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vol 12 highway design, construction and maintenance

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HIGHWAY SAFETY PROGRAM MANUAL

VOLUME 12

HIGHWAY DESIGN, CONSTRUCTION, AND MAINTENANCE

Nothing in this volume makes optional any mandatory requirement contained in promulgated Highway Safety Program Standards

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FOREWORD

As part of the Highway Safety Program Manual, this volume is designed to provide guidance to State and local governments on preferred highway safety practices. Volumes comprising the Manual are:

0. Planning and Administration
1. Periodic Motor Vehicle Inspection
2. Motor Vehicle Registration
3. Motorcycle Safety
4. Driver Education
5. Driver Licensing
6. Codes and Laws
7. Traffic Courts
8. Alcohol in Relation to Highway Safety
9. Identification and Surveillance of Accident Locations
10. Traffic Records
11. Emergency Medical Services
12. Highway Design, Construction, and Maintenance
13. Traffic Control Devices
14. Pedestrian Safety
15. Police Traffic Services
16. Debris Hazard Control and Cleanup

The volumes of the Manual supplement the Highway Safety Program Standards and present additional information to assist State and local agencies in implementing their highway safety programs.

The content of the volumes is based on the best knowledge currently available. As research and operating experience provide new insights and information, the Manual will be updated.

The volumes of the Highway Safety Program Manual deal with preferred highway safety practice and in no way commit the Department of Transportation to funding any particular program or project.

Many expert organizations and individuals at all levels of government and in the private sector contributed heavily in the preparation of the volumes of the Manual. The Department appreciates greatly this help in furthering the national program for improving highway safety for all Americans.

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

HIGHWAY SAFETY PROGRAM MANUAL

VOLUME 12 Highway Design, Construction, and Maintenance	TRANSMITTAL 18
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Par. 1. Introduction
2. Purpose
3. Specific Objectives

1. INTRODUCTION

a. Proper design, construction, and maintenance of streets and highways are important aspects of an effective highway safety program. Poorly designed roads, improper handling of traffic in construction zones, and inadequate maintenance can contribute directly to crashes and resulting serious injuries.

b. There are a great many things that can be done in the design, construction, and maintenance of highways to improve their contribution to safety. In the legislative deliberations which preceded enactment of the Highway Safety Act of 1966 it was stated that:

> "We can require that all new construction and reconstruction, regardless of where it is, be built to no less than Federal-aid primary design standards, even if this does mean building fewer miles, and we can require that those primary geometric design standards be substantially raised...
>
> "We can require that median barriers and guardrails be constructed of impact absorption materials that return cars with the least possible damage to positions parallel to traffic, and we can require that this be done immediately. We can also start replacing the present impact-dangerous barriers and guardrails with the improved types...

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"We can require that maintenance standards and practices be high enough to keep highways up to original construction standards."*

2. PURPOSE

The purpose of the Program is to assure that principles of safe design and operation are considered in the planning, construction, and maintenance of all streets and highways, thus resulting in the safest practicable physical environment for the road user.

3. SPECIFIC OBJECTIVES

The specific objectives of the Program are to ensure that:

a. Existing streets and highways are maintained in a condition that promotes safety.

b. Major improvements either to modernize existing roads or to provide new facilities are designed with proper application of approved safety standards.

c. Appropriate precautions are taken to protect passing motorists and pedestrians as well as highway workers from accident involvement at highway construction and maintenance sites.

*H. Rept. 1700, 89th Congress, 2d Session p. 15.

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Chapter 4 of Title 23, U.S.C., was adopted by Congress as part of the Highway Safety Act of 1966. Section 402(a) of Title 23 authorizes the issuance of a Highway Safety Standard related to highway design, construction, and maintenance. The Section requires that:

> "Each State shall have a highway safety program approved by the Secretary (of Transportation), designed to reduce traffic accidents and deaths, injuries, and property damage resulting therefrom. Such programs shall be in accordance with uniform standards promulgated by the Secretary. Such uniform standards shall include... highway design and maintenance (including lighting, markings, and surface treatment)..."

In addition, Section 402(b)(1)(B) states that:

> "The Secretary shall not approve any State highway safety program under this section which does not...authorize political subdivisions of such State to carry out local highway safety programs within their jurisdictions as a part of the State highway safety program..."

With regard to Federal highway safety fund participation, the limitation contained in subparagraph 402(g) applies:

> "Nothing in this section authorizes the appropriation or expenditure of funds for (1) highway construction, maintenance, or design (other than design of safety features of highways to be incorporated into standards)..."

In accordance with this chapter, the Department of Transportation issued Program Standard 4.4.12, Highway Design, Construction and Maintenance which is presented in Appendix A.

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Par. 1. General Policy
2. Specific Policies

1. GENERAL POLICY

The general policy of the Department of Transportation is to encourage and support in each State the Statewide application of safety principles to the design, construction, and maintenance of all roads and streets, both rural and urban.

2. SPECIFIC POLICIES

Within this broad policy, the following additional specific policies apply:

a. That State and local jurisdictions establish programs to correct safety deficiencies on all urban and rural roads with new construction, reconstruction, and improved maintenance.

b. That as a minimum the design criteria for safety features set forth in this volume should apply to construction, reconstruction, and improvement of all expressways, major streets, and major highways within the States, both on and off the Federal-aid system.

c. That safety improvements should be planned and implemented under provisions of the Highway Safety Act in close coordination with all other relevant programs as administered by the Federal Highway Administration.

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d. That a program for establishing priorities for the improvement of safety features on existing streets and highways should be undertaken, taking into consideration past accident involvement, current and future hazard potential, traffic volumes, cost, and reductions in deaths and injuries expected to result from a proposed improvement.

e. That design policies, standards, guides, and practices developed by the Federal Highway Administration (FHWA) and those of the American Association of State Highway Officials (AASHO) and Institute of Traffic Engineers (ITE), as specified in the references of this volume, should be used as criteria for safety features on applicable facilities.

f. That all personnel responsible for either supervising or performing work as it relates to highway design, construction, and maintenance should be thoroughly trained in the various aspects of highway safety.

g. That all levels of government having responsibility for streets and highways should utilize construction and maintenance procedures which assure the safe flow of traffic through construction projects and areas of maintenance activity.

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10. Rail-Highway Grade Crossings
11. Pedestrian Safety
12. Land Development
13. Training

1. INTRODUCTION

Safety must be a fundamental consideration in all planning, design, construction, reconstruction, and maintenance of highways and other features of the highway environment within the public right-of-way. In carrying out their responsibilities, all agencies responsible for work within the public right-of way should consider the provision of a hazard-free driving environment as a primary objective, along with other considerations such as cost and efficiency of vehicular or pedestrian movement.

a. Scope of the program.

The program should center on the ultimate purpose of reducing deaths, injuries, and property damage. This means there should be conscious and systematic efforts to adopt provisions that will result in reductions in deaths and injuries by:

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(1) The prevention of accidents (e.g., adequate sight distance).

(2) Improving the survivability of crashes and other loss-of control situations (e.g., breakaway sign supports, impact attentuating devices and other means).

(3) Prompt rescue and other postcrash measures (e.g., emergency roadside telephones).

b. Relationships between planning, design, construction and maintenance.

(1) Design is one of the early steps taken to initiate many highway and street improvements. Safety features, therefore, should be considered during the planning and design phase and not as an item for subsequent consideration.

(2) Safety features that were inadvertently excluded or developed subsequent to the design phase should be incorporated during the construction phase.

(3) Safety review and inspection of the facility should take place during the construction phase prior to its being opened to traffic. This should identify potential hazards which were not evident prior to construction as well as those hazards which evolved during or are a part of construction activities. New and relocated facilities should not be opened to traffic until:

(a) Construction equipment that would create a hazard has been removed or relocated to avoid possible harm to the motorists.

(b) Construction activities that would interfere with the safe movement of traffic have been completed.

(c) Unsafe conditions have been eliminated.

(d) Signs and devices have been installed to ensure effective traffic control. *

(4) During maintenance activities and where streets and highways are opened to traffic prior to completion of construction, it is essential to provide special safety precautions at every maintenance and construction site through which traffic must be maintained.

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*See Volume 13, Traffic Control Devices

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(5) Existing highway and street facilities should be maintained in a manner which will keep them at the highest reasonable level of safety through continuing improvements consistent with the changing character of traffic that the facility serves.

c. State and local relationships.

Within a State, responsibilities for highway design, construction, and maintenance may vary widely among State, county, or local agencies. Some incorporated areas, i.e. cities, may have these responsibilities for streets within their jurisdictions; others may not. In unincorporated areas, a local government may have responsibility for maintenance but not for design or construction. Therefore, the State should take appropriate steps to assure effective interfaces among adjacent local governmental units so that consistent levels of safety are achieved in all the local areas throughout the State.

d. Needs and priorities.

Every State and local agency with responsibility for design, construction, or maintenance should determine needs and assign priorities for improvements planned to correct safety deficiencies.

