements [4]. However, to make the most of the available improvement dollars and to enhance safety, a systematic process to prioritize incremental improvements is needed.

Functional Classification System

Public roads in the United States are categorized by the Federal Highway Administration (FHWA) into 12 functional classifications (see Table 2.1). Local roads and streets, rural and urban, account for 69 percent (2,687,983 miles - 4 325 771 km) of all roads. The single classification that accounts for more road length than all other classifications combined is the classification of rural local roads. Rural local roads account for 54 percent (2,112,194 miles - 3 399 153 km) of the total road length [22]. The functional classification of 54 percent of the nation's public roads into only one functional classification does not recognize many local road differences. Rural local roads include both paved and unpaved roadways. Sixty percent of the rural local roads are unpaved and carry less than 200 vehicles per day [21]. Operational characteristics for paved and unpaved roadways often are significantly different. Traffic volumes on local roads and streets vary and safety considerations are dependent on not only the traffic volumes, but also other traffic characteristics. For instance, from an economic and safety standpoint, does the design speed and roadway width for a road with the average daily traffic (ADT) of 15 vehicles per day of primarily local farmers need to meet the same criteria as that for a road with 1400 ADT, which includes a number of recreational vehicles?

Table 2.1 United States Public Road and Street Functional System - 1995 [22]

Functional Classification	Miles	Percent
Rural: Interstate	32,580	0.8
Other Principal Arterial	97,948	2.5
Minor Arterial	137,151	3.5
Major Collector	431,712	11.0
Minor Collector	274,081	7.0
Local	**2,119,048**	**54.2**
Urban: Interstate	13,164	0.3
Other Freeways	8,970	0.2
Other Principal Arterial	52,796	1.4
Minor Arterial	88,510	2.3
Collector	87,331	2.2
Local	**568,935**	**14.6**
Total	3,912,226	100.0

Even though FHWA currently does not sub-classify rural local roads, there are agencies that recognize for varying types of service and traffic volumes, the requirement of different minimum geometric and cross sectional design characteristics. The AASHTO “green book” provides guidelines for the design of local roads and streets and special purpose roads including recreational, resource development, and local service roads [1]. Minimum design speed, roadway widths, bridge clear widths and structural capacities all are dependent upon ADT. Many states have established guidelines for local roads and streets that also consider ADT as a determining factor for minimum design characteristics. Some agencies with jurisdiction over local roads, such as counties in Nebraska and the U.S. Bureau of Land Management, have varying design criterion dependent upon the road's functional use. Traffic demands on the road depict the functional use and often are described with terms such as local road, resource road, collector, scenic or recreational road [2, 18].

There has been considerable debate regarding minimum design guidelines on roads with less than 400 ADT. The Transportation Research Board, National Research Council currently is sponsoring a project to develop guidelines to functionally classify low volume roads. The research is being completed under NCHRP 20-7, Task 75. The debate regarding functional classifications for local rural roads is typified in comparing AASHTO's ADT design parameters to states such as Vermont [23] and the results of Delphi survey in this project.

While AASHTO has only one category for the design parameters of minimum roadway width for traffic volume of less than 400 ADT, Vermont utilizes four categories. Table 2.2 illustrates different use categories, minimum design speed and minimum roadway width utilized for rural roads from various local road agencies. The variation demonstrates the lack of consistency among agencies. For this project, the functional classification system presented in the Delphi survey included three categories for traffic volume of less than 400 ADT. The categories ranged from 0 - 50 ADT, 50 - 250 ADT and 250 - 400 ADT. The results of the Delphi survey completed for this project was used in the analysis of sub-classifications for local roads below 400 ADT.

Table 2.2 Width Design Parameters for Local Roads with Less Than 400 ADT

	Use Categories	ADT	Minimum Design Speed	Roadway Width (min)
AASHTO [1]	Local	0 - 250	30	22
		250 - 400	40	22
BLM [13]	Collector	50 - 150	30	20
		> 100	40	20
Nebraska [2]	Local	0 - 50	30	26
		50 - 250	50	28
Oklahoma [7]	Local	0 - 250	30	22
		250 - 400	30	24
Vermont [17]	Local	0 - 25	25	14
		25 - 50	25	16
		50 - 100	25	18
		100 - 400	25	22
Washington [18]	Access	0 - 150	30	18
		150 - 400	30	24
	Collector	0 - 150	30	20
		150 - 400	30	24
Wyoming [19]	Local	0 - 250	30	22
		250 - 400	40	24

*No minimum determined, values are preferred

The need for safety improvements and proper installation of traffic control devices on local roads is evident when one examines accident rates. Rural local roads, often with poorer geometric design and absence of shoulders, have considerably higher accident rates than other highways. The Bureau of Transportation Statistics, U.S. Department of Transportation reported that the fatal accident rate in 1992 on rural local roads to be 3.64 deaths per million vehicle miles. This is more than twice the fatal accident rate of 1.56 for the entire U.S. highway system. The 1992 nonfatal accident rate of 176.19 accidents per million vehicle miles on rural local roads also was significantly higher than the rate of 71.50 for all rural highways [3]. Since rural local roads include paved and unpaved roads, crash trends specifically for unpaved roads generally are not available. However, it was found that the injury crash rate on Wyoming unpaved road sections was more than five times higher than for all roads in the state. This analysis was based on traffic volume [4].

The effectiveness of safety improvements also is well documented. Many Transportation Research Board reports and Federal Highway Administration manuals have been published illustrating the proper procedures and effectiveness of safety improvements [11, 12, 14, 15]. However, most of these reports discuss safety improvements that bring the particular facility into compliance with established design guidelines. What has not been well documented is the effectiveness of incremental safety improvements — improvements that enhance the safety of the roadway, but do not bring the roadway into full conformance with acceptable minimum design criterion. Another issue is tort liability, which is discussed in the following section.

