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Publication of this paper sponsored by Committee on Geometric Design.

Survey of States' R-R-R Practices and Safety Considerations

JOHN M. MASON, JR., and HARRY C. PETERSEN

ABSTRACT

A survey was conducted of resurfacing, restoration, and rehabilitation (R-R-R) type programs throughout the United States. R-R-R practices of state highway departments were solicited, with emphasis on seeking cost-effective designs that maintained acceptable levels of safety and serviceability. The reported R-R-R actions by various states are summarized, and the primary rulings on R-R-R design standards are briefly discussed. A philosophy tailored toward maximum mileage standards, accompanied by the application of value engineering, forms the basis of many R-R-R state policies. In every case, safety was found to be of primary concern. Three general philosophies appear applicable based on this R-R-R review: (a) rehabilitation to standards below full AASHTO new construction standards, and correcting major defects but maximizing the number of miles of highway treated; (b) reconstruction to full AASHTO standards only, for greater safety on fewer miles of roads; and (c) full funding for all projects as an ideal. Preliminary safety studies are reviewed, and guidelines are presented for maximum mileage rehabilitation projects drawn from the state surveys.

Under a recent contract with the Auditor General's Office, State of Arizona, the Texas Transportation Institute (TTI) had the opportunity to survey resurfacing, restoration, and rehabilitation (R-R-R) type programs throughout the United States. The objective of the study was to provide a summary of R-R-R practices reported by state highway departments. Emphasis was placed on seeking cost-effective designs that maintained acceptable levels of safety and serviceability. The reported R-R-R actions by various states are summarized, and the primary rulings on R-R-R design standards are briefly discussed. A philosophy tailored toward maximum mileage standards, accompanied by the application of value engineering, appears to form the basis of future R-R-R state policies.

SUMMARY OF R-R-R ACTIONS

State highway departments were contacted by telephone regarding the implementation and results of R-R-R design features. Forty-one of the states responded that they regularly employ some type of R-R-R design. Although many of these states use some or all of the guidelines published in the Geometric Design for Resurfacing, Restoration, and Rehabilitation (R-R-R) of Highways and Streets (1), several states use R-R-R type actions that are not specifically enumerated in the guide.

The purpose in synthesizing information on R-R-R practices was to provide a reference source for future consideration by the Arizona Department of Transportation. Specific actions reported here were selected because the information was either not detailed or addressed in the R-R-R guide. The presentation that follows reflects the interpretations of the conversations and correspondence that the researchers had with representatives of various state agencies.

Although all states responded to the survey, the states listed in Table 1 provided the researchers with particular information on special R-R-R programs in the state. Their responses were grouped to isolate commonalities and type of project work. Each state indicated that safety considerations were

TABLE 1 Summary of State Special R-R-R Responses

STATE	SHOULDER LANE & WIDTH AND/OR PAVEMENT	4:1 OR STEEPER SIDE SLOPES	BRIDGE/ GUARDRAIL	ENVIRON-MENTAL IMPACT-SPECIAL
CALIFORNIA	*		*	
COLORADO	*	*	*	
IDAHO °	*			*
ILLINOIS	*			
IOWA	*	*	*	
MISSISSIPPI	*		*	
NEW MEXICO		*		
NORTH DAKOTA		*		
OKLAHOMA		*		
SOUTH DAKOTA		*	*	
VERMONT			*	
WASHINGTON				*
WYOMING	*			

NOTE: ALL STATES INCLUDE SAFETY CONSIDERATIONS

° IDAHO ALSO USES STAGE CONSTRUCTION

indeed a fundamental concern of R-R-R improvements. A brief synopsis of each state's practices follow; each is concise and highlights the primary contribution.

Alabama

Alabama follows the basic premise that R-R-R projects should be directed toward increasing safety. The Design Bureau of the Alabama Highway Department stated that "the most significant two features that could be constructed into the R-R-R program that would aid in the safe movement of motorists is the widening of pavements to 24 feet and resurfacing." They make sure to consider high accident potential, as well as current and past accident history, when planning R-R-R project standards. They will consider projects other than widening or resurfacing based on "volumes or capacities or accident experience. Major cost items, such as extensive shoulder work and bridge replacement, will not be considered for R-R-R work."

