TRANSPORTATION RESEARCH

Number 279, May 1984
ISSN 0097-8515

CIRCULAR

Transportation Research Board, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, DC 20418

OPERATIONAL AND MAINTENANCE PROBLEMS WITH HIGHWAY SAFETY APPURTENANCES

mode
1 highway transportation

subject areas
21 facilities design
40 maintenance
51 transportation safety
53 vehicle characteristics

PREFACE

This circular contains the proceedings of a workshop sponsored by the TRB Committee on Safety Appurtenances and the AASHTO Highway Subcommittee on Maintenance. It was held at the Hilton Inn, Santa Fe, New Mexico, July 15-16, 1982. Problem areas used as planning guidance at the workshop were generated by a questionnaire to the State Highway and Transportation Departments. Approximately 240 problems were submitted by 74 maintenance personnel in 24 states. By an iterative process of discussions and rankings the problems were reduced to the 20 high priority areas indicated in Appendix B of this circular.

Special credit for this publication is due Hayes E. Ross, Jr., and Frank N. Lisle who were responsible for planning and conducting the workshop and assembling this material. Sincere thanks are extended to the New Mexico State Highway Department for its hospitality and assistance during the workshop, and particularly for the help of Edmundo Lucero, Charles Barbee and Karleen Boggio. Grateful acknowledgment is also extended to each participant for his contributions and suggestions.

SPONSORSHIP OF THIS CIRCULAR

TABLE OF CONTENTS

I. INTRODUCTION

Hayes E. Ross, Jr., Texas A&M University
Frank N. Lisle, Virginia Highway and
Transportation Research Council

Roadside safety hardware such as breakaway signs and light poles, crash cushions and longitudinal barriers have played and will continue to play an extremely important role in reducing injuries and fatalities. When properly designed, installed and maintained these appurtenances perform as intended. Ideally, a good design is one that can be easily and properly installed and requires little or no maintenance. With the advent of a variety of new and somewhat complicated appurtenance designs it has become painfully evident that problems exist not only in their design but in their installation and maintenance as well. These problems have been compounded by the increased demand on highway maintenance in general coupled with reduced budgets.

It has also become evident that researchers and designers of highway safety appurtenances have failed in some cases to consider future maintenance requirements and possible problems. One way to mitigate this problem is for the researcher and designer to better understand the demands and limitations of those responsible for highway maintenance and vice versa. The workshop discussed herein was thus conceived as a forum by which views and concerns of those responsible for design, installation and maintenance of safety appurtenances could be expressed.

The workshop was jointly sponsored by AASHTO's Highway Subcommittee on Maintenance and TRB's Committee on Safety Appurtenances and was held in Santa Fe, New Mexico on July 15-16, 1982. The objectives of the conference were to (a) identify operational and maintenance problems relating to the safety readiness of highway appurtenances, (b) assess solutions to these problems being employed by highway agencies and (c) identify research needs. The safety appurtenances were examined from the viewpoint of highway personnel having the responsibility for maintaining such appurtenances on a day-to-day basis. Among those examined were longitudinal barriers and their transitions and terminals, crash cushions, sign and luminaire supports and miscellaneous appurtenances such as mailboxes, drainage structures, etc. The examination emphasized (a) costs for installation, repair and normal maintenance; (b) the difficulty of maintenance due to special parts, special equipment, skilled labor, rapid deterioration, etc.; and (c) factors adversely affecting operation of the appurtenances such as the accumulation of snow or sand, and unusual site requirements.

There were approximately 60 workshop participants representing state transportation agencies, the Federal Highway Administration, research agencies, private consultants, industry and the TRB. Various facets of highway engineering were represented including design, maintenance and research. A list of participants and their affiliations is given in Appendix C.

II. WORKSHOP AGENDA

The workshop was designed to allow each attendee ample time to express his views and suggestions on the various subjects. The agenda for the workshop is shown in Table 1.

In the introductory portion the objectives, procedures and assignments were given. The attendees were assigned one of five groups as given in Table 2. They stayed in these respective groups for each of the breakout sessions.

Table 1. Agenda

Sessions

Thursday, July 15, 1982

I. INTRODUCTION
- * Workshop Objectives, Procedures and Assignments -- Frank N. Lisle, Workshop Chairman
- * Status Report - 1981 A2A04 Summer Workshop -- John Viner
- * Highway Safety Hardware Maintenance -- William C. Grenke

II. SIGN AND LUMINAIRE SUPPORTS
- * Functional Requirements and General Problem Areas -- Donald L. Woods
- * Breakout Sessions
- * Report by Session Chairpersons

III. LONGITUDINAL BARRIERS AND END TREATMENTS
- * Functional Requirements and General Problem Areas -- Donald L. Woods
- * Breakout Sessions
- * Report by Session Chairpersons
- * Recess

Friday, July 16, 1982

IV. CRASH CUSHIONS
- * Functional Requirements and General Problem Areas -- Donald L. Woods
- * Breakout Sessions
- * Report by Session Chairpersons

V. OTHER APPURTENANCES AND TOPICS (drainage structures, mailboxes, etc.)
- * Functional Requirements and General Problem Areas -- Hayes E. Ross, Jr.
- * Discussion of Problems, Recommended Solutions and/or Suggested Research