Tort Liability

Litigation involving roadways that do not conform to acceptable design guidelines is a major concern of many transportation professionals. The number of law suits against highway agencies is growing each year. Design immunity has eroded or is no longer an acceptable defense for many local agencies. Every day, the road manager faces the consequences of his/her action, or inaction, involving proper maintenance and improvement to their agency's road system. During 1990, an estimated 35,000 tort claims were filed against state highway agencies alone [17]. While many of these claims involved deficient roadway design, a majority involved allegations of inadequate maintenance and faulty traffic control devices [19]. A tort is defined as a civil wrong. The liability of a highway agency associated with a tort is the responsibility for that agency to rectify the damages done to the injured party. Usually, that means a monetary award to a person(s) injured in an automobile accident. Nationally, more than one-half billion dollars was paid out to highway tort claims in 1990 [17]. In a highway tort liability case, the courts attempt to determine whether the highway agency committed a wrong. Usually, an injured party claims that negligence on the part of the highway agency caused or contributed to a traffic accident. Negligence involves the failure of what a "reasonable" person or agency would have done in the circumstances of the case.

The courts often measure the actions of the highway agencies against the prevailing standards of care. Often this standard of care is a published document, such as an AASHTO design manual or the agency's established design guidelines. While most highways were originally designed and built to some acceptable level, the design may not meet the criterion of today. The prevailing argument for the defense of such highways has been that if a road was designed and constructed according to the accepted guidelines of its day, then today it does not have to be upgraded if the guidelines have since changed. However in recent years, the courts have found that if conditions of the road has changed, such as a large increase in traffic volume, then upgrading the road may be required [9].

Economic or budgetary defense also has often been used to argue why the highway agency should not be required to bring all of its roads up to the most current guidelines. The agency often does not have available enough funds to immediately upgrade all of its roads, even if AASHTO were to publish new guidelines tomorrow. However, economic constraint has become less of a viable defense for most highway agencies due to the agencies failure to demonstrate to the court that they were reasonable in expending their available funds [9].

In more and more tort claims, the courts are findi ng that if a known safety deficiency exists on a road, then the highway agency has the obligation to rectify the situation and make the roadway safe. This does not mean that the highway agency is relieved of liability if the accepted standards of care have been followed. Conversely, if deviation from the accepted design guidelines has occurred, it does not automatically establish negligence on the part of the road agency. When the guidelines have not been obtained, a good design still often results if the engineer or road manager makes improvements to compensate or offset any deficiencies. For example, extra signs, markings, or other warning devices often alert the driver of a sharp curve that has been left in place.

A 1996 Arizona law suit involving a motorist who was injured in a single vehicle rollover accident demonstrates the importance of making incremental safety improvements [9]. The injured individual brought suit against the city because the roadway was dangerously designed and maintained. The court found that the state's immunity statutes generally provide some protection for the city when they "exercise" a required action but not in the absence of an action. The city was required to warn the public of any unreasonably dangerous hazard. The court further rejected the economic defense, stating that "governmental entities have the duty to keep its roads reasonably safe for traveling public; reconstruction and redesign of a dangerous curve is only one method of making streets safe, and in certain cases, warning signs may be appropriate." Local government highway agencies must evaluate the safety of their highway system and develop a reasonable improvement program.

Are incremental improvements a viable solution to unsafe roadways? Often local roads have unique characteristics. Incremental improvements to existing roadways were evaluated in this project as an important step to improve safety and limit liability, and to enhance roadway operations. Reported here are the results of this project, which used a U.S. focus group to provide input into the viability of implementing incremental safety improvements on unpaved local roads. The procedures and methods used to evaluate the focus groups input provided the basis for the analysis and results of the report.

CHAPTER III. METHODOLOGY

Project Scope

In this project, completed at the University of Wyoming in cooperation with the Mountain-Plains Consortium, a national focus group was established to provide input into the use of incremental safety improvements on local roads. Due to the many safety issues involved with local roads, the project's purpose was to identify if specific incremental improvements are acceptable. The investigation targeted horizontal curvature as a site deficiency on an existing unpaved rural road. The focus group was used to identify if, and when, incremental improvements should be considered.

There are many opportunities to improve unpaved roads. Horizontal curvature is a major improvement need. The targeting of this roadway deficiency was selected since it represents an area in which improvements to established roadway design guidelines often require considerable investment. There are obvious needs, but there also are obvious concerns with the spot improvements on an existing unpaved road. Similarly, the issue of signing inadequacy is not a solution that should be acceptable for all unpaved roads. The issue becomes deciding on which improvements are acceptable for which types of unpaved roads?

Utilizing information from AASHTO and other organizations, four functional classification systems for unpaved rural roads with less than 1,500 vehicles per day were developed. Functional classifications of rural roads by the character of service provided is influenced by many factors including the volume of traffic. In a report published by the Transportation Research Board, NCHRP Report 362 [26], it was noted that for a design average daily traffic (ADT) of 1,500 vehicles per day or more, capacity and level of service rather than safety are primary factors that influence cross-sectional road design such as lane and shoulder width. It also was reported in Report 362 that for traffic volumes of 250 vehicles per day or less, accident rates are not significantly different for unpaved versus paved surfaces. For this project, the concept of safety and type of service was used in establishing the range of ADT for various functional classifications. While level of service is an important consideration, safety and cost effectiveness are the primary factors considered for improvements to low volume rural roads.

Attributes for the various classifications used in this project were in the first round survey sent to the national focus group. A copy of the survey is in *Appendix A, Proposed Classification System*. The assumption was made that when considering incremental improvements on unpaved low volume rural roads, the roads must be functionally classified based on vehicle types, traffic volumes, and engineering judgment. This was based on the assumption that for a given classification of road, certain design guidelines and operational characteristics should be maintained to ensure safe vehicle operation on the road. However, if the guidelines currently are not met or exceeded, it is not often economically feasible to upgrade the road all at once. The question then becomes, are there certain acceptable incremental improvements that enhance safety? Are incremental improvements unacceptable in some situations, acceptable in others and do incremental improvements result in a more cost effective and safer roadway?