California

California allows shoulder and bridge width deviations on a case-by-case basis. The current philosophy of the California Department of Transportation toward R-R-R type projects is to fix but not upgrade such projects. They have completed a preliminary safety study that suggests that (a) widening 24-ft pavements to 28 ft has little effect, but at higher average daily traffic (ADT) counts, safety may be improved by widening to 32 ft or even to 40 ft, and (b) a central passing lane on 40-ft or wider roads can reduce accidents (2).

Colorado

Colorado has instituted a number of R-R-R type design standards and guidelines. They have eliminated the requirement for a 2-ft guardrail offset from shoulder edge for rehabilitation projects when the shoulder is wider than 6 ft. [This recommendation was derived from the AASHTO Highway Design and Operational Practices Related to Highway Safety (3).] Other principal savings are expected to come primarily from reductions of bridge widths that, for example, would have resulted in estimated cost savings of approximately $600,000 over 48 projects in 1976 had these reduced standards been in effect.

Based on projected 20-year design hourly volume (DHV) at service level C, new nomographs have been developed for design standards that involve

1. Improving two-lane highways to four lanes,
2. Improving low-type two-lane highways to high type,
3. Overlaying two-lane highways, and
4. Overlaying four-lane highways.

New traffic volume cutoffs and width effects were involved in the development of these nomographs. Benefits are expected to include cost savings and completion of construction in direct relation to needed improvements.

Colorado allows the use of partly paved shoulders (4-ft paved and 4-ft gravel versus 8-ft fully paved), which is estimated to save approximately $6,000 per mile in asphaltic concrete. Front slope widths beyond the shoulder have been reduced, and fill and cut slopes are as given in Table 2. Savings from these changes in front slope distances and fill slopes were expected to have reached $1.2 million in 1976-1977 (4).

TABLE 2 Colorado Front Slope Requirements

FILL HEIGHT	TOPOGRAPHY					
	PLAINS		ROLLING		MOUNTAINOUS	
4+ LANES & 2 LANES	4 + LANES	2 LANES	4 + LANES	2 LANES	4 + LANES	2 LANES
< 4′	6:1	4:1	4:1	4:1	4:1	4:1
< 10′	4:1	4:1	4:1	4:1	4:1	3:1
< 15′	4:1	4:1	3:1	3:1	3:1	3:1
> 15′	3:1	2:1	3:1	2:1	3:1	2:1

Idaho

Idaho will consider a reduction of rehabilitation design highway widths through environmentally sensitive areas, but these design widths will not be reduced below R-R-R minimums published in the 1977 AASHTO guide (1). The environmentally sensitive areas consist of national forests, national recreation areas, river canyons, and so forth (5).

Illinois

The special R-R-R type actions in Illinois include elimination of the requirement for gravel stabilization of shoulders for highways with an ADT less than 5,000. Minimum pavement widening requirements have been reduced by 2 ft from previous design resurfacing widths for minor roads with few trucks. The

Illinois Department of Transportation uses closer lateral clearances and a waiver of 3 in. of minimum resurfacing thickness for ADT less than 5,000 to reduce costs. For resurfacing, the following provisions apply.

1. The requirement for a 3-in. minimum resurfacing thickness is waived for all resurfacing projects with a current ADT of 5,000 or less. For these projects, a 2-in. resurfacing should be used unless a field analysis indicates the pavement has deteriorated to the extent that additional resurfacing is necessary to ensure a reasonable service life.
2. For resurfacing projects of 24-ft pavements, the 18-in. bituminous shoulder strip should be omitted. The edge striping should be placed 6 in. from the edge of pavement. This will provide some clearance to the shoulder edge to minimize drop-off.
3. For resurfacing 22-ft pavements, 12-in. bituminous shoulder strips (rather than 18 in.) should be used. The 12-in. shoulder strip can be omitted if truck volume is minimal (6).