VI. WORKSHOP SUMMARY -- Frank N. Lisle

VII. ADJOURN

Table 2. Group Assignments

GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V
R.G. Biller	G. Buth	D.E. Brighton	P. Bell	C.H. Barbee
K.J. Boedecker, Jr.	D. Chandler	R.E. Baumgardner	D. Bennett	A.G. Clary
C.T. Edson	R.D. Deike	R.E. Bliss	S.A. Bennett	W.W. Hunter
D.D. Fowler	J.J. Dolan	L.A. Garrido	M.E. Bronstad	R.M. Lewis
W.M. Gere	J.F. Dunn, Jr.	F.N. Lisle	O.S. Denman	J.S. Moulthrop
R.O. Gumtau	P.L. Frederick	T.B. McCarthy	A.M. Dinitz	J.F. Nixon
H.J. Henry	W.C. Grenke	W.G. McCully	E.B. Duran	H.E. Ross, Jr.
O.R. Martin	J.H. Hatton, Jr.	B.H. Ortgies	E.J. Kehl	R.G. Rutledge
R.E. McCoid	L.F. McNamara	E.R. Post	C.C. Kuehl	R.L. Schroeder
C.D. McQuarie	C.R. Miller	W.F. Rosser	G.T. Landsness	F.J. Tamanini
J.D. Michie	D.E. Orne	J.G. Viner	J.A. McGee	H.W. Taylor
D.L. Wheeler	L.F. Spaine	J. Young		

Prior to the workshop a questionnaire was mailed to the states seeking problem areas, suggested solutions and/or suggested research needs relating to installation and maintenance of safety appurtenances. Approximately 240 problems were submitted by 74 maintenance personnel in 24 states. These problem statements were categorized according to one of four subject areas, namely, Sign and Luminaire Supports, Longitudinal Barriers and End Treatments, Crash Cushions, and Other Appurtenances. Each of the five workshop groups were given copies of these statements and asked to consider them together with other statements of the groups in developing a prioritized list of problem areas. A summary of the problems is given in the next chapter.

III. PROBLEMS IDENTIFIED

Each of the five groups (see Table 2) reviewed problems within each of the four subject areas. Listed in Table A1 through A3 of Appendix A are results of those group sessions with the top five problem areas within each subject area prioritized as shown.

It can be seen that there was general agreement in some cases on certain problems and little agreement on others. Differences are attributed in large part to the diverse nature of the attendees in terms of their home state, their responsibility, etc. Overall, it is apparent that less maintenance intensive appurtenances are needed. Increased demands on all phases of maintenance, coupled with declining budgets, has created the need for appurtenances that require minimal maintenance. Furthermore, there is a need for standardization of devices and parts to reduce inventory, storage and problems with improper repair and usage. There is also a need to use life-cycle costs or cost-effective techniques in the selection and use of safety appurtenances.

IV. FOLLOW-UP SURVEY

The final phase of this effort involved a follow-up survey. Results of the initial survey and the workshop were summarized into a set of twenty problem areas. These twenty problems are believed to represent the highest priority needs identified via the above process. They are listed in Appendix B.

The twenty problem areas were submitted for a final prioritization to participants of the original survey, workshop participants and members of TRB Committee A2A04. Each recipient of the twenty problems was asked to rank the problems with a one (1) being the highest priority and a twenty (20) the lowest.

A total of 67 people responded to the follow-up survey. Respondents were placed in one of four categories: (1) those working for a state, county or municipal transportation agency; (2) those working within private industry, including consultants; (3) those working for a federal transportation agency; and (4) those working for research agencies. Most of those in category 1 were maintenance engineers; most of those in category 3 were engineers employed by the FHWA.

Shown in Table 3 are results of the follow-up survey grouped according to the above categories. Analysis of the survey data consisted of a simple addition of the rating for each problem, with the lowest total score receiving the highest rating or priority.

Table 3. Ranking of Top Twenty Problem Areas

PROBLEM	RANKING[a]				
	STATE (40)	INDUSTRY (12)	FEDERAL (8)	RESEARCH (7)	COMPOSITE (67)
Maintenance Worker Protection	1	4	4	3	1
Life-Cycle Costs	2	4	5	1	3
Unneeded Safety Appurtenances	3	6	8	2	4
Quality of Repairs to Safety Appurtenances	4	2	2	4	2
Location of Sign Supports	5	5	13	6	5
Upgrading Guidelines for Damaged Barrier	6	9	6	5	6
Safety of Damaged Crash Cushion	7	3	11	12	8
Rapid Change in Design Standards and Its Effect on Spare Parts Inventory	8	12	14	7	9
Low Guardrail	9	8	3	8	7

Table 3. Ranking of Top Twenty Problem Areas (Cont'd.)

PROBLEM	RANKING[a] STATE (40)	INDUSTRY (12)	FEDERAL (8)	RESEARCH (7)	COMPOSITE (67)
Delineation of Crash Cushions to Reduce Frequency of Impacts	10	7	10	13	11
Mailbox Support Standards	11	11	9	9	10
Vegetation Management	12	18	1	11	12
Debris or Snow Accumulation Adjacent to Barriers	13	13	12	19	14
Malfunction of BCT	14	14	7	10	13
Snowdrift Adjacent to W-Beam Guardrail	15	17	15	16	15
Litter and Dirt Accumulation under Crash Cushions	16	16	17	18	18
Repair of Guardrail in Winter	17	15	16	15	17
Vandalism of Breakaway Appurtenances	18	10	18	14	16
Handling 25' Guardrail Sections	19	19	19	17	19
Guardrail Straightening	20	20	20	20	20

[a]Numbers in parentheses are number of respondents within each category.