To address these concerns, a national focus group was established. The methodology used was based on the Delphi procedure [5]. As outlined in the next section, this procedure formed the analysis group to test the acceptance of the incremental improvements concept.

Delphi Procedure

A modified Delphi survey procedure was used to receive input from the national focus group. Individuals for the national focus group were selected based on their expertise involving safety on unpaved rural roads (see Section 3.3). Selected individuals came from a variety of employment classification backgrounds to assure that issues were addressed from a federal, state, local, and private perspective. To consider regional issues, focus group individuals provided representation from throughout the country.

Defining what incremental improvements are acceptable is not easily determined by quantitative or experimental measures. Rather, non-quantitative measures, such as engineering judgment, insight, experience and a broad understanding of the situation, are characteristics that often determine acceptability of an improvement. General methodology of the modified Delphi survey used was to ask for specific input from the focus group based on personal judgment and professional knowledge. The Delphi process often is used in situations where limited facts are available and results of the responses are not generally quantitative in nature [5, 7, 10]. Delphi results in such situations are a selection of expert opinions used in solving a problem so the focus group of transportation professionals, rather than a random sample of the population, provided the necessary "expert" opinion for determining acceptable incremental improvements. The project was to determine if certain incremental improvements were acceptable on existing unpaved rural roads with horizontal curvature deficiency.

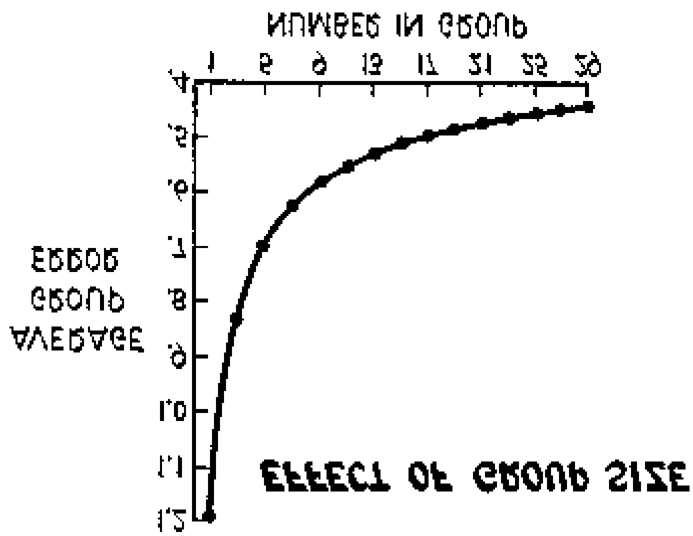

Figure 3.1 Effect of Group Size in Delphi Surveys

The number of "experts" used in the Delphi survey procedure is relatively small when comparing random sample surveys. Norman C. Dalkey performed an experiment demonstrating the effectiveness of the Delphi method on group opinion [5]. Illustrated in Figure 3.1 is the relationship of group size and the mean accuracy of a group response for a set of experimental derived answers to factual questions. The curve was derived based on the average error of the group where the answers were drawn from the experimental distribution. The average group error is the absolute value of the natural logarithm of the group median divided by the true answer. It is clear from the curve that the rate of reduction in group error does not substantially change when the size of the group increases beyond 21 individuals. For this project 35 individuals were identified as potential participants in the Delphi survey procedure.

Focus Group

Overall, individuals representing 22 agencies responded to the survey. Although input from the remaining individuals would have been welcome, as discussed in the previous section, there is no reason to believe that additional responses would have changed the primary findings. The focus group consisted of individuals from 15 states and Washington, D.C. (see Table 3.1).

Table 3.1 Demographic and Employer Information of Delphi Respondents

Organization	State
Boone County	Kentucky
Calcasieu Parish	Louisiana
Garfield County	Utah
Genessee County	Michigan
Local Road and Street Commission	Illinois
Park County	Wyoming
West Virginia DOT	West Virginia
Wyoming DOT	Wyoming
Federal Highway Administration	Colorado
Federal Highway Administration	Washington DC
Federal Highway Administration	Wyoming
US Bureau of Land Management	Wyoming
US Forest Service	Georgia
Arizona State University	Arizona
Louisiana State University	Louisiana
North Dakota State University	North Dakota
Texas T^2 Center (LTAP)	Texas
University of Memphis	Tennessee
West Virginia University	West Virginia
Private Consultant	Idaho
Private Consultant	Idaho
Private Consultant	Washington

They are affiliated with unpaved rural roads on a regional and national basis and were selected based on personal acquaintance and previous work in the field of transportation safety. Professional affiliation of the individuals included representatives from the Federal Highway Administration, U.S. Forest Service, U.S. Bureau of Land Management, various state departments of transportation, universities and local technical assistance program (LTAP) centers, counties and parishes, and private consulting engineers. Table 3.2 categorizes the Delphi survey respondents by employer classification.

Table 3.2 Focus Group Employment Classification

Employment Classification	No.
County/Parish	6
State DOT	2
Federal	5
University/LTAP	6
Private Consultant	2
Total	22

Survey Questionnaire

The first survey questionnaire identified four functional classifications for rural local roads (see Appendix A). The respondents were asked if, in general, functional sub-classifications for low volume rural local roads are warranted. Each of the classifications were categorized according to a defined character of service that the road is intended to provide. Particular characteristics of each classification included type of vehicle use, traffic volumes, travel way widths, operating speed, surface material, ride quality, opposing traffic influence, and surface drainage. The second round of the Delphi survey asked the respondents whether incremental improvements for the previously identified functional classifications were acceptable, conditionally acceptable, or unacceptable for a road with a deficient horizontal curve. Seventeen potential incremental improvements were presented to the respondents. The potential improvements ranged from do nothing to complete reconstruction of the deficient curve to conform with current design guidelines. Each survey also provided opportunity for respondents to provide comments. Improvements included changes to the geometric/roadway cross sectional elements, installation of traffic control devices, improvements to enhance the roadside clear zone, and methods to improve roadway delineation. These improvements are outlined in Table 3.3.