Iowa

The minimum rehabilitation design shoulder widths in Iowa are 8 ft, and shoulders may now be earth instead of stabilized. Other minimum standards for rehabilitation projects involve narrower bridges (widths of 44 ft may now be reduced to 40, 36, and 30 ft, depending on conditions), steeper foreslopes (the previously required 6:1 slope has been reduced to 4:1, 3:1, and even 2:1 for lower-volume highways), and narrower minimum lane design width requirements (12-ft minimum has been reduced to 11 ft) (7).

Maine

Maine reported the use of a 0.625-in. hot bituminous skinny mix that costs approximately $10,000 per mile (applicable to about 70 percent of their highway system), 0.75-in. bituminous concrete overlays that cost an estimated $20,000 per mile, and use of the existing base where possible to save on costs. (This information was provided by the State of Maine Department of Transportation.)

Minnesota

Minnesota has developed its own set of four-tier standards for two-lane rural highways. Tiers II and III were approved as geometric design standards for R-R-R projects for rural two-lane trunk highways (8).

Tier I design standards "will be used when elimination of the critical deficiencies require new construction or major reconstruction."

For tier II design standards: "Improvements to an existing highway will be designed to Tier II Standards when (1) all or most of the existing pavement structure is incorporated into the improved highway, and (2) except when the existing right-of-way is unusually narrow, construction is usually confined within the existing right-of-way. These standards are lower than Tier I Standards but will permit improvements to more mileage of existing highways."

For tier III design standards: "Improvements to an existing highway to bring it up to a minimum acceptable condition will be designed to Tier III Standards when (1) all or almost all of the existing pavement structure is incorporated into the finished project and (2) construction is usually confined within the existing ditches except, for example, where flattening of backslopes is required to eliminate 'snow traps.' These projects have the lowest minimum standards but will prolong the life of existing highways until sufficient funds become available to finance a more extensive improvement to the highway.... Projects consisting of a resurfacing of the existing pavement together with work on the shoulders to bring them up flush with the finished surface are frequently designed to Tier III Standards."

Finally, for tier IV design standards: "In some instances we may not be able to immediately finance the appropriate improvement to a highway, or we are unable to quickly resolve social, economic, or environmental concerns associated with the appropriate improvement. If the pavement has deteriorated to the extent that immediate resurfacing is essential to eliminate an unsafe condition or to prevent imminent loss of the pavement structure, a critical resurfacing project designed to Tier IV Standards will be permitted. Because this type of project is an extraordinary maintenance operation, there are no minimum standards. Usually the project will also require some construction on the shoulders to bring them flush with the new pavement surface. The projects normally are not eligible for Federal aid."

Minnesota has completed a statewide highway accident evaluation study on two-lane, rural trunk highways that concluded that R-R-R type standards had no statistical correlation of accident rates to ADT, shoulder type, and lane width. Present worths of estimated accident costs versus savings of other R-R-R measures would not justify additional extensive expenditures to reconstruct to new standards (9).

Mississippi

Mississippi has developed design guidelines for R-R-R projects (10). Among the special actions included in this guide is an R-R-R project design speed that "should be the average running speed plus ten percent (10%). Arterials that have obvious 'street-like' characteristics, operationally and physically, do not require a design speed determination. It is not intended that elaborate speed studies be conducted for R-R-R projects. A few simple representative measurements will be adequate."

Minimum widths include 8-ft-wide parking lanes and 9-ft minimum width lanes on one-way streets if a 1-ft curb offset is used or if trucks and buses are prohibited. Minimum surfacing and roadway widths are given in Table 3.

Nebraska

Nebraska reported that they use value engineering teams to do R-R-R type work on a case-by-case basis. In a telephone conversation, the staff at the Nebraska Department of Roads stated that their experience indicates that value engineering is beneficial in reviewing R-R-R projects.