V. SUMMARY

From the follow-up survey (see Table 3) it can be seen that with few exceptions there was general agreement between the state, industry, federal and research personnel regarding the top five to ten operational and maintenance problems with highway safety features. Topping the list is the problem of protection of maintenance and work zone personnel during maintenance or construction activities. Other major problems include the need to develop cost-effective solutions to safety improvements, the need to remove unnecessary appurtenances and the need to properly repair and maintain safety appurtenances.

APPENDIX A - PROBLEM AREAS IDENTIFIED IN WORKSHOP

Table A1. Sign & Luminaire Supports

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session II - Group I	
1. Acquisition of parts to maintain supports. Agencies tend to use whatever is available.	1. Color code parts; design parts so that they cannot be installed improperly; provide training to maintenance personnel; provide sketch on how to install with parts packages.
2. Failure of breakaway features due to environmental factors.	2. Redesign hardware; conduct research study to define appropriate design criteria and to develop improved hardware.
3. Proper applications of standards.	3. Educate and train specialized labor personnel; color code parts for easier inspection.
4. Unauthorized removal of supports and delineators.	4. Paint post and apply reflective beads; use less desirable reflectors, i.e., reflective panel; use special fasteners that are difficult to remove.
5. Location of supports in snow belt states interfere with snow plow operations.	5. Move supports as far from travelway as standards permit.
Session II - Group II	
1. Supports may be over designed.	1. Further research needed; more frangible and fewer mechanical breakaway designs needed.
2. Location of signs - gore light poles and signs often lit; signs located in ditch lines and near shoulder vulnerable to damage and hinder maintenance of roadside.	2. Eliminate light poles at gore areas or protect them; install wooden sign posts at gore areas; reduce number of signs or remove them beyond drainage ditches.
3. Standards are changed too frequently; need compatibility; inventory problems; difficult to keep field training at an	3. Encourage use of standardized parts such as those developed by AASHTO - ARTBA - AGC Task Force 13; put "maintainability" engineer criteria in design process.

Table A1. Sign & Luminaire Supports (Cont'd.)

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session II - Group II (Cont'd.)	
appropriate level.	
4. Lack of field training of maintaining personnel on functional purpose of breakaway supports.	4. Need more field training; need more liaison from manufacturers of hardware.
5. Failure of breakaway features due to environmental factors and improper torquing of bolts.	5. Redesign hardware; conduct research study to define appropriate design criteria and to develop new hardware; torque bolts according to specification.
Session II - Group III	
1. Location of supports - gore light poles and signs often hit; signs located in ditchlines and/or near shoulder vulnerable to damage and hinder maintenance; offset distance affects legend size.	1. Eliminate light poles at gore areas or put in protected area; put signs in gore areas as far back from nose of gore as possible; install wooden post signs in gore areas; reduce number of signs or move beyond drainage ditch if possible; relocate signs or safety/rehabilitation projects; use life-cycle costs in determining post type to use in vulnerable areas.
2. Breakaway features of many luminaire supports will not satisfy current AASHTO safety standards.	2. Develop new basis; identify methods to modify retrofit existing bases.
3. Reduction of breakaway feature effectiveness due to soil erosion or accumulation around bases of signs and luminaire supports.	3. Train maintenance personnel on proper maintenance; perform frequent inspection; maintain vegetation integrity near bases; riprap around base if possible; insure proper grading around bases.
4. Hand hole on some luminaire poles too small for proper access.	4. Enlarge hole; install box flush with surface and adjacent to pole base to accommodate connections, fuses, etc.
5. Failure of breakaway features due to environmental factors; improper torque in bolts.	5. Redesign hardware; use load limiting bolts.
Session II - Group IV	
1. Inadequate maintenance funds.	1. Design decisions should be based on total costs rather than just the initial cost; should let design groups know of maintenance problems.
2. Upgrading facilities.	2. Maintenance should consider upgrading facilities rather than just maintaining in kind.
3. Review policies.	3. States should develop a review policy to evaluate new technology and to eliminate ongoing maintenance problems.
4. Training.	4. More field training for maintenance personnel.
5. Torquing of bolts in breakaway systems.	5. Need policy on inspection and retorquing of bolts.
Session II - Group V	
1. Maintenance intensive appurtenances--maintenance personnel should not be expected to conduct frequent and detailed inspections of hardware.	1. Appurtenances should be so designed as to not need preventative maintenance, such as torque measurements of bolts, etc.; more training of maintenance personnel needed to acquaint them with functional requirements of appurtenances.
2. Location of supports--gore light poles and signs often hit; signs located in ditchlines and near shoulder vulnerable to damage and hinder maintenance.	2. Eliminate light poles at gore areas or put in protected area; reduce number of signs or move them beyond drainage ditch; more research needed to evaluate changes in visibility as signs moved off shoulder.
3. Vandalism of signs.	3. Use vandal proof bolts; use public appeals and education; need stiff penalties for violators.

Table A1. Sign & Luminaire Supports (Cont'd.)