The second survey questionnaire sent to the Delphi respondents is contained in Appendix B. The response from the survey was categorical in nature. The outcomes reflect the categories of acceptability or non-acceptability rather than a more usual statistical based interval scale of linear functions. Categorical data analysis is concerned with the analysis of response measures, regardless of whether any accompanying explanatory variables also are categorical. As such, while the survey respondents qualified their acceptability of various improvements, their response was dichotomous and was categorized as either positive — acceptable and conditionally acceptable — or negative — unacceptable.

Table 3.3 Incremental Improvements Description

Improvement	Description
Status Quo	
A	Do Nothing
Geometric/Cross Sectional	
B	Improve roadway surface on curves only
C	Improve roadway surface for entire road
H	Widen entire roadway
I	Widen roadway on curves only
P	Flatten curves as budget allows
Traffic Control	
D	Sign all curves, curves 10 mph or more below operational speed, include advisory speed plate
E	“Curve Ahead” sign at beginning but not individual curves
F	Sign only curves 10 mph or more below operational speed, no advisory speed plate
G	Sign only curves 10 mph or more below operational speed, include advisory speed plate
L	“Primitive Road” or “No maintenance” sign at beginning of road
Roadside Design - Clear Zone	
J	Remove vegetation and obstructions outside ROW
K	Remove vegetation and obstructions within ROW
Roadway Delineation	
M	Install guardrails
N	Delineation of curves with chevrons
O	Delineation of curves with delineator posts and reflectors
Current Design Guidelines	
Q	Reconstruct curve to design guidelines

McNemar's Test

Analysis of the categorical data are classified into those concerned with hypothesis testing and those concerned with modeling. Hypothesis testing was used to assist in evaluating associations in the data set. In this project, the hypothesis of interest determined whether an association exists between the various functional classifications. By placing the categorical responses into a 2 X 2 table, the information collected becomes related to matched pairs, experimental units for which two related responses are made. The survey questions are no longer treated as one response, but as a pair of related responses for a single improvement on two separate classifications. Table 3.4 contains a representation of matched pair data from the survey. The $n_{1\text{-}1}$ in the (1,1) cell depicts that $n_{1\text{-}1}$ pairs responded favorably to an incremental improvement for A-1 functional classification and A-2 functional classification; the $n_{2\text{-}1}$ in (2,1) cell illustrates that $n_{2\text{-}1}$ pairs responded favorable for functional classification A-2 and not favorable for functional classification A-1. The question of interest determines whether the proportion of pairs responding favorable for one classification is the same as the proportion of pairs responding favorable to the other classification. By answering this question, an evaluation is made whether there is any statistical significance between the two functional classifications and if there is a need for separate classifications based on incremental improvements.

Table 3.4 Matched Pairs Data (2 X 2 Table)

Incremental Improvement A	Classification A-2 Acceptable	Classification A-2 Unacceptable
Classification A-1		
Acceptable	n_{1-1}	n_{1-2}
Unacceptable	n_{2-1}	n_{2-2}

McNemar (1947) developed a chi-square test based on the binomial distribution to address this situation [6, 13]. He demonstrated that only the off-diagonal elements of the 2 X 2 table are important in determining whether there is a difference in the proportions. The off-diagonal elements represent the change of acceptability of a given improvement for different roadway functional classifications. By measuring this change in acceptability, the association between the two functional classifications is evaluated. The test statistic is written as such:

$$Q_M = \frac{(n_{1-2} - n_{2-1})^2}{(n_{1-2} + n_{2-1})}$$

and is approximately chi-square with one degree of freedom. The results of the McNemar's test are compared to a chi-square distribution with one degree of freedom to determine if the relationship is significant. If the McNemar's test value exceeds the chi-square value, there is significance between the two pair of responses. Results of the McNemar's test relative to the matched pair data for the various functional classification proposed in this project is contained in Appendix D.

The analysis of the Delphi survey are contained in Chapter IV. The results of the analysis provide the basis for the conclusions and recommendations of this project.

CHAPTER IV. ANALYSIS AND RESULTS

Evaluation of Data

Analysis of survey data received from the respondents for the first round of the Delphi survey was straight forward. The focus group was asked:

1. *Do you think sub-classifications for unpaved low volume rural roads are warranted?*
2. *Should design standards for unpaved low volume rural roads vary depending on classification?*

Focus group members unanimously agreed that sub-classifications for low volume rural roads are warranted. The group also indicated that design guidelines should vary depending on the road's functional classification. Recall that there were four sub-classifications proposed.

The results were significant because they illustrate the importance of functional sub-classifications and the relationship to design guidelines for unpaved rural roads. Unilaterally, the national focus group with representatives from federal, state, local and private highway agencies, recognized that low volume local roads have unique characteristics which require varied design guidelines, relative to traffic volumes and traffic loading. While many of the individuals on the focus group have responsibility for rural local roads, others do not. Yet, even the individuals that do not have direct responsibility for local rural roads recognize the importance of sub-classifications and design guidelines that are dependent on the particular parameters of the local rural unpaved road.

The results of the first round survey demonstrated the need for functional sub-classifications of rural local roads and provided the basis for structuring analysis of the second round of the Delphi survey. Evaluation of the survey results followed the premises that rural local roads have unique attributes and their functional classification is dependent on traffic characteristics including type of vehicles and traffic volumes. It is important that geometric design parameters for rural local roads vary depending on the functional classification and other attributes of the individual roadway. However, as shown in Chapter II, that there are many functional use categories and design guidelines used throughout the United States for rural local roads. The lack of consistency among agencies presents the question, which one(s) is right or better? Categorical analysis of the second round Delphi survey focused on specific functional classifications of rural roads and based incremental improvement considerations on the functional classifications.