(1) The needs identification and improvement program.

A program for correction of hazards requires an inventory of the system's needs as well as a procedure for identifying hazardous elements of the system and specific locations based on accident analyses.

(a) Improvements may be programmed either by selecting certain routes for overall improvements or by selecting specific types of hazards and correcting them on a systematic basis.

(b) The hazard removal program should include a schedule for the correction of these hazards within a reasonable period of time.

(c) The goals of the program should be stated in terms which lend themselves to evaluation of progress.

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(2) The priorities program.

There should be a program for assigning priorities to all hazard correction requirements that are identified in the needs program.

(a) Reduction in deaths and injuries that are expected to result from each proposed improvement must be examined in relation to the cost of the improvement and comparable benefits of other proposed improvements.

(b) The effects of the proposed improvement on such traffic factors as capacity, volumes and speeds should be considered in establishing priorities. It should be recognized that safety-related improvements may have an adverse effect on these factors.

(c) The priority assignments should utilize fully the results of the surveillance program that establishes high accident locations. This program is described in Volume 9, Identification and Surveillance of Accident Locations, which calls for a discussion of the inventories of design and operating features associated with accident locations.

e. Records.

Agencies assigned the responsibility for highway design, construction, and maintenance should maintain detailed records of physical features of the highway sufficient for relating these features and accident experiences. These agencies should provide for the data requirements of the surveillance and traffic records programs as described respectively in Volumes 9 and 10 of the Highway Safety Program Manual.

2. GEOMETRIC DESIGN

The program should provide that standards relating to safety features such as sight distance, horizontal and vertical curvature, spacing of decision points, width of lanes, etc., must be followed for all new construction, reconstruction, and maintenance on all streets and highways in all jurisdiction. In all new construction and reconstruction, the highest practical standards for the type of highway concerned should be used.

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a. Design standards should be based upon proven principles and accepted practice by the highway engineering profession. *

b. All standards and related working instructions adopted by State, county, and local agencies should be periodically reviewed and updated to reflect new technology and changes in operating conditions so as to reflect at least current minimums necessary for safe traffic operations. Existing policies, standards, and guides of AASHO should be used for all roadways to which these policies could apply.

c. Design standards should cover all aspects relating to safety including, but not limited to, such safety features as sight distance, horizontal alinement, cross-section, access control, design consistency, and spacing of decision points. A Policy on Geometric Design of Rural Highways offers the most complete text in this area and should be used as a basic source in setting design standards. Some of the general criteria to be considered are:

(1) In the design of streets and highways, the driver's view of the highway under both day and night conditions should be considered. A detailed review by specialists in the various highway engineering disciplines will often reveal unsafe features which can be corrected prior to the construction phase.

(a) Safe and effective placement of roadside and overhead signs and signals needed by the driver should be carefully planned.

(b) Design policies should include sight distance at railroad grade crossings. Speed zoning and distribution of speeds of both highway vehicles and trains at the site should be considered. **

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*See Appendix C for a list of references containing design policies, standards, guides, and practices. Where alternatives exist in the references, those producing the safest practical results should be used.

**For a discussion of desirable sight distances, see National Cooperative Highway Research Program (NCHRP), Report No. 50, Factors Influencing Safety at Highway-Rail Grade Crossings, Chapter IV.

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(c) Desirably, the calculation of safe stopping sight distance should be computed using wet coefficients of friction and the roadway design speed for braking distance. A reduction from the design speed, because of assumed reductions in vehicle speed when traveling on wet roads; could provide inadequate stopping distances for present traffic. The consistent annual increase in traffic speeds on existing highways and the reluctance of the driver to reduce his speed in wet weather require the use of longer design stopping distances in the interest of safety.

(d) Special attention should be given to the design of roadway drainage to prevent the accumulation of water on the pavement surface and thereby reduce the possibility of hydroplaning. This is particularly important in the transition area between tangent sections and superelevated horizontal curves.

(2) Design criteria should be applied uniformly throughout the highway system. Although deviations might be necessary on some specific section, these should be kept to a minimum inasmuch as a lack of uniformity can itself introduce hazards.

(3) Overall system design should ensure that the road user will not encounter any abrupt changes that would not be expected, such as the introduction of a sharp horizontal curve at the end of a long straight section of roadway. This means that design criteria should be applied within the context of the total facility as it would be used by motorists; they should not be applied on a disjointed, piecemeal basis.

d. Several other aspects of geometric design for safety are discussed under the heading "Crash Survivability" in paragraph 6 of this Chapter.

3. PAVEMENT DESIGN AND CONSTRUCTION

a. The skid resistance of pavement surfaces is important in maintaining vehicular control. Low skid resistance increases sharply the chances of skidding when the pavement is wet. As a general rule, low skid resistance also increases the possibility of hydroplaning. Both are important factors in wet weather collisions.

b. State and local highway agencies accordingly should require that in the design and construction of all new pavements, adequate standards of skid resistance be met. This requirement pertains to all paved roads, including bridge decks. This is to ensure that in new construction, pavement surfaces will meet the friction requirements necessary to minimize skidding and hydroplaning and the resulting accidents. A further goal is to design pavements to maintain these skid resistant qualities for as long as possible, preferably for the service life of the pavement.

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(1) Wearing surface qualities should minimally include the following design and construction considerations. It is recognized that methods of obtaining adequate skid resistance differ with type of surface as well as with local conditions.

(a) Pavement design considerations:

1 Aggregate size, shape, and hardness that will produce durable skid resistant surfaces.

2 Composition of the paving mix to allow the pavement surface to develop its skid resistant qualities.

3 Exclusion from the wearing surface of specific aggregate types and sizes which experience has shown will reduce skid resistant qualities.

(b) Pavement construction considerations:

1 Methods of constructing pavements that will retain the skid resistant qualities designed for the surface.

2 Finishing the wearing surface to provide a durable skid resistant roadway.

(2) While there has been considerable research in this field, there still is no nationally accepted minimum coefficient of skid resistance. However, as a general guide, the minimum skid numbers given in Table I offer the most current information on the subject. New pavements should be designed to obtain a high skid resistant surface that will retain these characteristics as long as practical.

(3) Records of the coefficient of skid resistance for new pavement surfaces and periodic additional skid tests will assist the roadway designer in determining which design mixes and construction procedures produce desirable skid resistance qualities.

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TABLE I

RECOMMENDED MINIMUM INTERIM SKID NUMBERS *

MEAN TRAFFIC SPEED, V(MPH)	SKID NUMBER	
	SN**	SN_{40} ***
0	60	--
10	50	--
20	40	--
30	36	31
40	33	33
50	32	37
60	31	41
70	31	46
80	31	51

*Skid numbers measured in accordance with ASTM E-274 Method of Test.

**SN = skid number, measured at mean traffic speeds.

***SN_{40} = skid number, measured at 40 mph, including allowance for the skid number reduction with speed using a mean gradient of G = 0.5.

Source: Tentative Skid Resistance Requirements for Main Rural Highways (1967) National Cooperative Highway Research Program Report No. 37, Highway Research Board, page 54.

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4. PAVEMENT TREATMENT FOR SKID RESISTANCE

Each State and local government should have a program for resurfacing or other surface treatments to correct street and highway locations where inadequate skid resistance contributes to high accident experience.

a. Because skid resistance of a pavement deteriorates with use, State and local agencies should follow a systematic plan for checking the skid resistance periodically at problem locations, and on a sampling basis at all other locations.

(1) Criteria for including a location in the periodic schedule are:

(a) High accident experience.

(b) Indications of excessive skidding.

(c) Potentially hazardous locations such as sharp curves and intersection approaches on high-speed highways.

(d) Locations where traffic volumes are heavy.

(e) Locations where the pavement is constructed of materials known to polish rapidly.

(f) Locations where the pavement is in poor condition.

(2) Any method of determining the coefficient of skid resistance is satisfactory, if it produces reliable results that can be correlated with the standard skid trailer tests. Measurements should be made at enough places on the road to assure that results are representative of the entire length in question.

(3) The purpose of this spot check program is to identify sections of roadway with inadequate skid resistance for possible corrective action. Road surfaces with a skid resistance value less than the interim skid numbers listed in Table I should be analyzed for corrective treatment.

b. State and local agencies should establish and implement a systematic program of corrective resurfacing of roadway elements to improve skid resistance. As a minimum, the program should include:

(1) Methods for immediate, although possibly temporary, spot improvement surface treatments on roadway sections with inadequate skid resistant characteristics.

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(2) A system for assigning priorities for temporary or permanent resurfacing or other corrective measures for roadway segments with high or potentially high skid-related crash experience.

(3) A systematic correction program for entire roadway routes having inadequate skid resistant surfaces.

5. ROADWAY LIGHTING

The Standard requires that roadway lighting be provided or upgraded on a priority basis on or at expressways and other major arteries in urbanized areas, junctions of major highways in rural areas, locations or sections of streets and highways having high ratios of night-to-day motor vehicle and/or pedestrian accidents, and tunnels and long underpasses.

a. Proper roadway lighting is an effective way of reducing night driving hazards. Each State therefore should have a program:

(1) To provide adequate street lighting on all urban sections of roadways or intersections where severe night driving hazards may exist.