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session II - Group V (Cont'd.)	
4. Torquing of bolts in breakaway features.	4. Adhere to specifications; use frequent maintenance checks; (see item 1 above for comments regarding maintenance of appurtenances).
5. Improper installation of supports--bases are installed greater than 4 to 5 inches above ground.	5. Instruct maintenance personnel of importance of proper basepost embedment.

Table A2. Longitudinal Barriers

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session III - Group I	
1. Information explosion--large amount of information not being sorted and disseminated to right people.	1. More use and understanding of AASHTO - ARTBA - AGC Task Force 13 standardized hardware manuals and more training needed--would solve many problems currently encountered with barriers and end treatments, i.e., the BCT.
2. Snow and debris accumulation next to barriers.	2. Remove as quick as possible; have snow plows as near barrier face as possible; use cable barrier if acceptable.
3. Small car behavior upon impact with W-beam guardrail--car may underride and snag on posts.	3. Consider upgrading; add rub rail if necessary; use thrie beam if necessary.
4. Upgrading guidelines for damaged barriers--should they be replaced in kind?	4. Prepare guidelines; train personnel on proper replacement procedures; coordinate upgrading with design section.
5. Low guardrail--at what height should corrective action be taken?	5. Remove and reset rail (can be costly); use adjustable blockout that will allow rail eight adjustments (State of Illinois is using such a blockout).
Session III - Group II	
1. Unnecessary use of barrier.	1. Remove if not warranted by AASHTO guidelines; flatten slopes, remove or make breakaway rigid poles or signs.
2. Lack of maintenance considerations in barrier design and selection.	2. Reduce number of barrier types and/or have standardized parts for all systems; use life-cycle costs when developing and selecting traffic barriers.
3. Maintenance of barriers under traffic.	3. Use barriers that require little maintenance when impacted where impacts are frequent and maintenance zone traffic control difficult.
4. Repair of guardrail in winter.	4. Use posts that can be driven in frozen soil or drill holes for replacement--may be a need for improved extraction and drilling equipment.
5. Need to know quality and quantities of barriers.	5. Use photologging and/or physical inspection to inventory and determine serviceability of barriers.
Session III - Group III	
1. Rapid changes in design standards--multitude of guardrail and median barrier types.	1. Reduce number of rail types and/or have standardized parts; use AASHTO - ARTBA - AGC standardized hardware; develop catalog list of parts for old installations; future hardware should be developed with standardized hardware when possible.
2. Low guardrail.	2. Reset to proper height if funds permit; provide new guardrail when pavement overlayed, especially if old rail is substandard use thrie beam if feasible; use an adjustable blockout (State of Illinois is using such a blockout).
3. Accumulation of debris and snow in front of barrier.	3. Remove debris and snow as necessary; run snow plow as near to face of barrier as possible.

Table A2. Longitudinal Barriers (Cont'd.)

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session III - Group III (Cont'd.)	
4. Malfunction of breakaway cable terminal.	4. Construction must comply with BCT standards--especially the 4 ft flare.
5. Repair of guardrail in winter--difficult to remove and install posts.	5. Provide appropriate signs and barricades until weather permits repair; replace timber posts with steel posts which can be driven in frozen soil adjacent to broken wood posts.
Session III - Group IV	
1. Unnecessary use of barrier.	1. Perform maintenance reviews and remove unwarranted barrier.
2. Rapid changes in design standards--multitude of guardrail and median barrier types.	2. Reduce number of types of barriers and/or have standardized parts; use barriers standardized by AASHTO - ARTBA - AGC in Task Force 13.
3. Malfunction of breakaway cable terminal.	3. Construction must comply with BCT standards--especially 4 ft flare; redesign systems for small cars.
4. Maintenance of BCT--broken stand post difficult to remove; foundation frequently pulled from ground.	4. A 2 inch wide, 18 gauge steel strap placed in sleeve prior to setting post that stands above top of sleeve by several inches has been very effective in facilitating post removal; need to develop system with more reusable parts.
5. Support posts in first 25 ft of twisted and turned down guardrail end treatment.	5. Remove all interior posts in 25 ft turned down section.
Session III - Group V	
1. Rapid changes in design standards--multitude of guardrail and median barrier types.	1. Reduce number of barrier types and/or use standardized parts for all systems; need to continue to educate maintenance personnel regarding changes in hardware.
2. Use of unnecessary barrier.	2. Traffic and design reviews should consider need for barrier and identify unnecessary barrier for removal.
3. Low guardrail.	3. Research study needed to determine course of action; remove and reset guardrail if feasible; use an adjustable blockout (State of Illinois is using such a blockout).
4. Upgrading guidelines for damaged barrier--should maintenance personnel replace in king?	4. Research study needed--should include legal questions.
5. Maintenance of BCT cable tension.	5. Problem should be studied--it may not be necessarily detremental to have some slack in cable.

Table A3. Crash Cushions

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session IV - Group I	
1. Stocking of spare parts-too many different designs--replacement of more expensive types must be obtained by competitive bid.	1. Standardization of crash cushion types needed; designing review to possibly replace with standard units; minimize technology required for multiple systems.
2. Safety of damaged crash cushions--how soon should they be returned to service? should temporary cushion be used until permanent cushion repaired?--major repair may require contract.	2. Sand barrels are easiest to restore; large number of designs complicate repair/maintenance--use as few systems as necessary.
Session IV - Group II	
1. Safety of damaged cushions--how soon should they be returned to service?--	1. Install warning device if repair cannot be quickly made; some states contract repair service on 48 hr response time; sand

Table A3 Crash Cushions (Cont'd.)