Categorical Analysis of Survey

As discussed in Section 3.5, the McNemar's test was used to assist in evaluating the association between the various proposed functional classifications of rural local roads. For purposes of analysis of the categorical data, a 2 X 2 matrix table was used to evaluate the strength of the association. Each individual response was placed in a 2 X 2 table, comparing the acceptability of the specific incremental improvement to each classification.

Recalling from Section 3.5, if the McNemar's test value of the off-diagonal elements of the 2 X 2 table exceeds the chi-square value, there is a significant difference between the two functional classifications. Using a 95 percent confidence interval, (alpha = 0.05) with one degree of freedom, the chi-square statistical value of 3.84 is compared to the McNemar test value of the matched pairs.

Table 4.1 Statistical Significance with Minor Collector, A-1 Classification

Improvement	McNemar's Test Value		
	Intercounty Routes, A-2 Classification	Local Land Access Routes, B Classification	Limited Access Routes, C Classification
A	0	**9**	**13**
B	2	**4**	0.2
C	1	2	**5**
D	0	0	**8**
E	2	**9**	**12**
F	**4**	**7**	1.3
G	1	0.3	**5.4**
H	3	**4.5**	**10.3**
I	1	3	3.6
J	1	2	**4**
K	0	1	2
L	0	**5**	**17**
M	2	**6**	**11.3**
N	1	**5**	**12**
O	0	2	**5.4**
P	0	1	**6**
Q	0	2	**11**

Table 4.1 illustrates the results of the McNemar's test for determining if a significant relationship exists between the Minor Collector, A-1 classification, and the other proposed classifications. The significance between the classifications was tested for each incremental improvement. The McNemar's test results indicate that with the exception of one incremental improvement, F, there was no significance between the Minor Collector, A-1 classification, and the Intercounty, A-2 classification. Even the McNemar's test value of 4.0 for improvement F is not substantially larger than the chi-square value of 3.84. When evaluating the significance between the Minor Collector classification (A-1) and

the Intercounty classification (A-2) based on incremental improvements, it was found that the two classifications were closely related.

However, when reviewing the McNemar's test between the Minor Collector classification (A-1) and the Local Land Access and Limited Access classifications (B and C), there was a significant difference between the matched pairs. The results of the McNemar's test indicated that the classification Minor Collector (A-1), separate from the Local Land Access and Limited Access classifications (B and C) was justified based on the acceptability of incremental improvements.

The significance between the Intercounty (A-2) classification and the Local Land Access and Limited Access (B and C) classifications is illustrated by the McNemar's test results in Table 4.2. While the difference between the classifications is not as great as the difference between the Minor Collector (A-1) classification and the Local Land Access and Limited Access (B and C) classifications, there still is a substantial degree of significance. The test results indicated that both the Local Land Access (B) and Limited Access (C) functional classifications, separate from Intercounty (A-2) classification, are needed based on the McNemar's test of the incremental improvements.

Table 4.2 Statistical Significance with Intercounty, A-2 Classification

Improvement	McNemar's Test Value	
	Local Land Access Routes, B Classification	Limited Access Routes, C Classification
A	**9**	**13**
B	2	0.2
C	0.3	2.7
D	0	**8**
E	**7**	**10**
F	3	0.2
G	0	**4.5**
H	1.8	**7.4**
I	1	**4.5**
J	1	3
K	1	2
L	**5**	**17**
M	**4**	**12**
N	**4**	**11**
O	2	**8**
P	3	**6**
Q	2	**11**

The McNemar test also was used to compare the Local Land Access, B classification with the Limited Access, C classification. Illustrated in Table 4.3 are the McNemar's test values between the two classifications. Comparing the chi-square value of 3.84 to the McNemar's test value, there was a significant difference between the two classifications. This test indicated that the classification of Local Land Access and Limited Access classifications are justified based on the acceptibility of incremental improvements. However, several respondents commented that the categorical range of 0 - 50 ADT for the Limited Access classification still was too large. Their perspective was that this high a volume classification did not recognize the

How characteristics of roads with less than 25 ADT that have extremely limited use and were not regularly maintained. In the next section the proposed incremental improvements have been analyzed.

Table 4.3 Statistical Significance Between Local Land Access, B Classification and Limited Access, C Classification

Improvement	**McNemar's Test**
A	**4**
B	1.8
C	3
D	**8**
E	3
F	**4**
G	**6**
H	**6**
I	**4**
J	2
K	1
L	**12**
M	**8**
N	**7**
O	**6**
P	3
Q	**9**

Incremental Improvement Analysis

The proposed improvements include items which normally are categorized as site specific elements. The elements include no changes, roadside design/clear zones, roadway delineation, traffic control, geometric design/cross sectional issues and improvements to meet design guidelines.

Respondents to the Delphi survey indicated that the type of acceptable incremental improvement was influenced by the functional classification of the roadway. Depending on classification of the road, some improvements had a higher degree of acceptability than others. Table 4.4 illustrates the level of acceptance of the individual improvements for each functional classification. As an example, 95 percent of the respondents indicated that improvement M was an acceptable improvement for an A-1 classification road, while only 32 percent indicated that the same improvement was acceptable for a C classification road. Improvement M is the installation of guardrails.