(2) To upgrade presently deficient street lighting systems. A lighting improvement program should include a determination of the need for lighting on at least the following facilities:

(a) All expressways, major streets, and major highways in urban and suburban areas.

(b) The junctions between expressways and major highways in rural areas.

(c) Pedestrian crossings with high nighttime pedestrian volumes, or which otherwise constitute a hazardous location.

b. Because resources for improving roadway lighting are usually far below needs, States should develop and apply methods for determining where new or improved lighting will produce significant reductions in crashes. For general guidelines on lighting warrants see the AASHO publication, An Informational Guide for Roadway Lighting. Listed below are three additional methods that may prove to be effective in this regard.

(1) Streets and roads where excessive night hazards are indicated by a ratio of night-to-day crashes which is more than 1.5 times the night-to-day ratios of similar locations. For the purpose of this analysis, "similar locations" are those with comparable traffic volumes, traffic speed, access control, highway geometrics, adjacent land use, and ambient light levels.

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(2) In urban areas, locations where over 30 percent of the total nighttime crashes involve injuries or fatalities are considered to be excessive nighttime hazards.

(3) In rural areas, locations where over 50 percent of the total nighttime crashes involve injuries or fatalities are considered to have excessive nighttime hazards. This method of classification will only be meaningful for locations which have a relatively high nighttime crash experience.

c. Implementation of lighting improvements at locations with a high mighttime crash experience should be scheduled on a priority basis, taking into consideration nighttime crash frequency and severity and the potential effectiveness of roadway lighting in reducing the nighttime crash experience. The allocations of funds to improve roadway lighting should be reviewed periodically to assure that maximum safety returns for the lighting dollar are being realized.

d. The following references should be used as a guide for designing roadway lighting under this program.

(1) Illuminating Engineering Society, American Standard Practice for Roadway Lighting.

(2) The AASHO publication, An Informational Guide for Roadway Lighting.

e. It is recognized that many questions regarding lighting as related to safety remain unanswered. The program therefore may include tests of different lighting intensities and arrangements as well as the provision of new lighting at selected locations. It may also include light provided under spot improvement programs or at rail-highway grade crossings where there are frequent slow-speed trains during hours of darkness.

6. CRASH SURVIVABILITY

The out-of-control vehicle can produce deaths and injuries by striking another vehicle, striking a fixed object such as a bridge abutment, or leaving the roadway and thereby crashing. Whereas a vital part of the overall safety effort in highway design, construction, and maintenance is to reduce the likelihood of vehicles going out of control, no less important are the aspects of highway engineering that increase survivability when drivers lose control of their vehicles. These cover a wide range of techniques and devices including: the elimination of roadside obstacles; proper location of traffic control devices and highway lighting; use of breakaway supports and protective devices that afford maximum protection to the occupants of vehicles; bridge railings and parapets which are designed to minimize severity of impact and guardrails and other design features which protect pedestrians from out-of-control vehicles. Every State and local agency, therefore,

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should have an active program in all phases of highway design, construction, and maintenance to protect the occupants of an out-of-control vehicle and to avoid collisions with other vehicles and pedestrians. The program should, as a minimum, center on the following general principles, based on accepted practice.

a. Provisions should be made on all expressways and on high speed highways in rural areas to reduce the possibility that out-of-control vehicles will crash into fixed objects or to increase survivability if they crash. *

(1) Roadsides should be clear of obstacles that could be struck by out-of-control vehicles. There should be a driver-control recovery area clear of obstructions as wide as practicable for the conditions of traffic volume, prevailing speeds and the nature of development along the street or highway. Wherever practicable it is desirable that a driver control recovery area, clear of obstructions for a distance of 30 feet or more from the edge of the traveled way, be provided in rural areas. The recovery area should contain gentle slopes that can be safely negotiated by an out-of-control vehicle. Ditch sections should be fully rounded and have gentle side slopes.

(2) In cases where roadside obstacles, such as sign and light posts, cannot be located in an unexposed position and may constitute a hazard to an out-of-control vehicle, yielding or breakaway supports should be used.

(3) To assure at least minimum protection to the occupants of vehicles striking fixed objects that cannot be removed easily or designed so as to yield, provision should be made to install energey absorbing barriers such as guardrails or other similar protective devices. **

(a) Recognizing that there are locations where design cannot eliminate the use of guardrails, their installation should be designed to minimize possible injuries to vehicle occupants.

(b) Guardrail installations should have the ability to prevent errant vehicle penetration, redirect errant vehicles to a direction parallel to traffic flow and minimize hazard to vehicle occupants during impact.

(c) All approach ends of guardrail should be designed in such a manner as to minimize the hazards to the motorist while retaining the structural integrity of the installation.

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*American Association of State Highway Officials, Highway Design and Operational Practices Related to Highway Safety.

**Valuable references for adequate design and construction of guardrails are included in Appendix C of this volume.

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b. In urban areas the clear roadside principles established for rural roads are not as important on streets with low speed limits and concentrated roadside development. However, on many high-speed urban expressways, the same clear roadside principles should be followed to the extent feasible. Opportunities to set back trees and utility poles to provide a safer roadside environment on major urban facilities should not be overlooked.

c. The safety design of structures should include at least the following features.

(1) The Standard* sets several performance requirements for the design of bridge railings and parapets. In addition to the lateral stability of the railing structure, consideration should also be given to providing:

(a) Adequately attached approach guardrails or other roadside protective barriers to eliminate the vertical face obstruction so common on existing bridges and to provide a smooth and increasingly rigid transition between the semirigid approach barrier and rigid bridge railing or parapet to prevent pocketing of a vehicle between the structure and approach guardrail.

(b) Bridge widths consistent with approach roadway widths including shoulders.

(c) Continuous bridge deck, including a median barrier where appropriate, across openings between parallel bridges.

(2) Clear roadside and flat slope concepts should be considered when designing structures over a highway. Such consideration should include:

(a) The application of clear roadside principles at bridge overcrossings on divided highways, including slope transition on the abutment fills.

(b) The installation of protective barriers at piers or obstructions exposed to a probable collision with an out-of-control vehicle. If curbs are used for drainage, they should be positioned to maintain the effectiveness of the guardrail. In general, the face of the curb should not be located in front of guardrail where it may result in a dynamic jump by the vehicle before it strikes the barrier.

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*Highway Safety Program Standard 12 (Appendix A).

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7. EMERGENCY RESPONSE

a. The time it takes to get medical assistance to the scene of an accident, together with the time to transport the injured to hospitals, often will spell the difference between death and survival, or between permanent disabilities and quick, full recovery. Every highway system should therefore be designed, constructed, and maintained to provide for safe and prompt response to emergencies produced in crashes.

b. The capacity for emergency response on highways is important because of the large number of crashes occurring daily on highways. It is also important because highways must be used in virtually all emergency transportation for other reasons, such as heart attacks, births, injuries in the home, and fires. Every State and local government must therefore have a comprehensive program to assure that the highways are designed and maintained to expedite the capability to respond to all types of emergencies. Furthermore, this program must be carefully coordinated with the operations of the community emergency medical facilities, including ambulance services, hospital emergency rooms, and the communications network for command and control.

c. Therefore, the highway features of the emergency response program as described here must be part of a broader plan that includes the activities under the Standards on Emergency Medical Services and (Accident) Debris Hazard Control and Cleanup as described respectively in Volumes II and 16 of this Manual.

(1) Principal requirements.

The principal objectives that the highway system should meet in an effective overall emergency response program are: (1) communications to provide for notification of an accident and the need for emergency medical services, (2) access, to enable emergency vehicles to get to the accident scene quickly, and (3) directional signing, to indicate the route to the nearest hospital or first-aid station.

(a) Emergency communications.

1 Roadside telephones (wire or radio) or other forms of call boxes should be provided where an evaluation of environmental conditions indicates their presence would contribute to the reduction of highway crashes or the resultant damage therefrom.

2 The frequency of such installations should consider such factors as:

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a Type of highway.

b Traffic volume.

c Frequency of police and maintenance patrols and the nature of the surrounding area and availability of commercial facilities.

3 The location of emergency telephones should be adequately identified by signs and on maps issued by the State highway agency.

4 Continuous availability of communications facilities should be assured by a thorough program of inspection and maintenance, including periodic checks to assure that all are in proper working order.

5 The corollary benefits of these communication aids for other traffic benefits should be recognized in evaluating their benefits.

(b) Ease of access.

1 Every point in a highway system should be considered as the site of a possible accident, requiring emergency vehicles to reach the location quickly and thence travel to hospitals, or other medical facility. Provisions for entrance and exit of emergency vehicles accordingly must be included in the highway system.