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session IV - Group II (Cont'd.)	
should temporary cushion be used until permanent cushion repaired?--some states do not allow intermixing of sand barrels--replacement must be "in kind."	barrels can be used as a temporary cushion; FHWA should notify states that intermixing of sand barrels satisfactory.
2. Stocking of spare parts--spare requirements for storing a problem.	2. Standardization of types would help; use special crews for repairs; contract repair service; computerize materials inventory on terminals.
3. Alternatives to conventional crash cushions--present systems are expensive to replace and maintain.	3. More research needed; remove hazards being shielded where possible.
4. Mobile crash cushions--slow moving maintenance vehicles create hazards--need protection for short term projects (1/2 to a full day).	4. Use portable mobile alternatives.
Session IV - Group III	
1. Effectiveness of delineation systems in reducing crash cushion impacts.	1. Studies are needed to evaluate various delineation systems--limited accident data suggest delineators may be very effective in reducing accident frequency.
2. Selection of proper design taking into account societal costs, capital costs, normal maintenance, collision maintenance, design life, etc.	2. Obtain advice from industry; use cost-effectiveness procedure in AASHTO Barrier Guide.
3. Stocking of spare parts--too many parts and barrier types.	3. Standardize parts; increase crew training; maintain barriers by contract in big cities.
4. Safety of damaged crash cushions.	4. Repair as soon as possible; contract repairs if feasible; preassemble parts as much as possible.
5. Splitting of sand barrels.	5. Use improved designs.
Session IV - Group IV	
1. Alternatives to conventional crash cushions.	1. Remove hazards if possible so that cushion not necessary; develop more maintenance free barriers.
2. Safety of damaged cushions--replacement parts not always available--manufacturers maintenance procedures not always reaching maintenance personnel--stocking of spare parts a problem.	2. Provide periodic and adequate instructions to maintenance personnel; reduce number of components to enhance inventory problems; emphasize visual aid instructions; standardize parts; develop maintenance records to better determine inventory requirements.
3. Truck mounted crash cushion--present systems too expensive and require special mounting hardware.	3. Develop lower cost systems that are easily mounted on trucks.
4. Litter, debris, snow, etc. accumulation in front of and within crash cushion.	4. Clean around units periodically; use snow cones, debris skirts and rails currently available; clean up site to reduce debris build up.
5. Pulling restraining cables loose at reaction wall upon repair of hi-dro or hi-dri barriers.	5. Use shock absorbing device on pulling cable; train crew in proper maintenance procedures.
Session IV - Group V	
1. Safety of damaged crash cushion.	1. Repair is a priority item that should be addressed quickly; use temporary cushion if necessary and if room permits; use federal funds available to stock spare parts; if cushion hit frequently there should be a study undertaken to find out why and if other improvements can be made.

Table A3. Crash Cushions (Cont'd.)

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session IV - Group V (Cont'd.)	
2. Stocking of spare parts.	2. Standardize parts and systems.
3. Delineation of crash cushions.	3. Develop standardized delineator system.
4. Truck mounted crash cushions.	4. Warrants for truck mounted cushions should be established.
5. Temporary barriers--present guidelines; recommend same criteria for temporary barriers as permanent barriers.	5. Develop a realistic set of design criteria for temporary barriers.

Table A4. Miscellaneous Appurtenances and Topics

PROBLEM IDENTIFICATION PRIORITIZED	SUGGESTED SOLUTION
Session V - Groups I & II	
1. Protection of work zone personnel.	1. Use appropriate traffic control devices.
2. Safety inspection of highway facilities costly and requires specially trained personnel.	2. No easy solutions.
3. Use of cost-effectiveness procedures not sufficiently considered--selection of appurtenances often builds in ongoing maintenance problems.	3. More use of cost-effectiveness procedures needed; hazards should be engineered out of design projects so protective devices not needed.
4. Removal of trees.	4. No easy solution but a serious roadside hazard--site specific policies needed in some cases.
Session V - Groups III & IV	
1. Protection of work zone personnel.	1. Need further research to develop portable protective devices.
2. Use of cost-effectiveness procedures not sufficiently considered--selection of appurtenances often builds in ongoing maintenance problems.	2. More use of cost-effectiveness procedures needed; hazards should be engineered out of designs so protective devices not needed; need more information on cost of maintenance.
3. Quality of repairs--maintenance workers do not always follow standard plans when making repairs--small variations can have significant effectson impact performance.	3. Keep personnel appraised of functional requirements--more training.
Session V - Group V	
1. Use of cost-effectiveness procedures not sufficiently considered--selection of appurtenances often builds in ongoing maintenance problems.	1. Use cost-effectiveness procedures more; hazards should be engineered out of design projects so that protective devices not needed.
2. Protection of work zone personnel--need better protection for moving operations.	2. More research needed; Texas has developed portable longitudinal barrier made from used cars.
3. Vegetation management--trees are greatest roadside hazard.	3. A management program needed to control growth of unsafe vegetation and removal of unsafe vegetation; need to better educate public on hazard of trees and the need for tree removal.
4. Safety inspection--need to repair damaged appurtenances as soon as possible.	4. Need adequate record keeping; pinpoint roadway and roadside features that have high involvement in tort claims; rank order problems.
5. Small car safety--how will small car perform upon impact with present safety appurtenances?	5. Research now underway on national level.