Table 4.4 Incremental Improvement Survey Results

Approval of Improvements (%)				
Improvement	A-1	A-2	B	C
A	29	29	71	90
B	64	73	82	68
C	91	86	82	68
D	95	95	95	64
E	18	27	59	73
F	45	64	77	59
G	95	91	91	64
H	86	73	59	32
I	91	95	86	68
J	91	86	82	73
K	100	100	95	91
L	5	5	27	82
M	95	86	68	32
N	95	91	73	41
O	95	95	91	59
P	91	91	77	64
Q	95	95	86	43

Improvements to enhance roadside clear zones were regarded by the respondents as highly acceptable incremental improvements for all functional classifications of unpaved rural roads. There was little significant difference between the classifications when comparing the acceptability of roadside incremental improvements (Figure 4.1). Safety improvements involving roadside design and clear zone elements were generally acceptable for al classes of local rural roads and the focus group recommended considering these when evaluating safety improvements.

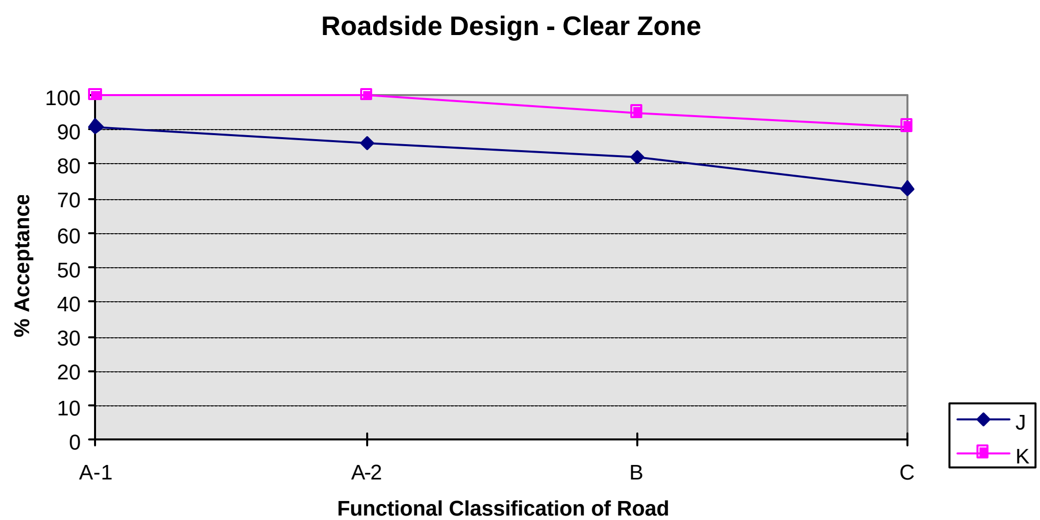

Figure 4.1 Roadside Design - Clear Zone Elements

Improvements

J - Remove vegetation and obstructions outside of ROW

K - Remove vegetation and obstructions within ROW

When improvements involving roadway delineation (Improvements M, N, and O) were evaluated, the respondents indicated a high level of acceptability of the improvements for only the higher functional classifications of roads, A-1 through B (Figure 4.2). However, there was a substantial non-acceptance of roadway delineation improvements for the lower classification of roads (Limited Access, C classification).

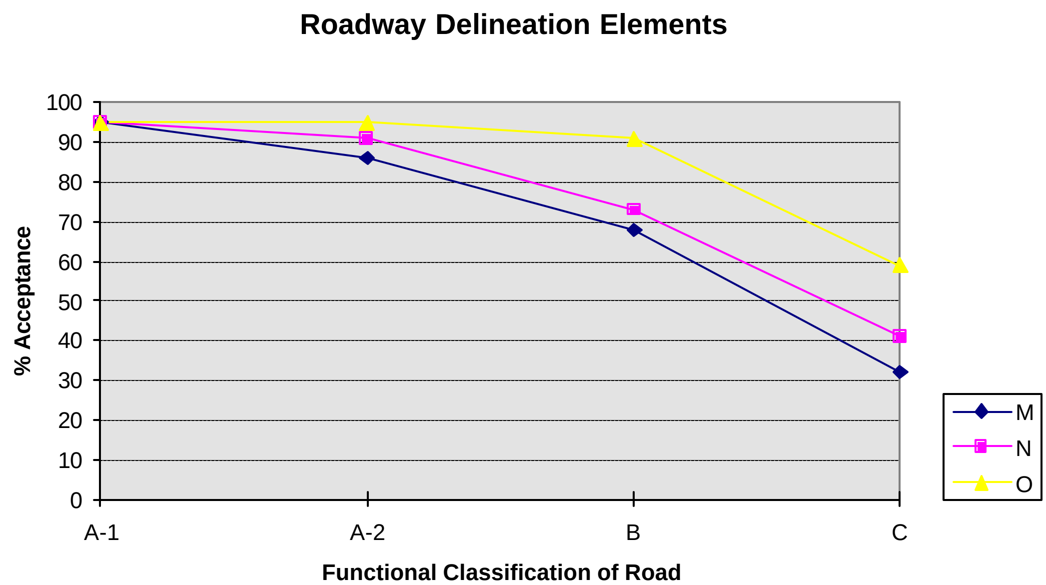

Figure 4.2 Roadway Delineation Elements

Improvements:

M - Install guardrails
N - Delineate curves with chevrons
O - Delineate curves with delineator posts and reflectors

Many respondents stated that the reason for their non-acceptance of roadway delineation as an incremental improvement, was that the improvements were not economical or simply not needed for a Limited Access, C classification roadway.