2 Access to freeways and other limited access highways should be considered at points between interchanges where such access would significantly reduce emergency travel time. Positive control of these access points to preclude unauthorized use is vital to the safe operation of the highway.

a Care must be taken to ensure that access points are consistent with good freeway design and do not create undue hazards to other motorists on the freeway.

b The location of freeway access points for emergency vehicles should be coordinated with the comprehensive plan for emergency-medical services.

3 Wherever the width of the right-of-way is adequate, provisions should be made for movement of emergency vehicles, either on the shoulders or in the median.

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4 Although median crossovers present serious operational problems, sometimes they may be needed to expedite postcrash operations. A complete and thorough analysis of all pertinent factors should precede the construction of such crossovers. Among the many factors to be considered are traffic volume, location of emergency facilities, location of maintenance crossovers, spacing of interchanges, and so on. Local police officials, hospitals, and ambulance service operators should be consulted in the planning stages. Such crossovers should not be installed unless savings in response time and other postcrash advantages offset the operational problems they create.

(c) Hospital Guide Signs.

1 Guide signs should be strategically placed to direct motorists and ambulance drivers to the most expeditious route to Class I and Class II* emergency medical facilities.

2 The signs should be easily recognizable, and developed in conformance with general guides described in the Manual on Uniform Traffic Control Devices for Streets and Highways.

3 The signs should be installed to provide continuous identification of the route to emergency facilities. Signing of emergency routes should follow consistent standards on freeways and surface streets.

(2) Program Plan.

(a) The response features of the emergency plan as it relates to highways should be organized in a comprehensive overall plan.

(b) The plan should make specific provisions for all types of roads in all jurisdictions to function as an integrated, unified network.

(c) The emergency routes over the street and highway network should be planned for close correlation with spatial distribution of emergency medical facilities in the region.

(d) Plans for future expansion of the street and highway network should be closely coordinated with plans for future expansion of medical facilities in the region. Conversely, medical facilities also should be located so as to increase their accessibility to principal emergency routes on the highways.

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*See Highway Safety Program Manual Volume 11, Emergency Medical Services for a description of Class I and Class II emergency medical facilities.

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(3) Appraisal.

(a) Every State and local community should have a program to inventory the emergency response capability of its street and highway system, to assess its effectiveness, and to determine priorities for its improvement.

(b) The effectiveness of the system should be periodically re-evaluated.

8. MAINTENANCE

The relationship of safety to proper maintenance of the highway system and all of its features is indisputable. In order to provide for the safe and efficient movement of traffic,it is absolutely essential that all aspects of the road and right-of-way be maintained in a manner which will keep them at the highest reasonable level of safety and that there be continuing improvements consistent with the changing character of traffic that the facility serves. Every State and local agency, therefore, should have a program under which all streets and highways in all jurisdications are kept in a proper state of repair and safe working condition.

a. The major elements of a program to maintain existing facilities at a reasonable level of safety are:

(1) Clearing of debris from pavement surface, shoulder, and drainage facilities.

(2) Trimming of vegetation.

(3) Crash debris removal.

(4) Proper placement of working or parked equipment.

(5) Traffic control device location and state of repair.

(6) Traffic operations at work sites.

(7) Correction of hazards caused by weather conditions, such as snow removal, flooding or pavement "blow ups."

(8) Correction of slippery and other hazardous pavement conditions such as pot holes and low shoulders.

b. An important corollary aspect of a maintenance program is to establish and enforce procedures that ensure that the maintenance work will be conducted in a safe manner:

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(1) To protect the motoring public.

(2) To protect the workman.

c. The maintenance program should be conducted according to a routine schedule or plan:

(1) The plan should include such features as the regular clearing of debris from the pavement surfaces and shoulders and the trimming of vegetation to provide clear sight distances and removal of excessively large vegetation to provide traversable driver- control recovery areas.

(2) Pavement surfaces and shoulders should be maintained on a regularly scheduled basis to prevent hazards created by deterioration of roadway surfaces, erosion of shoulders, edge dropoffs, etc.

(3) Bridge structures should be inspected to assure that structural deterioration is not affecting the structural integrity of the bridge.

d. Maintenance programs should include emergency procedures for debris removal and roadway repair caused by traffic accidents or storm damage.*

e. The surveillance concepts presented in Volume 9 of this Manual should be used on maintenance projects to identify the existence of potential hazards. In addition, such items as parking of equipment and vehicles in a position exposed to an out-of-control vehicle, inadequate or missing traffic control and protective devices, and other deficient features should be corrected immediately.

f. Procedures should be established, if they are not presently used, for a plan of operation to repair and correct crash-damage highway safety features and to perform temporary repairs on an emergency basis to damaged highway features that may create a hazard to the traveling public.

g. Careful documentation and analysis of crash-damaged highway appurtenances should be a feature of any maintenance program.

(1) Fixed objects which are struck by vehicles should be surveyed to determine if they are contributing to highway crashes, and, if so, whether they can be relocated or redesigned to reduce both crash frequency and severity.

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*Vol. 16, Debris Hazard Control and Cleanup

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(2) Highway appurtenances that are repeatedly damaged by vehicles should not be repaired without corrective action to reduce both hazards to the road user and frequency of maintenance.

(3) An analysis should be made of every feature involved in a collision to determine whether it is needed, whether it can be put in a better location, and whether its energy absorption properties on impact can be improved by breakaway or yielding provisions.

h. There should be a systematic schedule or plan for preventive maintenance of highway appurtenances, such as traffic control devices, highway lighting, guardrails, and other safety devices.*

i. A Manual on maintenance operations should be developed to aid in all maintenance operations at all levels of government. The appropriate sections of the Manual on Uniform Traffic Control Devices for Streets and Highways should be used as a guide in developing this material.

j. The maintenance program should include provisions to remove all signs, markings, and other control devices when they are no longer applicable. This is necessary in order to create and maintain respect for traffic control devices that are required for safe operations.

k. There should be an established procedure for notifying the public and operations personnel of the possibility of weather conditions which may create unsafe road conditions and for alerting and assembling the snow removal force.

l. There should be a comprehensive plan for coordinating snow removal and the application of corrective materials on continuous road systems between adjacent jurisdictions. The plan should also establish priority routes for snow removal to ensure that the more important roadways are safe for traffic as soon as practicable.

m. There should be continuing inspection of the road system for the detection of unsafe conditions and a procedure for dispatching equipment to hazardous locations on a priority basis. Surveillance operations should be active not only during an actual snow or ice storm but also immediately after roads are cleared to detect unforeseen hazards such as patches of ice on the roadway.

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*For information regarding the maintenance of traffic control devices, see Vol. 13, Traffic Control Devices.

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n. There should be a method of advising motorists of and correcting road surfaces known to become hazardous before normal roadway condition deteriorates, such as icy bridge decks. In addition, these locations should be given special attention by maintenance personnel to minimize the danger to the motoring public.

9. WORK SITE SAFETY

Sites where construction or maintenance is in progress can be very hazardous. Serious safety problems of traffic movement occur when traffic must move through or around road construction and maintenance operations. Because of the temporary nature of these operations, which rarely follow the normal pattern of operations, the possibility of an accident is much greater than under normal highway conditions. Such situations therefore require special attention.

a. Each State and local agency having responsibility for construction, maintenance, and safe operation of streets and highways within its jurisdiction should have a program to assure that appropriate actions are taken to protect passing motorists, as well as highway workers, from accident involvement during the course of construction and maintenance operations.

(1) The program should apply to all construction and maintenance situations:

(a) On high-speed thoroughfares as well as on minor low-speed subdivision streets.

(b) Nonroutine construction and maintenance of streets as well as routine daily operations.

(2) A comparable program should apply to all other disruptions of normal traffic patterns such as those caused by:

(a) Utility operations.

(b) Building construction by private or government contractors.

(3) The program as a minimum should assure that adequate advance warning, guidance, and regulation of traffic is provided to the motoring public:

(a) In approaching and passing the site.

(b) In traveling over detours around the site.

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(4) No one pattern of traffic alinement, design speed, or sequence of signs or control devices can be established to satisfy all of these situations. Therefore, a range of requirements from the simplest caution sign to a positive barricade must be considered to minimize the hazard(s) of each situation.

(5) Particular attention should be directed to construction site safety at night or any other time when no work is going on.

(6) Minimum standards of safety should be established for detours or other temporary conditions.

(a) If it is economically feasible to do so, temporary roadways should be provided with alinement and surfacing consistent with the quality of the road which has just been traveled by the motorist.

(b) As soon as it is dark on the first day that a detour is opened to traffic, and periodically during extended construction, an inspection should be made of the entire detour to make sure that warning devices are properly visible and to identify hazards of nighttime operation.

(c) Practices such as parking of equipment and vehicles in a position exposed to an out-of-control vehicle, inadequate or missing traffic control devices, and other deficient features should not be permitted.

(7) Throughout the course of construction, field surveillance and other inspections should continously be conducted to assure that proper levels of safety are being maintained.

(8) Consultation with police traffic authorities should become a routine activity in setting up maintenance of traffic procedures for construction and reconstruction.