APPENDIX B - SUMMARY OF HIGH PRIORITY PROBLEMS

1. Topic: Maintenance Worker Protection

Description: There is an urgent need for a highly portable positive protection barrier for maintenance workers. The longitudinal "New Jersey" concrete barrier is used extensively to protect workers on freeway construction projects. A similar device is needed for maintenance workers exposed to the same hazards as construction personnel.

Possible Remedy: For slow moving and short term maintenance operations portable truck mounted attenuators are the best available device for protecting maintenance workers. However, warrants for their use should be developed.

The Texas Transportation Institute has developed and tested a portable longitudinal barrier that consists of five station wagons with thrie beam guardrail mounted on the sides.

2. Topic: Life-Cycle Costs

Description: It is believed that the life-cycle costs of safety appurtenances vs those of alternatives are not sufficiently considered in the design process. In some instances the appurtenances are installed when for a comparable expenditure the hazard could be eliminated along with the future cost for maintenance of the appurtenance.

Possible Remedy: There is a need to determine the life-cycle costs of highway safety appurtenances. Which appurtenances are most cost-effective? What are optimum designs for different highway classes? Is the long term cost for maintenance and repair considered? There is a need for more attention to alternatives that will reduce or eliminate the need for safety appurtenances.

3. Topic: Unneeded Safety Appurtenances

Description: Many safety appurtenances on highways were installed under old standards. Many of these may not be needed under current standards, or the hazard could possibly be removed and thus eliminate the need for the safety appurtenance. The unwarranted safety appurtenances constitute a hazard and an unnecessary maintenance cost to the motoring public.

Possible Remedy: Traffic, design and maintenance engineers should evaluate existing safety appurtenances in light of the AASHTO "Guide for Selecting, Locating and Designing Traffic Barriers," and should identify those unnecessary devices which can be removed. Maintenance crews should be advised of the potential tort liability incurred for removal of any safety appurtenance without a documented engineering analysis.

4. Topic: Rapid Change in Design Standards and Its Effect on Spare Parts Inventory

Description: It is very difficult to upgrade existing safety appurtenances because of the rapid change in design standards. Spare parts for many safety appurtenances are ordered and obtained and become obsolete before they are completely utilized. This makes it very difficult to stock a sufficient supply of replacement materials and causes confusion for those charged with repair and replacement. The multitude of safety appurtenance types also increases the number of spare parts on hand and the taining requirements for maintenance crews, inspection personnel and designers.

Possible Remedy: The American Association of State Highway and Transportation Officials, the Associated General Contractors of America and the American Road and Transportation Builders Association have developed two guides which may help to reduce the effects of the changing design standards on the inventory of spare parts. These are "A Guide to Standardize Highway Barrier Rail Hardware" and "A Guide to Standardized Highway Lighting Pole Hardware." The interchangeable parts in current barrier and light pole designs are identified, and the new designs will utilize the hardware listed in these publications to the maximum extent possible.

5. Topic: Location of Sign Supports

Description: Sign and luminaire supports have been located in gore areas, in ditch lines and in the shoulder area. The placement of supports in these locations makes them vulnerable to damage by vehicles and hinders shoulder, ditch line and mowing operations.

Possible Remedy: The maintenance engineers should work with design and traffic engineers to reduce the number of sign supports or move them beyond drainage ditches or as far back from the gore as possible. For those supports which must remain in these areas life-cycle costs rather than initial costs should be considered in determining the type of support used. The relocation of these supports should also be considered in safety and rehabilitation projects.

6. Topic: Quality of Repairs to Safety Appurtenances

Description: Although safety appurtenances may be constructed correctly when originally installed occasionally maintenance workers do not follow standard plans when making repairs, and apparently do not realize how important minor details may be to the proper function of an appurtenance. What methods are used to ensure that men doing the work understand the critical nature of safety devices and have all standard plans at their disposal so they know exactly how the appurtenances should be constructed? To what extent and how often do headquarters personnel verify that work is being done properly in the field?

Possible Remedy: The development of training programs and the formation of specialized maintenance crews appear to be the most practical approach to this problem.

Training is provided by the "Functional Requirements of Highway Safety Features" training course. The course describes how the various highway safety features work and why they are used. It identifies the factors that will adversely affect the intended performance of each. It illustrates what field personnel should look for to identify safety problems in field installations. Further information may

be obtained from the National Highway Institute, Federal Highway Administration, 400 7th Street, S.W., Washington, DC 20590.

7. Topic: Delineation of Crash Cushions to Reduce Frequency of Impacts

Description: The major cost of maintaining crash cushions is incurred when restoring or replacing an impact system. Are there any low cost methods of reducing the number of impacts?

Possible Remedy: Limited studies in two states have shown delineation of the nose of crash cushions to be effective in reducing the frequency of collisions. Other states are encouraged to perform similar studies to evaluate this approach.

8. Topic: Litter and Dirt Accumulation Under Crash Cushions

Description: The effectiveness of impact attenuators is reduced when snow, ice or other materials such as litter and sand accumulate around and under them. The bottoms of these units rest very close to the pavement, making it difficult to clean out the area under the attenuator.

Possible Remedy: Periodic maintenance is required to remove litter and dirt from around and under crash cushions. This can be accomplished by flushing with water or blowing out the material with compressed air. Snow covers and debris skirts to reduce this problem are available from most manufacturers.