The installation of traffic control signs was an acceptable incremental improvement for all classifications of roadways. However, as the functional classification of the road increased, traffic control signs that give specific instructions or warning for the particular curve became more prevalent as an acceptable improvement (Figure 4.3). While still an acceptable of the road increased, traffic control signs that give specific instructions or warning for the particular curve became more prevalent as an acceptable improvement (Figure 4.3). While still an acceptable

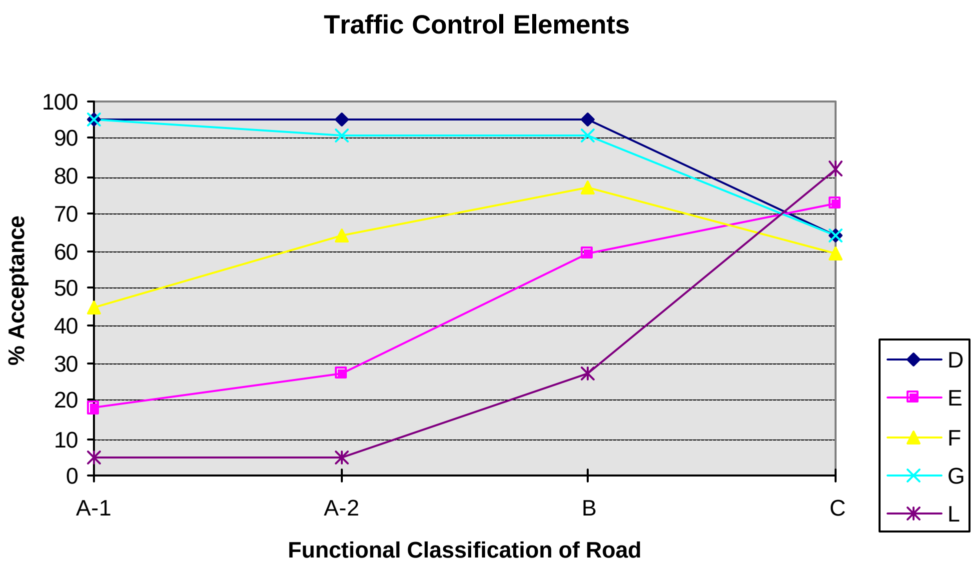

Figure 4.3 Traffic Control Elements

Improvements

- **D - Sign all curves, include advisory speed plate**
- **E - "Curve Ahead" sign at beginning**
- **F - Sign only curves 10 mph or more below speed limit, no speed plate**
- **G - Sign only curves 10 mph or more below speed limit, include speed plate**
- **L - "Primitive Road" sign at beginning**

improvement,

respondents did not indicate the same degree of support for site specific signs on the roads with lower functional classifications. Conversely, general warning signs, such as "curve ahead" signs (improvement E) and "primitive road" signs (improvement L) found higher degree of acceptability from the respondents for the lower functionally classified roads.

The significance between the sub-classifications for the various incremental improvements was not as well defined for geometric design and cross sectional safety issues. Generally, the incremental improvements were more acceptable for the roads with higher functional classifications (Figure 4.4). Driver expectancy, roadway consistency,

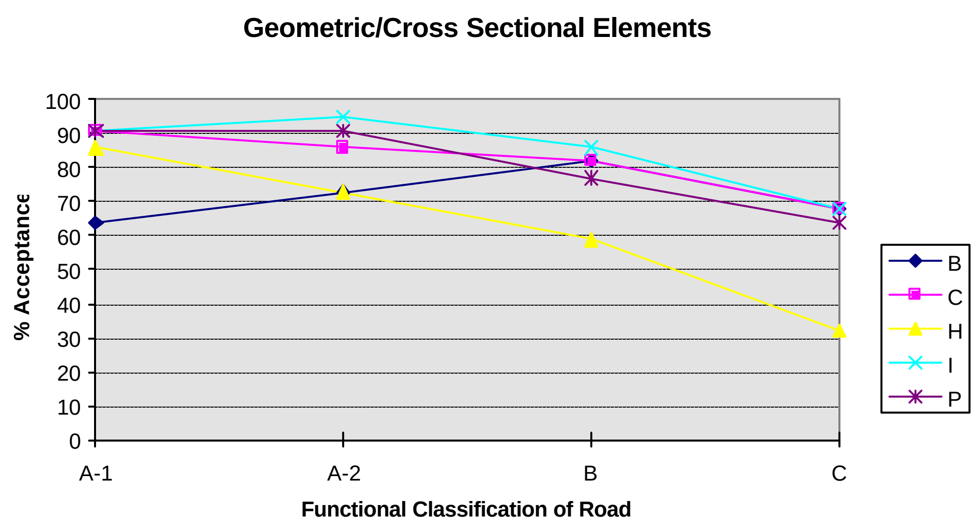

Figure 4.4 Geometric/Cross Sectional Elements

Improvements

B - Improve roadway surface on curves only
C - Improve roadway surface for entire road
H - Widen entire roadway
I - Widen roadway on curves only
P - Flatten curves as budget allows

operating speed, environmental issues, cost and other economic considerations all were issues that the respondents indicated should be considered when evaluating incremental improvements of the various road classifications. The respondents indicated geometric design and cross sectional incremental improvements were less acceptable as the functional classification of the roadway decreased.

The alternative of "do nothing" (improvement A) received an increasing level of acceptance as the roadway functional classification was lowered. Conversely, the alternative of "reconstruct curve to design guidelines" (improvement Q) received a high level of acceptance for the higher classified roadways and decreasing level of acceptance for the lower classified roadways (Figure 4.5).