New Mexico

The R-R-R standards in New Mexico apply to two-lane rural highways and "puts emphasis on improved riding quality and safety" (11). The R-R-R costs are estimated to be one-third to one-half of that required for full reconstruction. They recommend R-R-R projects that will consist of wider resurface and overlay sections or paved top width (usually by

TABLE 3 Minimum Roadway and Surfacing Widths for Two-Lane, Two-Way Rural R-R-R Projects in Mississippi

CURRENT TRAFFIC (ADT)	DESIGN SPEED (MPH)	WIDTH (FEET)			
		10% OR MORE TRUCKS		LESS THAN 10% TRUCKS	
		ROADWAY	SURFACING	ROADWAY	SURFACING
1 - 400	ALL	24	20	24	20
401 - 4000	50 OR LESS	26	22	24	20
" "	OVER 50	30	24	28	22
OVER 4000	ALL	32	24	30	22

adding shoulders), combined with improved skid resistance and safety.

"To insure adequate pavement structure, each R-R-R project will be analyzed based on 10-year and 20-year projected traffic volumes. Wherever possible, a 10-year minimum design will be used. Stage construction specifying future overlay will be permitted" (11).

Vermont

Vermont's approach to R-R-R, as outlined in a letter from the State of Vermont Agency of Transportation, is "to bridge the gap in scope between routine maintenance and full reconstruction of nonfreeway facilities. Such projects are intended to extend the service life and restore the structural or functional adequacy of the existing facility in a mannor conducive to safety, durability, and economy of maintenance." In order to qualify for R-R-R, the project must comply with, or contain design features that will eliminate noncompliance with, the following:

1. Roadway width must be within 10 ft of the applicable new construction standard,
2. Average running speed must be reasonably uniform and consistent with the remainder of the route segment,
3. Stopping-sight distances must be appropriate for the average running speed,
4. Accident rate must be below the statewide average for the class of highway,
5. No clustering of accidents will occur within the project site,
6. The highway has no structural deficiencies within the project site,
7. No reconstruction within the project site is contemplated within 10 years, and
8. The existing highway is functionally adequate and provides the capacity to meet foreseeable traffic demand.

Washington

Washington requires an environmental assessment of the effects of R-R-R projects to assure proper consideration of social, environmental, and economic effects (12).

Wisconsin

Wisconsin has incorporated R-R-R programs in their 6-year highway programs. They recycle and republish 6-year programs on a 2-year cycle. Their analysis begins by investigating the effects of three alternative funding levels (a recommended program, higher funding, and lower funding), and the trade-offs involved, including the trade-off of maximizing federal funding versus maximizing resurfacing objectives and trade-offs concerning energy and environmental impacts. State officials and the public can then choose the desired program, often combining portions of more than one funding level plan into the final program. Concern was expressed that, although the current program will preserve the highway system for the time being, programmed work will have to be increased in the future to achieve preservation. The Wisconsin Department of Transportation uses improvement level threshold deficiency guidelines to describe the levels of deficiencies that should be present before a higher type of improvement project can be considered. R-R-R standards had not been completed at the time of this paper but are anticipated early in 1983 (13).

NATIONAL R-R-R EVALUATIONS

The intent of the AASHTO R-R-R publication (1) on geometric design was to give state agencies considerable flexibility in the use of federal funds for the purpose of obtaining maximum use from the extensive system of existing facilities. By improving a road's serviceability through measures short of complete reconstruction, it was assumed that these R-R-R techniques would protect previous investments without extensive revisions to geometric features.

FHWA R-R-R Alternative Evaluations

This analysis of the cost-effectiveness impacts of various courses of action was prepared for the FHWA in 1979 to evaluate the R-R-R impact and to assist the FHWA in developing an action plan (14).

Three cases of standards were considered. Case one, the upper bound, was based on current AASHTO standards as the minimum tolerable conditions (MTC), with emphasis on improving lane and shoulder widths, horizontal and vertical alignments, and operating speeds for all R-R-R projects. Case two, the lower bound, used standards proposed in Docket 78-10 (similar to the AASHTO R-R-R guide) as MTC. The midcase standards were midway between these two.

A performance investment analysis process (PIAP) was developed, and data were analyzed from a number of accident studies made across the country. It was generally found that accidents increased as lane widths became narrower than 11 ft; also, accidents increased as shoulders became narrower (particularly unpaved, unstabilized shoulders). Grades in excess of 6 to 8 percent, particularly when combined with adverse alignment, appeared to cause significant increases in accident rates.