(9) Procedures should be developed to expedite the completion of all highway construction and maintenance operations, utility repairs, building construction, or other "temporary" situations causing serious and hazardous disruptions of traffic. The possible savings in construction cost attained by long contract periods should be weighed against the increased hazards and the costs thereof which result from the longer periods during which traffic is subjected to abnormal situations.

(10) Where feasible, construction and maintenance operations should be limited to off-peak hours on high volume roadways. Peak hour restrictions on road work activities can materially reduce traffic congestion and its associated hazards. Savings in construction costs should not be the only criteria for determing project sequencing. These costs must be weighted against the increased delay and hazard created by interrupting the safe flow of traffic.

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(11) It is suggested that in order to assure the implementation of proper safety measures during the course of construction, the timely completion of the work, and the early restoration of normal traffic operations, appropriate guarantees be required:

(a) In all contracts and plans for highway construction and maintenance work.

(b) Prior to issuance of highway encroachment permits to utility or other repair groups.

(c) Prior to issuance of building permits to contractors in residential or commercial construction.

b. Each State in cooperation with its local subdivisions should develop a Manual or other materials to serve as a guide for implementing adequate levels of construction site safety.

(1) It is suggested that such a Manual be developed around the principles outlined in the Manual on Uniform Traffic Control Devices for Streets and Highways.

(2) Provisions should be made to distribute the Manual to all local government agencies, utility companies, and highway and building contractors.

10. RAIL-HIGHWAY GRADE CROSSINGS

The inherent danger in rail-highway crossings at grade can be fully removed only by replacing them with full grade separations. Such capital improvements are very costly and, while a desirable national goal might be to eliminate all grade crossings, only comparatively small numbers of such improvements are possible with available resources. This necessitates other less costly solutions which can be effective, although not to the same degree as afforded by full grade separation.

a. Each State should have a comprehensive program designed to provide and maintain adequate levels of safety at all rail-highway grade crossings, coupled with a plan for progressive improvements of the most hazardous of these.

(1) An inventory should be established and maintained of all rail-highway grade crossings in the State. In addition to the precise location and past accident experience at each crossing, the inventory should include a complete record of all critical elements such as sight distance, type of protection, average daily highway traffic, average daily train traffic, and the horizontal and vertical alinement of the roadway approaches to the crossings, the number of tracks, number of highway lanes, angle of crossing, speed of trains and vehicles, volume of trucks and school buses.

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(2) The inventory should further include a record of all conditions that increase the hazard at each site. Some examples are:

(a) Fixed objects in the vicinity of the crossing.

(b) Rough crossings which are not in character with adjacent segments of the highway or street.

(c) Inadequate warning devices at the crossing.

(d) Inadequate sight distance.

(e) Sharp horizontal and vertical curves in the roadway.

(f) Roadway surface characteristics which adversely affect stopping or starting after a stop.

(3) A detailed analysis should be made of alternative types of improvements that are most suitable for the prevailing conditions at each site. For example, alternative improvements such as increasing sight distance, highway lighting, flashing lights and gates, or grade separation could all produce benefits worth considering.

(4) Crossings with comparatively low volumes of vehicle or train movements should not be treated lightly, for records indicate that these account for substantial percentages of all accidents at grade crossings, in part because of the large number of low volume crossings.

(5) Procedures for the assignment of priorities should be developed around estimated costs of improvements and reductions in deaths and injuries that a particular type of improvement will produce:

(a) An expenditure on a number of comparatively low cost improvements at several sites may yield more benefits than an equivalent expenditure on a major, costly improvement at a single site.

(b) The efficacy of resource allocations to temporary expedients should be weighed against the costs of permanent solutions.

(6) Particular attention should be directed to corollary benefits that a particular improvement will produce in addition to hazard reduction. Such benefits can provide a basis for arriving at equitable formulae for cost-sharing by government agencies at all levels and, in some situations, the railroad. Among these corollary benefits are:

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(a) Improved highway capacity at the crossing.

(b) Reduced delay to motorists at the crossing.

(c) Improved train schedules.

(7) Implementation of all priority improvements should be carefully programmed within available budgets.

b. The effectiveness of a State's overall program of rail-highway grade crossing safety depends on and requires positive action by the operating railroad companies. Cooperative working relationships between the highway agencies, the railroads and the State regulatory agencies are vital. Each State should therefore undertake cooperative programs with these groups to improve all rail-highway grade crossing safety by such activities on the part of the railroad as:

(1) Assuring that railroad signaling devices with adequate levels of performance and reliability are used.

(2) Assuring adequate levels of maintenance of these devices.

(3) Providing sufficient fail-safe redundancy in signaling and warning devices.

(4) Testing new and improved devices.

(5) Adjusting train schedules and switching operations to reduce as far as practicable the interference to heavy vehicular cross traffic.

(a) Reduce the number of switching operations at crossings with heavy traffic volumes.

(b) Limit the number of slow moving or stopped trains at grade crossings during the hours of darkness.

(c) Scheduling trains to minimize highway crossings during periods of peak hour vehicular traffic.

11. PEDESTRIAN SAFETY

Pedestrian safety should be provided by proper design, construction, and maintenance of highways. In planning to improve pedestrian safety, the principles

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of pedestrian safety as described in Volume 14* should be carefully observed. The primary consideration should be the likelihood of a pedestrian-vehicle conflict, bearing in mind that high hazards might prevail in all combinations of pedestrian movements and vehicular traffic. Examples of potentially high hazard situations are:

a. Heavy concentrations of pedestrians.

The streets and intersections near schools, churches, shopping centers, theaters, sports stadiums, and bus stops are the principal locations of high pedestrian concentrations and present the likelihood of vehicular conflicts.

b. Light concentrations of pedestrians.

(1) Neighborhood streets that are feeders to major arterials are high hazard locations even though pedestrian concentrations are light.

(2) All surburban and rural streets present the hazard associated with the unexpected encounter between the occasional vehicle and occasional pedestrian. Greater reliance must be placed upon the safety inherent in the design and maintenance of the highway in these situations than on any other countermeasure.

12. LAND DEVELOPMENT

When subdivisions and residential areas are developed or redeveloped, the new street system should be carefully designed to provide for pedestrian safety, coupled with safe and rapid movement of vehicle traffic.

a. Each level of government having zoning authority should adopt a zoning ordinance developed with the full cooperation of those agencies of that government having responsibility for roadway design, construction and maintenance. Within the guidelines of a comprehensive zoning ordinance, changes in land use of any type should be reviewed to determine the impact of subsequent development on safety to the public.

*Volume 14, Pedestrian Safety.

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b. The specific elements of land use design which should be reviewed are access and egress to the development, sight distance, traffic control, and elements of internal traffic circulation which could result in unsafe traffic operations from the site to the public streets or highways.

(1) Pedestrian and vehicle conflicts resulting from new development should be reduced to a minimum. Streets should be designed to provide a safe traffic environment for both pedestrians and motorists.

(a) Safety features, such as the physical separation of the pedestrian and vehicular traffic, adequate sidewalks and other street design features which provide for pedestrian traffic, should be considered in early planning phases of projects.

(b) Traffic circulation patterns should be developed specifically to minimize the intrusion of through traffic onto primarily local streets.

(c) Careful attention should be given to the development of traffic facilities that will be compatible with existing and planned adjacent land use. Traffic generators should provide adequate off-street parking facilities connecting with the street system at locations that will not produce undue hazards to the highway user.

(2) Design features for the development or redevelopment of residential subdivision streets should be consistent with the standards recommended by the Institute of Traffic Engineers.* Good design criteria should be followed with respect to sight distance, corner radii, approach grade, etc.

c. Implementation of this program requires cooperation between private individuals and corporations and one or more governmental agencies. To be effective, zoning ordinances and permit policies should be reviewed and improved where necessary to reflect safe principles of development. Those agencies which perform the site plan review function and which have zoning authority may find it desirable to obtain professional traffic engineering assistance in developing review guidelines that incorporate safety elements.

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*Recommended Practices for Subdivision Streets.

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13. TRAINING

All personnel with responsibilities in highway design, construction, and maintenance must be thoroughly familiar with those safety fundamentals that bear directly on their specific work. They also should have a working understanding of more general safety principles. States, accordingly, are encouraged to establish training programs to accomplish these goals.

a. All office personnel should be trained to include safety principles in all phases of planning and design.

b. All field personnel, professional engineers and technicians alike, should be able to identify hazards not recognized during the design phase but which become obvious during the course of construction and maintenance, such as the location and condition of utility poles, control devices, drainage structures, roadway slopes, shoulders, etc. They also should be trained in the use of equipment for identifying pavements with low skid resistance. The field personnel should further know how to initiate the elimination of these hazards. In those cases where improvements are accomplished by maintenance personnel, they should be trained to perform the work with minimum hazard to themselves and passing traffic.

c. Because of the vital importance of crash survivability concepts in highway design, construction, and maintenance, special training programs are strongly encouraged to assure that all personnel are thoroughly familiar with this aspect of highway engineering responsibilities for safety. Films depicting clear roadside concepts and the dynamic characteristics of vehicles impacting guardrails have been prepared by several organizations, and personnel should have an opportunity to view illustrations of all facets of clear roadsides, breakaway post features, guardrail design, and other crash survivability techniques.

d. Technician training in safety may be conducted in any accepted method ranging from vocational schools to on-the-job training courses.

e. The instruction for engineers may range in scope from single lectures, one-day meetings, or short courses of one to three weeks duration to full programs of graduate level study.

f. States are encouraged to assist local agencies in meeting their training requirements:

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(1) By making instruction available to employees of local agencies.