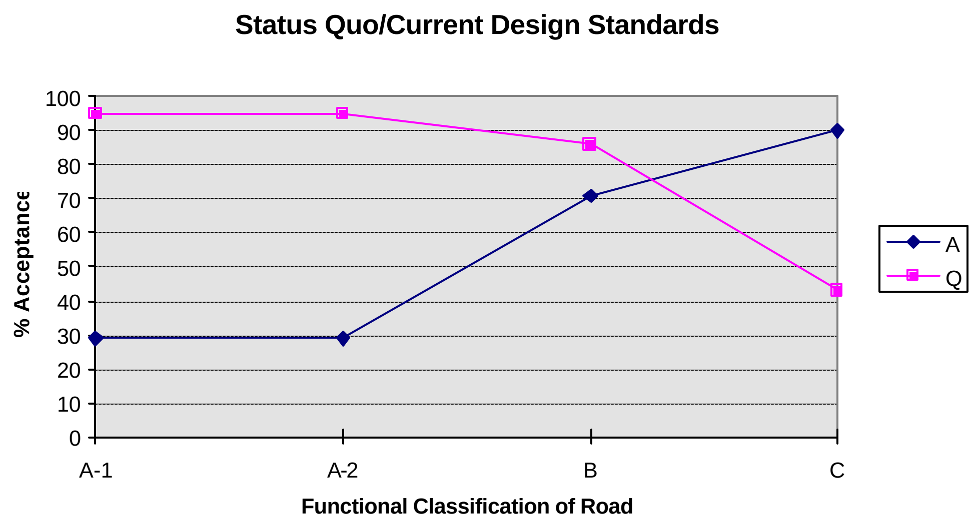

Figure 4.5 Status Quo/Current Design Guidelines

Improvements

A - Do nothing

Q - Reconstruct curve to design guidelines

The Delphi survey respondents identified the need for sub-classification of low volume rural roads. The survey results illustrated the significant difference between the various proposed classifications. Depending on the classification of the road, some of the incremental improvements were more acceptable than others. The following chapter contains the summary, conclusions, and recommendations for implementing incremental safety improvements for unpaved rural roads.

CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Incremental improvements are important tools for the road manager to enhance safety on local roads. Tort liability claims against government highway agencies has been increasing at the rate of 16 percent per year since 1972 [17]. The threat of a lawsuit has caused many managers and highway agencies to be hesitant in making improvements to the road unless it meets or exceeds established minimum design criterion. Courts are finding that governmental entities have the duty and responsibility to provide a safe transportation system regardless if the entity can "afford" the improvement or not. When establishing reasonable care by the highway agency, the courts are finding that "reasonable" care does not always mean to improve the roadway to current design guidelines. Reasonable care means that certain improvements may be acceptable if they protect and warn the traveling public of dangerous roadway conditions.

By utilizing care and sound engineering judgment, incremental improvement strategies minimize liability risk and improve roadway safety. Economical and cost effective improvements provide a safer roadway environment. The local road manager must be able to evaluate the potential improvements to ensure that improvements maintain roadway consistency and support driver expectancy. The results of this research indicated that incremental improvements were not acceptable on some roads and yet were perfectly acceptable on others.

Categorizing the majority of the nations roads into one functional classification — rural local roads — does not take into account the unique characteristics of the various roads. Traffic volumes, types of vehicles, level of service and driver characteristics are important attributes to consider to functionally classify a roadway. There is a need to sub-classify the rural local roads into categories that recognize the particular attributes of the road. This study found that based on incremental improvements, only three of the four classifications proposed were justified. However, an additional classification for unimproved roads with less than 25 ADT was recommended. Development of improvement guidelines to address the needs for the local road based on its classification characteristics is important.

Conclusions and Recommendations

The results of the research indicate two important concepts when considering incremental improvements on local roads.

1. The functional classification of the rural local road must be established and improvement guidelines for the classification identified.
2. Incremental improvements are an important strategy to enhance roadway safety.

Traffic volumes and road user characteristics are important attributes to be considered when establishing the functional classification of the local road. Due to the variable traffic volumes and loading on rural local roads, additional sub-classifications beyond "rural local" is recommended. It is important that various sub-classifications be developed on a national basis to assure acceptance and uniformity. Improvement guidelines must be developed for the various functional sub-classifications. The guidelines need to reflect the safety aspects and other parameters of the local roadway. Improvement guidelines should not only consider the parameters of the local roadway, but also the safety issues and economical constraints. It is recommended that additional research be conducted to determine the appropriate ADT range to be used for the specific functional sub-classifications.

It is not suggested that design guidelines for the construction of new low volume rural roads be reduced. A properly designed and constructed rural road not only enhances safety, but also minimizes the cost of maintenance. Most local road agencies do not have adequate resources to properly maintain their existing facilities. A new road that has not been properly designed or constructed to accommodate future traffic, yet has been brought into the local system is not good management and will create additional liabilities. However, the local road manager must have the flexibility to incorporate improvement designs incrementally on existing unpaved rural road improvement projects that improve the safety of the road in a cost effective manner. In designing incremental improvements, future traffic demands should be considered. Design guidelines for improvements to existing unpaved rural roads must be developed to accommodate incremental or staged construction of roadway improvements.

If improvements are not completed to bring the deficient roadway into conformance with existing criterion, then incremental improvements are essential. Incremental improvements enhance roadway safety by improving the operation of the road and, as a result, limit the highway agency's liability. Incremental improvements must be carefully planned to maintain roadway consistency. Roadway consistency is an important component to keep from violating driver expectancy. Reconstruction of a dangerous curve may not be an acceptable improvement on certain roadways if the drivers' expectancy is not maintained, thereby creating another dangerous situation at a different location along the road. It is recommended that additional research be conducted to further evaluate the acceptability of incremental improvements on functionally classified unpaved roadways with other types of site deficiencies.

Developing an incremental improvement program for a specific local road or street involves five fundamental steps:

1. Establish a functional sub-classification for the roadway.
2. Identify the site deficiencies.
3. Review the incremental improvement alternatives.
4. Analyze the effect of the improvements on driver expectancy.
5. Implement the improvement program.

Each step involves careful consideration of the roadway and traffic characteristics. A site evaluation checklist (Appendix E) was developed as part of this project to assist the local road manager in evaluating the potential for incremental improvements for the roadway. It is recommended that a site evaluation checklist for low volume rural roads be developed on a national basis.

Local highway agencies often do not have the resources or training to establish an effective incremental improvement program. It is recommended that a training program be developed to assist local highway agencies in planning and implementing an incremental improvement program. Incremental improvements are an important safety consideration and should be used for rural local roads.

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