9. Topic: Handling 25' Guardrail Sections

Description: The 25' lengths of some guardrail sections (for example, the thrie beam guardrail on bridges and the one piece rail for the breakaway cable terminals /BCT/) are very heavy, difficult to handle without a mechanical lifting aid and difficult to transport.

Possible Remedy: The 12.6' sections of the thrie beam guardrail performed satisfactorily when impacted by a school bus in full scale crash tests.

The BCT system was originally crash tested with 12.6' sections of guardrail. The 25' sections were specified to increase the safety factor by eliminating the splice joint. If the 12.6' sections are used the splice joint must be installed properly.

It is up to each state to change its standards to allow the shorter guardrail sections in the cases cited above.

The Federal Highway Administration Technical Advisory T5040.23 dated March 13, 1984 states that the use of the 12.6' section is acceptable.

10. Topic: Mailbox Support Standards

Description: Most states do not have any standards regarding mailbox supports on state highways. As a result numerous unnecessary deaths and injuries result each year from vehicle impacts with these fixed object hazards located on the roadway shoulder.

Possible Remedy: An effort should be made to develop guidelines or standards for mailbox designs on a national level. This effort should include the participation of the Federal Highway Administration, the American Association of State Highway and Transportation Officials (AASHTO) and the United States Postal Service.

The AASHTO publication "A Guide for Erecting Mailboxes on Highways" has been rewritten to include guidelines on mailbox supports and location. In April of 1984 it is in the process of being voted on by AASHTO.

11. Topic: Vegetation Management

Description: Trees represent a significant fixed object hazard to motorists. However, programs to remove trees and other vegetation are generally resisted by environmentalists.

Possible Remedy: A vegetation management program to control the growth of unsafe vegetation and the removal of existing unsafe vegetation is needed. This program should consider site specific information, roadway geometrics and education of the public as to the danger involved.

12. Topic: Safety of Damaged Crash Cushion

Description: When a crash cushion is struck two questions arise:

(a) How soon should it be returned to service?
(b) Should a temporary crash cushion be placed in front of the damaged installation until it can be repaired?

Possible Remedy: When a crash cushion is damaged and repairs cannot be made when reported or observed some warning device should be installed at the approach to the area. A temporary crash cushion should be installed when the damaged cushion cannot be repaired within a reasonable time period. A reasonable time period should be established by each state based on traffic characteristics and roadway geometrics. A method for establishing this time period is in the report "A Procedure for Determining Frequencies to Inspect and Repair Highway Safety Hardware" (Report No. FHWA IP-83-4). This document is available to the U.S. public through the National Technical Information Services, Springfield, Virginia 22161. The NTIS No. is PB 84154491 and in April 1984 the paper price was $8.50 and the microfiche price was $4.50.

13. Topic: Vandalism of Breakaway Appurtenances

Description: Many safety appurtenances are knocked down, shot at, and have bolts stolen from them. This is senseless distruction of public property that adds significantly to the maintenance of the roadway and often endangers the motoring public by making devices inoperable.

Possible Remedy: Vandal proof bolts should be used where theft is a major problem.

Public appeals and education of the public as to the seriousness of the problem should be used.

Assistance should be requested from the

public and police in the apprehension of the violators.

14. Topic: Upgrading Guidelines for Damaged Barrier

Description: Maintenance crews are told to replace in kind. Often it would be equal or less costly to replace with a latest standard barrier. Guidelines need to be developed to aid in deciding when upgrading is desirable.

Possible Remedy: This problem should be studied with due consideration being given to legal problems.

15. Topic: Repair of Guardrail in Winter

Description: When the guardrail post is damaged or broken and replacement is required in the winter how do you replace a post in solidly frozen ground and still provide a properly functioning guardrail?

Possible Remedy:

1. Most states have a method of doing this but, because it is costly and exceptionally time consuming to replace posts in frozen soil, they avoid or postpone the replacement until the ground thaws if at all possible.

2. Several states use temporary repairs. Alaska and Vermont sometimes use snow berms as replacement barriers. Other states use N.J. barriers, bolt new guardrail sections over the damaged ones or string cable across the damaged area. Some states place barrels in the opening.

3. The steps required for post removal are typically:

a) Thawing - using calcium chloride, steam generators, or fires.
b) Excavation - using air hammers or spades, hand shovels, back hoes or small power augers (6" - 8").
c) Pulling - attaching a chain to some portion of the broken post (or screwing a large lag screw into the post) and lifting with a front end loader, back hoe, the tailgate of a dump truck or the snow plow lift on the front of a dump truck.
d) Straightening - damaged steel parts are straightened using propane torches.
e) Splicing - damaged steel posts are cut off at ground level and a new section welded on.
f) Backfiling - styrofoam panels or polyurethane material is used to insert posts in holes where posts were extracted; where holes are enlarged sand is used to backfill.

16. Topic: Low Guardrail

Description: The standard guardrail height is 27". At what height should some corrective action be taken to return guardrail to the standard height? What is the best method of achieving this?