(2) By assisting local officials in organizing their own training programs.

g. Emergency assistance.

(1) Because maintenance forces are frequently the first to appear on the scene of an accident, all highway field personnel should be trained to summon aid in emergency situations. Training programs should include information on the extent and type of emergency facilities available, how the services can be summoned and proper use of emergency warning devices to provide maximum protection to the road user.

(2) First aid training is encouraged, particularly for maintenance personnel in remote areas.

(3) Training of crews may be programmed to begin with crews normally stationed on roads with high accident frequencies, on a district or subdistrict basis, or on a position classification basis depending on the organization of maintenance forces and the manner of their deployment over the system.

h. States and local agencies should require that supervisory employees of contractors be similarly trained and that this training be applied to work in process.

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HIGHWAY SAFETY PROGRAM MANUAL

VOLUME 12 Highway Design, Construction, and Maintenance	TRANSMITTAL 18
CHAPTER V. Program Evaluation	March 15, 1971

(HS-1)

Par. 1. Introduction
2. Evaluation Objectives
3. Evaluation Planning
4. Evaluation Procedure

1. INTRODUCTION

a. The highway design, construction, and maintenance program should be periodically evaluated to determine its effectiveness as measured against the requirements of the Standard and established State objectives.

b. Each State should define qualitative and quantitative measures to evaluate its progress in improving highway design, construction, and maintenance.

c. Based on this evaluation, the State should plan short-and long-range programs to improve highway design, construction, and maintenance and identify areas of needed research.

2. EVALUATION OBJECTIVES

a. Determine program status and progress made since the last evaluation.

b. Identify areas where program adjustment or additional emphasis is needed.

c. Determine areas which have a high payoff in terms of casualty reduction.

d. Optimize effort applied and make program administration more efficient.

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3. EVALUATION PLANNING

Prior to the implementation of a highway design, construction and maintenance program, certain steps should be taken to facilitate a comprehensive evaluation.

a. Short-and long-range goals to be met by the program should be established.

b. Where practical, a budget should be developed for each program area.

c. Procedures for performing the evaluation should be developed.

d. A determination should be made of what data will be required and measurement techniques developed.

e. Where available, pre-implementation data should be gathered for comparison with data gathered during evaluation.

f. An implementation schedule should be set for the program.

4. EVALUATION PROCEDURE

a. Qualitative measures.

(1) The State program should be measured against established objectives and the implementation schedule to determine progress made.

(2) The following questions may be helpful in making judgments as to the quality and value of the State highway design, construction, and maintenance program.

(a) Geometric design.

1 Are all standards and related working instructions adopted by State, county, and local agencies periodically reviewed and updated to reflect new technology?

2 Are the most current design standards relating to safety factors - e.g., sight distance, horizontal and vertical curvature, spacing of decision points, width of lanes - being incorporated in construction, reconstruction, and maintenance on all streets and highways by all jurisdictions?

3 Do design standards cover all aspects relating to safety?

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4 Are design criteria applied uniformly to the highway systems throughout the State?

(b) Pavement design and construction.

1 Are standards for skid resistance being incorporated in the design and construction of all new pavements in the State and local highway system?

2 Are periodic skid tests being conducted?

3 Are skid resistance data for pavement surfaces being recorded and analyzed?

(c) Pavement treatment for skid resistance.

1 Is there a program at the State and local levels for resurfacing or surface treating streets or highway locations where inadequate skid resistance contributes to high accident experience?

2 Is there a systematic plan for checking skid resistance at problem locations?

3 Is there a system for assigning priorities for temporary or permanent resurfacing of roadway segments with high skid-related crash experience?

(d) Roadway lighting.

1 Is adequate street lighting installed on all sections of roadways or intersections where severe night driving hazards may exist?

2 Is there a lighting improvement program at the State and local levels?

3 Has the need for lighting improvement been determined for at least the following:

a Expressways, major streets, and major highways?

b Junctions between expressways and major highways in rural areas?

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c Pedestrian crossings with high nighttime pedestrian volumes?

d Other areas such as tunnels, long underpasses, etc.?

4 Has the State developed methods for determining where new or improved lighting will produce significant reductions in crashes?

5 Are funds allocated to lighting improvements periodically reviewed to assure that maximum safety returns are being realized?

6 Are lighting needs analyzed during the design phase?

(e) Crash survivability.

1 Are provisions made on all expressways and high speed rural highways to remove fixed objects?

2 Have fixed objects along the roadside been designed and constructed to yield upon impact or absorb energy upon impact?

3 Are established performance standards for guardrails, bridge railings, and parapets being met in highway construction?

(f) Emergency response.

1 Is there a comprehensive program at State and local levels to assure that highways are designed and maintained to expedite the response to all types of emergencies?

2 Does this program provide for:

a Adequate communications for notification of an accident and the need for emergency medical services?

b Access to enable emergency vehicles to get to the accident scene quickly?

c Directional signing to indicate the route to nearest hospital or first aid station?

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3 Is there a program at State and local levels to identify the requirements of emergency vehicles on the existing street and highway system and to determine priorities for needed improvement?

(g) Maintenance.

1 Is there a comprehensive and continuing program at the State and local level for maintaining existing facilities to assure a high level of safety?

2 Does this program make provision for:

a Expeditious clearing of debris from pavement surface, shoulder, and drainage facilities?

b Trimming of vegetation?

c Crash debris removal? *

d Proper placement of working or parked equipment?

e Proper use of adequate traffic control devices by maintenance forces?

f Traffic operations at work sites?

g Correction of cold weather hazards such as snow and ice removal, etc.?

(h) Construction site safety.

1 Is there a program at the State and local level to assure that appropriate actions are taken to protect passing motorists and highway workers at construction sites?

2 Is adequate advance warning, guidance, and regulation of traffic provided to the motoring public at construction and maintenance sites and on detours?

3 Is adequate emphasis directed toward construction site safety at night and during nonworking hours?

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*See Volume 16, Debris Hazard Control and Cleanup.

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4 Are local police consulted in developing the traffic control plan?

5 Are minimum safety standards established for detours?

6 Does the State have a manual for implementing construction site safety?

(i) Rail-highway grade crossings.

1 Does the State have a program to provide and maintain adequate levels of safety at all rail-highway grade crossings?

2 Is there a plan for progressive improvement of the most hazardous crossings?

3 Is there an inventory established and maintained of all rail-highway grade crossings in the State?

4 Are detailed analyses made of alternative types of improvements possible at each site?

5 Are procedures established for the assignment of priorities for improving or eliminating rail-highway grade crossings?

6 Do cooperative, productive, working relationships exist with operating railroad companies?

(j) Land development.

1 When new residential areas are developed, does the new street system incorporate pedestrian safety into the design?

2 Are changes in land use reviewed to determine the impact of subsequent development on safety to the public?

3 Are traffic circulation patterns developed to minimize intrusion of through traffic onto local streets?

(k) Training.

1 Has a training program incorporating the materials in this Manual been implemented at State and local levels?

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2 Does the State assist local agencies in meeting training needs?

3 Are contractors required to provide relevant training to their employees?

b. Quantitative measures.

(1) Quantitative evaluation of the highway design, construction, and maintenance program involves primarily:

(a) Comparing crash frequency and severity rates on highways that have been designed, constructed, or maintained in accordance with the Standard and guidelines in this Manual with highways that have not.

(b) Comparing the crash frequency and severity rates on given sections of highway before and after application of maintenance and reconstruction practices called for by the program.

(2) The State should define specific quantitative measures to evaluate progress in each area comprising its highway design, construction, and maintenance program. The following are examples of quantitative measures that can be considered:

(a) Crash rates at given locations before and after roadway lighting improvements.

(b) Percentage of identified highway structural deficiencies corrected within one, two, three, etc., years of their identification.

(c) Response time of emergency vehicles arriving at crash sites before and after highway features are installed to expedite such response.

(d) Crash frequency and severity rates at construction sites before and after implementation of specific improvement programs aimed at this problem.

(e) Increased protection installed at "most hazardous" rail-highway grade crossings.

(3) The State and local governments should make cost-benefit analyses to identify relative payoffs in the various elements of this program.

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c. Identification of research areas.

(1) Based on an analysis of information available, the States should plan future research areas and indicate areas of information deficiencies.

(2) The research areas to be considered are the definitions of where, when, why, and how accidents occur and future preventive measures.