Based on assumptions derived from these findings, total accident, maintenance, operating, and time-cost savings were estimated for rural non-Interstate arterial and collector highways for the years 1975 to 1990 at full, high, low, and zero construction investment levels. It was found that in all cases, full standards (case 1) provided the lowest cost-effectiveness ratios (less than 1.0) and in some cases resulted in the least total savings (in some cases even accident savings were lower than for midcase). The midcase appeared to provide the best cost-effectiveness ratios for limited funding, but by only moderate margins over the lower case 2.

The final recommendation was to use case 2 or

midcase MTCs, which emphasize resurfacing and shoulders "until traffic or pavement conditions dictated extensive or major improvements be implemented" (14). Flexibility and tolerance for existing conditions were stressed.

Safety Effectiveness Evaluation

The National Transportation Safety Board (NTSB) reviewed the FHWA R-R-R policies and concluded "that the 5-year rulemaking record is contradictory, unsupported by fact, and seriously misleading (15). They disagreed that lower standards that would allow maximization of number of highway miles upgraded would provide greater systemwide safety, they feared the loss of safety improvement funds, and they stated that FHWA policy is unguided.

The NTSB reviewers concluded that the FHWA had not provided accurate information to Congress and the public; the FHWA approach would lead to inconsistency between states and will allow AASHTO R-R-R standards to be used before analysis of the safety impacts. They believed that more data should be required from states in many R-R-R projects in a uniform manner, with explicit plans, standards, and definitions. The NTSB recommended that Congress limit R-R-R funds until the FHWA meets these perceived deficiencies. They recommended that the Secretary of Transportation direct the FHWA to review R-R-R practices, develop analyses, publish plans for monitoring R-R-R projects, and direct the FHWA to require new construction standards that allow only carefully documented exceptions.

July 1982 Rule

The FHWA adopted a rule, effective July 12, 1982, that individual states would have the option of continuing under Part 625 (current new construction standards for all R-R-R type projects) or of developing new rehabilitation standards (16). After considering arguments in favor of this approach, as well as both stricter and more lenient approaches, the FHWA concluded that the flexible approach of letting states develop their own guidelines would encourage maximum safety and cost-effectiveness. Rehabilitated miles could be maximized with limited funding and a minimum red tape. The FHWA would review these guidelines and monitor the programs to provide oversight necessary to ensure that objectives for federal assistance were being met. The following primary considerations of this ruling have been extracted from the Federal Register (16).

The FHWA's choice of the individual state approach as opposed to national criteria was based primarily on nontechnical factors. The major advantages of this approach are summarized as follows:

1. Provides needed program flexibility and discretion at the state and local level;
2. Encourages the design of projects that conform to the particular needs of each locality [23 U.S.C. 109(a)(2)];
3. Maintains sufficient federal oversight to ensure that proper consideration is given users and preventing continued deterioration of the U.S. highway system;
4. Reflects the intent of Congress to provide greater flexibility in the use of federal funds for obtaining maximum use from the extensive system of existing highway facilities;
5. Implements the requirements of Executive Order 12291, Federal Regulation (46 FR 13193, February 19, 1981), the national policy on minimization of red tape in federal highway programs as expressed by Congress in 23 U.S.C. 101(e), and the FHWA's well-established policy on the minimization of red tape (43 FR 10578, March 14, 1978); and
6. Avoids disproportionate impacts on urban areas and rural communities that might result from the imposition of uniform criteria nationwide.

A disadvantage of this approach is that in order to use the flexibility provided by the regulation, it is necessary for states to develop their own criteria or procedures for R-R-R projects. However, FHWA believes that sufficient resources are available to minimize the burden on state highway agencies. The states may select from or expand on a variety of existing references with adequate technical support and guidance provided by FHWA. If a state is not interested in exercising its option under this regulation, it can simply notify the FHWA of its intention to continue operating under geometric design criteria currently adopted for new construction and reconstruction (16).