Possible Remedy: It is possible to disassemble the system, drill new mounting bolt holes 2" higher and 1" ahead of existing holes and reassemble the rail. This will provide a 2" raising of rail. Costs may be close to that of abandoning low installations and installing new rail. If installation has 12'-6" post spacing it is possible to jack up existing posts and install new posts at the proper height between the existing posts (6'-3" spacing). The new posts will keep the old posts from sliding down into their holes. Jacking posts up and pouring urethane foam into the void under the post has been tried. However, until cost-effective quipment is developed this method does not appear to be cost-effective.

17. Topic: Malfunction of BCT

Description: We have had some reported accidents involving fatalities and injuries where the breakaway post on the BCT did not break.

Possible Remedy: Construction of the BCT unit must comply with standards, especially the 4' flare.

18. Topic: Debris or Snow Accumulation Adjacent to Barriers

Description: In areas of frequent and heavy snowfalls a problem is created when snow and ice are piled against the median or roadside barriers. A "hard pack" develops after several plow passes and creates a potential for vehicle ramping. There is a need for either improved plowing techniques or efficient removal of the "hard pack" in front of the barrier.

Possible Remedy: Constant removal of snow and ice along the barrier with proper equipment appears to be the only practical solution to this problem.

19. Topic: Snowdrift Adjacent to W-Beam Guardrail

Description: The W-beam guardrail is one of the greatest causes of snowdrifts on rural highways in many states. The W-beam, originally designed to enhance safety, has created a wintertime hazard. It has been shown in some studies that other sections, such as box beams, can reduce the drifting considerably.

Possible Remedy: Consideration should be given to developing a guardrail section, through aerodynamic testing, that could satisfy safety requirements and minimize the snowdrift problem.

20. Topic: Guardrail Straightening

Description: A large number of sections of flex beam guardrail are damaged each year. If straightened these sections could be reused.

Possible Remedy: Portable rail straighteners are commercially available, and their use in many states has been proven to be cost-effective. In one state the initial cost of the equipment was recovered in less than a year.

APPENDIX C - LIST OF ATTENDEES

BARBEE, Charles H., New Mexico State Highway Department
BAUMGARDNER, R. Edward, Pennsylvania Department of Transportation
BELL, Parker, New Mexico State Highway Department
BENNETT, Douglas, Federal Highway Administration
BENNETT, S. A., New Mexico State Highway Department
BILLER, Randall G., West Virginia Department of Highways
BLASCHKE, Byron C., Texas Department of Highways & Public Transportation
BLISS, Rex E., Federal Highway Administration
BOEDECKER, K. J., Jr., Texas Corrugaters, Inc.
BRIGHTON, David E., TUFNUT Works
BRONSTAD, M. E., Southwest Research Institute
BUTH, Gene, Texas Transportation Institute
CHANDLER, David, Foresight Industries, Inc.
CLARY, Adrian G., Transportation Research Board
DEIKE, R. D., Foresight Industries, Inc.
DENMAN, Owen S., Energy Absorption Systems
DINITZ, Arthur M., Transportation Industries, Inc.
DOLAN, John J., The Dolan House
DUNN, John F., Jr., New Jersey Department of Transportation
DURAN, Emilio B., New Mexico State Highway Department
EDSON, Charles, New Jersey Department of Transportation
FOWLER, Donald D., Illinois Department of Transportation
FREDERICK, P. L., Louisiana Department of Transportation
GARRIDO, Louis A., Louisiana Department of Transportation
GERE, W. M., South Dakota Department of Transportation
GRENKE, William C., Roy Jorgensen Associates
GUMTAU, Richard O., Federal Highway Administration
HATTON, J. H., Jr., Federal Highway Administration
HENRY, Herbert J., Unistrut GTE Products Corporation
HUNTER, William W., University of North Carolina
KEHL, Edward J., Illinois Department of Transportation
KUEHL, Claus C., South Dakota Department of Transportation
LANDSNESS, G. T., Wisconsin Department of Transportation
LEWIS, Russell M., Consulting Engineer
LISLE, Frank N., Virginia Highway & Transportation Research Council
MARTIN, O. Raymond, Delaware Department of Transportation
McCARTHY, Thomas B., Energy Absorption Systems, Inc.
McCOID, Ronald E., Welded Beam Company
McCULLY, Wayne G., Texas Transportation Institute
McGEE, James A., Arizona Department of Transportation
McNAMARA, Lawrence F., Minnesota Department of Transportation
McQUARIE, C. D., New Mexico State Highway Department
MICHIE, Jarvis D., Southwest Research Institute
MILLER, Charles R., Florida Department of Transportation
MOULTHROP, James S., Pennsylvania Department of Transportation
NIXON, John F., Texas Department of Highways & Public Transportation
ORNE, Donald E., Michigan Department of Transportation
ORTGIES, Bitt H., Iowa Department of Transportation
POST, Edward R., University of Nebraska-Lincoln
ROSS, Hayes E., Jr., Texas A&M University
ROSSER, William F., North Carolina Department of Transportation
RUTLEDGE, Robert G., New Mexico State Highway Department
SCHROEDER, Robert L., Oregon Department of Transportation
SPAINE, Lawrence F., Transportation Research Board
TAMANINI, F. J., Energy Absorption Systems, Inc.
TAYLOR, Harry W., Federal Highway Administration
UMBS, Rudy, Federal Highway Administration
VINER, John G., Federal Highway Administration
WHEELER, Dan L., New Mexico State Highway Department
WOODS, Donald L., Texas A&M University
YOUNG, James, Franklin Steel Company
ZOOK, Roland L., Ohio Department of Transportation