(3) Particular attention should be directed toward improving the data collection and reporting in those areas where existing data are inadequate or where information gaps presently exist.

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HIGHWAY SAFETY PROGRAM MANUAL

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CHAPTER VI. Reports	March 15, 1971

(HS-1)

Par. 1. Introduction
2. Program Evaluation Reports
3. Reports to Federal Highway Administration

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1. INTRODUCTION

Highway safety programs to reduce accidents or their severity should be evaluated to monitor progress against the program plan and to determine the effectiveness of accident-reducing measures. Operating personnel will require activity reports, summaries of accident location reports, and other reports for reducing hazards and supervising operations. Management will find special studies, as well as statistical summaries and classifications, essential in planning new tasks and manpower assignments, adopting new methods, allocating funds, and establishing policies.

2. PROGRAM EVALUATION REPORTS

Reports developed to justify program recommendations and to document program results include:

a. Intra-agency reports.

These are exchanges in information and experiences among highway design, traffic, construction and maintenance engineers. They provide the basis for agency management to justify and document project or program recommendations, to establish new programs, and to evaluate project or program accomplishments.

b. Inter-agency reports.

Effective administration of coordinated highway safety programs is greatly enhanced by a free exchange of information between the State and its local subdivisions in those matters of common interest. The results obtained in

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the evaluation of a particular safety improvement undertaken by one jurisdiction may be of significant value to another agency having the same problems. Many agencies presently prepare reports on a regular basis evaluating significant findings. These reports might easily be used to aid other jurisdictions facing similar problems.

c. Public information reports.

Highway safety programs are dependent upon an informed public. Therefore the following reports should be provided for general information:

(1) Individual program reports on needs, finances, and accomplishments.

(2) Reports to develop public understanding of specific hazard reduction activities through design, construction, and maintenance methods.

3. REPORTS TO FEDERAL HIGHWAY ADMINISTRATION

The Standard requires periodic summary information from the States to assist in an appraisal of the program. These reports should describe measures taken or programs developed including methods, cost, staffing, effectiveness, and recommendations for further action or modifications in future programs. The State should receive evaluation reports from all local units and should issue a summary report annually to local units and the FHWA which summarizes progress and effectiveness of the program. It is anticipated that these summary reports will contain information similar to that specified in paragraph 2 of this chapter.

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CHAPTER VII. Local Government Participation	March 15, 1971

(HS-1)

Par. 1. Responsibilities
2. Responsible Agencies
3. Description of Activities

1. RESPONSIBILITIES

Highway design, construction, and maintenance activities, for the purpose of crash reduction, apply to all categories of public ways and to all public agencies responsible therefor. The initial role of local government can be one of identifying problem areas where design improvements can reduce highway crashes. Having identified the problem areas, local authorities should develop accident countermeasures through local resources or, if not capable thereof, bring the information to the attention of responsible agencies. State guidelines should be sufficiently flexible to serve the needs of government units of all sizes. Finally, local units should have the capability and the responsibility for evaluating their own highway safety activities and providing reports and other information necessary for the management of the highway safety programs under their jurisdictions. Each local program should be coordinated with the Statewide highway safety plans.

2. RESPONSIBLE AGENCIES

The use of adequate standards for highway design, construction, and maintenance applies to local governments and other participants, as well as to the State government, including:

a. Counties (parishes).

b. Boroughs.

c. Cities.

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d. Townships.

e. Towns.

f. Villages.

g. Road authorities or boards.

h. Road districts.

i. Private individuals and corporations.

j. Toll road authorities.

3. DESCRIPTION OF ACTIVITIES

a. The technical areas of the program where primary participation is generally provided by local governments are:

(1) Maintenance.

(2) Lighting.

(3) Zoning, including redevelopment and development.

(4) Pedestrian protection.

(5) Emergency services.

b. Local participation in other areas can be effective even if the local agencies are not charged with explicit responsibilities. For example, local agencies frequently are given an opportunity to review planned improvements in their jurisdictions. Even though some local agencies may be unable to maintain a highly-trained engineering staff, their knowledge of local problems and insight into local safety and operations matters may provide valuable counsel in attaining the objectives of the improvement plan. Therefore, the involvement of local agencies is extremely beneficial to the program.

c. The value of local participation in programs carried out by the State and Federal Government can be enhanced even more by:

(1) Including local officials in training programs.

(2) Maintaining close liaison with local officials.

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(3) Keeping local officials advised on the status of projects in their respective areas.

(4) Including local officials on the mailing list of periodic summaries and evaluation reports of general program interest.

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APPENDIX A

Highway Safety Program Standard 4.4.12

HIGHWAY DESIGN, CONSTRUCTION, AND MAINTENANCE

Purpose

To assure: (a) that existing streets and highways are maintained in a condition that promotes safety, (b) that capital improvements either to modernize existing roads or to provide new facilities meet approved safety standards, and (c) that appropriate precautions are taken to protect passing motorists as well as highway workers from accident involvement at highway construction sites.

Standard

Every State, in cooperation with county and local governments, shall have a program of highway design, construction, and maintenance to improve highway safety.

I. The program shall provide, as a minimum that:

A. There are design standards relating to safety features such as sight distance, horizontal and vertical curvature, spacing of decision points, width of lanes, etc., for all new construction or reconstruction, at least on expressways, major streets and highways, and through streets and highways.

B. Street systems are designed to provide a safe traffic environment for pedestrians and motorists when subdivisions and residential areas are developed or redeveloped.

C. Roadway lighting is provided or upgraded on a priority basis at the following locations:

1. Expressways and other major arteries in urbanized areas.

2. Junctions of major highways in rural areas.

3. Locations or sections of streets and highways having high ratios of night-to-day motor vehicle and/or pedestrian accidents.

4. Tunnels and long underpasses.

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D. There are standards for pavement design and construction with specific provisions for high skid resistance qualities.

E. There is a program for resurfacing or other surface treatment with emphasis on correction of locations or sections of streets and highways with low skid resistance and high or potentially high accident rates susceptible to reduction by providing improved surfaces.

F. There is guidance, warning, and regulation of traffic approaching and traveling over construction or repair sites and detours.

G. There is a systematic identification and tabulation of all rail-highway grade crossings and a program for the elimination of hazards and dangerous crossings.

H. Roadways and the roadsides are maintained consistent with the design standards which are followed in construction to provide safe and efficient movement of traffic.

I. Hazards within the highway right-of-way are identified and corrected.

J. There are highway design and construction features wherever possible for accident prevention and survivability including at least the following:

1. Roadside clear of obstacles, with clear distance being determined on the basis of traffic volumes, prevailing speeds, and the nature of development along the street or highway.

2. Supports for traffic control devices and lighting that are designed to yield or break away under impact wherever appropriate.

3. Protective devices that afford maximum protection to the occupants of vehicles wherever fixed objects cannot reasonably be removed or designed to yield.

4. Bridge railings and parapets which are designed to minimize severity of impact, to retain the vehicle, to redirect the vehicle so that it will move parallel to the roadway, and to minimize danger to traffic below.

5. Guardrails, and other design features which protect people from out-of-control vehicles at locations of special hazard, such as playgrounds, schoolyards, and commercial areas.

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K. There is a postcrash program which includes at least the following:

1. Signs at freeway interchanges directing motorists to hospitals having emergency care capabilities.

2. Maintenance personnel trained in procedure for summoning aid, protecting others from hazards at accident sites, and removing debris.

3. Provisions for access and egress for emergency vehicles to freeway sections where this would significantly reduce travel time without reducing the safety benefits of access control.

II. This program shall be periodically evaluated by the State for its effectiveness in terms of reductions in accidents and their end results, and the National Highway Safety Bureau shall be provided with an evaluation summary.

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APPENDIX B

GLOSSARY OF DEFINITIONS

This glossary defines those terms whose meanings may be unclear in the context in which they are used. These definitions are meant to apply only to the usage of these terms in this volume.

Control of Access - The condition where the right of owners or occupants of abutting land or other persons to access, light, air, or view in connection with a highway is fully or partially controlled by public authority. Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct private driveway connection. Partial control of access means that the authority to control access is expected to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.

Divided Highway - A highway with separated roadways for traffic in opposite directions.

Expressway - A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at major intersections.

Freeway - An expressway with full control of access.

Highway, Street, or Road - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Hydroplaning - A condition where one or more tires of a moving vehicle are separated from the pavement by a film of water; usually due to a combination of depth of water, pavement surface texture, vehicle speed, tread pattern, tire condition and other factors.

Interchange - A system of interconnecting roadways in conjunction with one or more grade separations, providing for the movement of traffic between two or more roadways on different levels.

Intersection - The general area where two or more highways join or cross, within which are included the roadway and roadside facilities for traffic movements in that area.

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Local Street or Local Road - A street or road primarily for access to residential, business, or other abutting property.

Major Street or Major Highway - An arterial highway with intersections at grade and direct access to abutting property and on which geometric design and traffic control measures are used to expedite the safe movement of through traffic.