This approach is of great benefit to states in allowing them to develop their own standards for rehabilitation projects and allowing project implementation without the excessive red tape that would be generated by the need for a project-by-project review.

April 4 and 8, 1983, FHWA R-R-R Revisions

On April 4, 1983, the FHWA issued Technical Advisory T 5040.21 to emphasize that R-R-R projects are consistent with the intent of Congress that they be constructed in accordance with standards to preserve and extend the service life of highways and enhance highway safety. They wanted to demonstrate their commitment to the enhancement of highway safety as a primary objective of R-R-R projects (17).

On April 8, 1983, the FHWA instructed its field officers to ensure that all state procedures and geometric design criteria for nonfreeway R-R-R projects be consistent with this revised Technical Advisory and Section 109(o) of the R-R-R regulation, as amended March 31, 1983. In addition, criteria approved before these orders, including approvals under Certification Acceptance or Secondary Road Plan Procedures, will be reevaluated to assure they are consistent with this position (17).

On June 16, 1983, the FHWA published a notice in the Federal Register to clarify how they are implementing R-R-R program changes incorporated in the Surface Transportation Assistance Act of 1982. The notice also helped resolve challenges by critics of R-R-R programs by making it clear that FHWA field offices will review geometric design criteria submitted before March 31, according to the FHWA's April 8 instructions (18).

MAXIMUM MILEAGE REHABILITATION

The conversations and correspondence with various state departments of transportation indicate that safety and economics are primary in their attempts to maximize their R-R-R mileage. Although each state's specific needs differ, each is faced with limited budget problems while trying to achieve overall safety and improved capacity.

The key problem is to maximize safety and at the same time try to live within limited budgets. Taxes and funding have not kept pace with highway deterioration, let alone generated enough for needed improvements. In reality, there are only three philos-

ophies that can be followed in this situation. Any approach that includes safety must consist of one or a combination of these.

1. Maximize safety by making intermediate improvements during rehabilitation and restoration of the maximum miles of highways. Correct problems on a priority basis while attempting to maximize total system safety. This is the R-R-R approach.
2. Insist on going the "last extra yard" and rebuild all reconstruction projects to full AASHTO new construction standards, which will result in some safe stretches of highway, but many miles would still be hazardous. Given the current realities of funding, this is the approach of the critics of R-R-R, who fear that the R-R-R projects may not be later reconstructed to full standards.
3. Increase funding to such a degree that all needed projects can be reconstructed to full AASHTO new construction standards. This alternative would only be viable if road use taxes were increased or other general funds were diverted to highway reconstruction.

Various studies suggest that the first improvements to a hazardous road may have the greatest cost-effective improvement on safety; after that, increased improvement toward new construction standards give diminishing returns. For example, Figure 1 shows a reduction of approximately one accident per million vehicle miles when widening an 18-ft pavement with 2-ft shoulders to 22 ft with 2-ft shoulders, and approximately one-half accident per million vehicle miles in further widening to 26 ft with 10-ft shoulders; the first 4 ft have about twice the effect of the last 18 ft (19). California's study concluded with a recommendation that widening 24-ft pavements to 28 ft was not cost justified, although at higher ADTs widening to 32 or 40

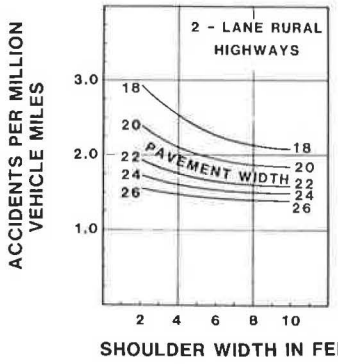

FIGURE 1 Accident rate for variable pavement and shoulder widths on two-lane highways.

ft might be justified from a safety standpoint (2). A study by Hayward (Figure 2) indicates that easing a few sharp curves can have much more of an effect on safety improvement than easing more gentle curves (20). This suggests that improving the maximum miles of unsatisfactory roads to an intermediate level might bring about the greatest accident reduction, rather than insisting on a few miles of excellent highways while exposing motorists to many miles of dangerous highways that must wait for future funding.

A survey of safety studies of R-R-R projects by Brinkman appears to support this approach (21). It suggests that, contrary to fears of critics of R-R-R

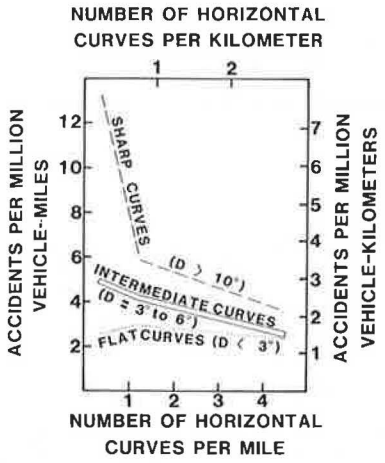

FIGURE 2 Accident rate related to curve frequency.

rehabilitation, these projects have resulted in the following safety improvements.

1. Widening pavements from 18 to 22 ft showed a significant decrease in accidents, whereas widening from 22 to 24 ft gave no statistically significant accident decrease. Accidents also decreased with increasing shoulder width.
2. Increased delineation reduced accidents; delineation is a simple and inexpensive way to improve highway safety.
3. There was a pronounced tendency for vehicles to depart from the right side of the road as opposed to departing from the left side. Nearly 75 percent of single-vehicle accidents on curves involved departure on the outside of the curve.

Brinkman also noted that resurfacing did not have a significant effect on the mean skid number of test sections studied and suggested that skid resistance must be considered when resurfacing roadways. The studies did not contain adequately separated data to support firm conclusions, however, and Brinkman indicated that further research is needed.

R-R-R type standards and maximum mileage rehabilitation philosophies are not ideal but approach overall system safety improvement within limited budgets. Generalized guidelines for maximum mileage rehabilitation drawn from this independent survey of state R-R-R procedures can be summarized under the following basic considerations.

1. No R-R-R project should result in a significant reduction in design standards.
2. Overall safety should be carefully evaluated based on past experience and current research literature.
3. Major traffic volume increases and travel pattern changes should be anticipated in the near future (1 to 5 years).
4. Value engineering and value engineering through contractor incentive clauses can result in additional cost savings in R-R-R projects.
5. Multilevel sets of standards should be considered to differentiate between available capacity, traffic volume, existing geometry, and cross section and pavement condition. Accident analysis should also be used in establishing an appropriate level of restoration.
6. Intermediate roadway cross sections and staged construction should be considered when reviewing R-R-R projects.

7. Selective use of 3:1 roadside side slopes when safe and practical should be a basic R-R-R consideration. The AASHTO barrier guide (22) should be consulted for design requirements and limiting values.

CONCLUSIONS

To meet the original intent of R-R-R programs, standards, guidelines, and policies developed by the states have addressed projects that lie somewhere between pure pavement resurfacing and rehabilitation to full AASHTO policy. This variety is present because of the diversity of each state's functional class of roadway. However, there also appears to be a tendency toward R-R-R standards tailored to the needs and situations of each state. The adoption of a properly established and approved specific set of guidelines tends to streamline the rehabilitation project design and review procedures. A few states also indicate success with reviewing R-R-R projects with value engineering teams to ensure the maximum number of miles of rehabilitation for the money expended.

In every case safety was found to be of primary concern. What does appear to be lacking is sufficient evaluation of particular R-R-R improvements from an accident analysis, and thus a cost-effectiveness, point of view. States would probably be more apt to pursue the development of individual standards and guidelines if additional information were available on specific R-R-R improvements. Some safety results have been reported, and additional research is currently being considered by the Transportation Research Board. These efforts may reinforce the contention that R-R-R standards, applied with limited funds to maximize highway miles rehabilitated, could result in overall safety improvement for the highway system.

ACKNOWLEDGMENT

The information presented in this paper was obtained initially through a contract with the Auditor General's Office of Arizona. Additional inquiries were made following the complete study by contacting several of the state highway departments for particular clarifications.

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Publication of this paper sponsored by Committee on Geometric Design.