Median - The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Need - A deficiency which should be corrected in the interests of public safety.

Right-of-Way - A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to transportation purposes.

Roadside - A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside Control - The public regulation of the roadside to improve highway safety, expedite the free flow of traffic, safeguard present and future highway investment, conserve abutting property values, or preserve the attractiveness of the landscape.

Roadway - (General) The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways. (In construction specifications, the portion of a highway within limits of construction.)

Shoulder - The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use, and for lateral support of base and surface courses.

Skid Number - The coefficient of friction times 100 (100X) of a tire sliding on wet pavement when tested at 40 MPH with a two wheel skid trailer or equivalent device following the procedures outlined in ASTM E274-65T.

Standard - One of the 16 Highway Safety Program Standards promulgated by the Department of Transportation to implement the National Highway Safety Act of 1966, e.g., Appendix A is Standard 4.4.12, Highway Design, Construction and Maintenance.

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Through Street or Through Highway - Every highway or portion thereof on which vehicular traffic is given preferential right-of-way, and at the entrances to which vehicular traffic from intersecting highways is required by law to yield right-of-way to vehicles on such through highway in obedience to either a stop sign or yield sign.

Traffic Control Device - A sign, signal, marking or other device placed on or adjacent to a street or highway by authority of a public body or official having jurisdiction to regulate, warn, or guide traffic.

Volume - The number of vehicles passing a given point during a specified period of time.

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APPENDIX C

REFERENCES

The following is a selected list of recognized authoritative references which may be helpful in implementing the program specified in this volume. This list is not intended to be a bibliography of all documents available in this field. Where design values on a specific item differ between references, the values that provide the road user with the greatest practical factor of safety should be used.

Publications of the American Association of
State Highway Officials
341 National Press Building
Washington, D.C. 20004

A Design Guide for Local Roads and Streets - Rural - Part I (1970)

A Guide on Safety Rest Areas for the National System of Interstate and Defense Highways (1968)

A Guide for Accommodating Utilities on Highway Rights of Way (1970)

AASHO Informational Guide for Roadway Lighting (1969)

An Informational Guide on Fencing Controlled Access Highways (1967)

An Informational Guide on Services to Motorists on Interstate Highways (1961)

A Policy for the Accommodation of Utilities on Freeways (1969)

A Policy on Access Between Adjacent Railroads and Interstate Highways (1960)

A Policy on Design Standards for the Interstate System (1967)

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A Policy on Geometric Design of Rural Highways (1965)

A Policy on Locating Police Stations and Maintenance Yards Serving Interstate Highways (1959

A Policy on U-Turn Median Openings on Freeways (1960)

Geometric Design Standards for Highways Other Than Freeways (1969)

Highway Design and Operational Practices Related to Highway Safety (1969)

American Standard Practice for Roadway Lighting (1962). Illuminating Engineering Society, 345 East 47th Street, New York, New York 10017. For roadways and expressways (except freeways and tunnels).

Factors Influencing Safety At Highway - Rail Grade Crossings (1968). National Cooperative Highway Research Program Report No. 50, Highway Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Geometric Design, Barrier Rails, and Sign Supports (1967). Highway Research Record No. 152, Highway Research Board, 2101 Constitution Avenue, N.W. Washington, D.C. 20418.

Geometric Design of Barrier Rails (1965). Highway Research Record No. 83, Highway Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Guardrails, Barriers, and Sign Supports (1967). Highway Research Record No. 174, Highway Research Board, 2101 Constitution Avenue, N. W., Washington, D. C. 20418.

Handbook of Safe Highway Design and Operating Practices (1968). Federal Highway Administration, Washington, D.C. 20591.

Location, Selection, and Maintenance of Highway Guardrails and Median Barriers (1968). National Cooperative Highway Research Program Report No. 54, Highway Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Manual on Uniform Traffic Control Devices for Streets and Highways (1961). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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Measuring Road Surface Slipperiness, Special Technical Publication No. 366, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Recommended Practices for Subdivision Streets (1967). Institute of Traffic Engineers, 2029 K Street, N. W., Washington, D. C. 20006.

State of the Art of Rigid Pavement Design, Research on Skid Resistance Pavement Surface Evaluation (1968). Highway Research Board Special Report No. 95, Highway Research Board, 2101 Constitution Avenue, N. W., Washington, D.C. 20418.

Tentative Method of Test for Skid Resistance of Highway Pavements Using a Two-Wheel Trailer, American Society for Testing and Materials, Standard E274-65T, 1916 Race Street, Philadelphia, Pennsylvania 19103.

Tentative Skid Resistance Requirements for Main Rural Highways (1967). National Cooperative Highway Research Program Report No. 37, Highway Research Board, 2101 Constitution Avenue, N.W., Washington, D. C. 20418.

Traffic Control and Roadway Elements - Their Relationship to Highway Safety (1968). Automotive Safety Foundation, 1200 - 18th Street, N. W. Washington, D. C. 20036

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APPENDIX D

REPRESENTATIVE PROJECTS

The importance of proper engineering and operational considerations has long been recognized by the highway engineer. For many years, the engineering community has developed and maintained design and construction policies to provide guidance to political subdivisions in preparing adequate highway designs. One of the benefits of deep involvement in highway design is an early indication of areas which, for any reason, may be potentially inadequate for future traffic requirements.

States and local subdivisions are encouraged to define specific problem areas involving safety aspects of highway design, construction, and maintenance and to take aggressive action for initiating development and demonstration projects to determine methods of improving safety conditions in these problem areas. Examples of typical projects which may be undertaken are listed below.

1. Typical Projects

Almost any one of the present design, construction, or maintenance policies may be an appropriate subject for safety study and analysis. This is also particularly true of presently used items of hardware. Typical topics for safety evaluation and improvements are listed below:

a. Develop highway design details to improve safety.

(1) Shoulder width.

(2) Pavement width.

(3) Cut and filled slopes.

(4) Guardrail placement and/or attachment.

(5) Design features related to operating speed.

(6) Bridge width.

(7) Fixed objects removed or motorists protected from such objects.

(8) Antiskid pavements.

(9) Trees replaced with shrubs.

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b. Develop methods to provide skid resistant surfaces on existing roads.

c. Develop methods to improve safety of traffic and workmen at points where work in the street or highway must be undertaken.

(1) Sign design and placement.

(2) Flagman training.

(3) Detour selection and designation.

(4) Other temporary measures.

d. Develop programs for improvement of street lighting at:

(1) Intersections and interchanges.

(2) Pedestrian crossing points.

(3) Tunnels and underpasses.

e. Develop programs for improvement of railroad-grade crossing protection including such factors as:

(1) Inventories.

(2) Elimination of vision obstructions.

(3) Warning devices based on vehicle volume and speed.

(4) Priority listing of improvements.

2. Representative Project

An outstanding example of a specific project undertaken to increase engineering, construction, and maintenance staff awareness of the safety considerations involved in highway design has been undertaken by one State. It is summarized below.

a. Project Description

(1) A small review committee in each District of the State Highway Department reviews projects in its District for safety features.

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(2) A 12-hour course of instruction was conducted for approximately 2,500 employees throughout the State to emphasize the importance of proper design and location of bridge rails, guardrails, curbs, signs, lights drainage facilities, and side slopes to increase safety.

b. Significance

(1) Of total accidents occurring on the State's highways, 30 percent are single vehicle accidents involving primarily vehicles striking fixed objects or overturning along the roadsides.

(2) The design and construction of highways require such things as bridges, guardrails, curbs, signs, lights, drainage facilities, side slopes, landscaping, etc., and while their design and placement are generally governed by manuals and letters of instruction, the latitude permitted in exact design and placement requires independent judgment on the part of the personnel involved.

(3) This particular course of instruction discussed and illustrated the results of past design and emphasized considerations which can be implemented to minimize potential hazards, reduce the number of accidents, and reduce the severity of those accidents which do occur. A course of this type is much more effective in teaching correct principles and techniques to improve highway safety than revisions of manuals and letters of instruction.

(4) This course of instruction is also being summarized in a "packaged" presentation which will be obtained and used by city and county jurisdictions.

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APPENDIX E

RESOURCE ORGANIZATIONS

Listed below are national organizations which conduct tests and research programs, convert accumulated data to design, construction and maintenance criteria, and have general policies for particular portions of this Standard.

American Association of State Highway Officials (AASHO)
341 National Press Building
Washington, D. C. 20004

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103

Federal Highway Administration (FHWA) and/or
National Highway Traffic Safety Administration (NHTSA)
Washington, D. C. 20591

Highway Research Board (HRB)
2101 Constitution Avenue, N. W.
Washington, D. C. 20418

Illuminating Engineering Society (IES)
345 East 47th Street
New York, New York 10017

Institute for Municipal Engineering (IME)
(American Public Works Association)
1313 East 60th Street
Chicago, Illinois 60637

Institute of Traffic Engineers (ITE)
2029 K Street, N. W.
Washington, D. C. 20006

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