TRB Study on Geometric Design Standards for Highway Improvements

ROBERT E. SKINNER, JR.

For nearly 10 years, a controversy has persisted over highway geometric standards for federal-aid resurfacing, restoration, and rehabilitation (RRR) projects. The U.S. Congress reacted to increasing concern over deteriorating highways by establishing the Federal-Aid RRR Program. The program not only provides funds to help preserve and repair federal-aid primary, secondary, and urban highways, but also provides an opportunity to enhance highway safety by upgrading roadway geometric features, particularly on older facilities with narrow lanes, sharp curves, or restricted sight distances. To a great extent, the tradeoff between using RRR funds to preserve existing highways, especially pavement surfaces, and using funds to enhance highway safety has depended on the minimum geometric standards to be applied to RRR projects. Over the years various organizations have proposed or commented on minimum standards, but none has been adopted for nationwide use. Finally, in the Surface Transportation Assistance Act of 1982, Congress requested the National Research Council's Transportation Research Board to study the issue and recommend minimum standards. A 17-member TRB Committee for the Study of Geometric Design Standards for Highway Improvements cochaired by Peter G. Koltnow, President of the Highway Users Federation for Safety and Mobility and Herbert H. Richardson, Associate Dean of Engineering at the Massachusetts Institute of Technology, was appointed. Since September 1983, the committee has convened three times; a detailed study work plan has been completed, and staff and consultant efforts are being directed by the committee. These efforts include field visits to state highway agencies to review state use of the federal RRR program and critical reviews of prior research to establish the most probable relationships between key geometric features and accident rates.

OVERVIEW OF FEDERAL RRR PROGRAM

Until 1976 federal funding for highways was limited to construction of new federal-aid highways. Financing of maintenance work, including major items such as resurfacing or lane widening, remained the responsibility of the states. This situation was changed by the Federal-Aid Highway Act of 1976, which authorized the use of federal funds for resurfacing, restoration, and rehabilitation (RRR) projects on existing federal-aid system highways under the Federal-Aid RRR Program. In making this change, Congress reacted to widespread concern over the deteriorating condition of the nation's highway system and to the need to shift the emphasis from building new facilities to preserving and improving existing facilities.

RRR projects may include resurfacing, pavement structural and joint repair, minor widening of lanes and shoulders, minor alternations to vertical and horizontal alignment, bridge repair, and removal of roadside hazards. More extensive improvements of existing facilities are not considered to be RRR projects but instead fall under the separate category of reconstruction. In general, RRR activities fall into two classes—repairs of the road surface and improvements in highway geometric characteristics. While concerns over highway deterioration have been directed largely at the first class (roadway surface and pavement repairs), safety concerns have focused on geometric characteristics, such as lane widths, shoulder widths, horizontal curvature, vertical grades and curves, superelevation, and cross slopes.

The Federal-Aid RRR Program is limited to the federal-aid highway system. Although the federal-aid system accounts for only 20 percent of the nation's highway mileage, it serves 80 percent of all highway travel. Excluding the Interstate system, which has its own separate RRR program, the federal-aid system consists of three administrative systems—primary, secondary, and urban—for which funding is provided on a 75 percent federal/25 percent state or local matching basis. Characteristics and available federal funding for each of these systems are summarized in Table 1.

Of the three systems, the primary system accounts for the most vehicle-miles traveled (49 percent) and the most fatalities (50 percent). Considered to be the system of greatest federal interest, it receives about 60 percent of non-Interstate federal-aid funding, of which at least 40 percent must be spent on RRR and reconstruction projects. The system is overwhelmingly rural (89 percent of mileage) and consists predominantly of two-lane roads (82 percent). As a result, considerable attention in the RRR program has been directed at rural arterial roads, particularly two-lane roads.

RRR spending from state and federal sources, excluding Interstate RRR, is roughly $2 billion annually. Of this, federal-aid projects account for about 65 to 70 percent of RRR spending for rural and urban arterials. With local spending included, total spending for RRR approaches $3 billion annually.

For RRR projects on the federal-aid system, federal assistance is more likely to be used for projects involving more extensive RRR work such as pavement rehabilitation, bridge rehabilitation, and geometric modifications. About 20 percent of the federal-aid funding is asso-

Skinner is Program Manager for Policy Studies, TRB Special Projects Division.

TABLE 1 Available Funding under Federal-Aid RRR Program[a]

	Primary	Secondary	Urban
Mileage (thousands)	255	401	129
Location	89% Rural	Rural only	Urban only
Functional class	Arterial	Collector	58% Arterial 42% Collector
Annual vehicle-miles (billions)	457	143	327
Fatalities (thousands)	17	8	9
Nonfatal injuries (thousands)	736	252	963
Authorized FY 1985 federal funding ($millions)[b]	2,300	650	800
Two-lane highways (percent)	82	99	76
Divided highways (percent)	13	0.5	10
Lanes 10 ft or less (percent)	16	33	35

[a] 1981 data (except as noted). *Highway Statistics 1981,* Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1982.
[b] Surface Transportation Assistance Act of 1982.

ciated with project classifications that clearly involve geometric improvements. For nonfederal-aid RRR projects on the federal-aid system, the proportion going to geometric modifications is smaller. Overall, the bulk of RRR spending is directed at road surface repairs without geometric improvements.

RRR GEOMETRIC STANDARDS

When RRR projects originally became eligible for federal aid, RRR design standards had not been developed by the Federal Highway Administration (FHWA). As an interim measure, the FHWA applied its new construction standards to RRR projects while it considered separate RRR standards. These new construction standards had been developed by the American Association of State Highway and Transportation Officials (AASHTO). Exceptions were permitted on a case-by-case basis, and became commonplace for RRR projects, because upgrading to the geometric standards for new highways was often extraordinarily expensive. In the northeastern states, where highway systems are relatively old and the topography is severe, the FHWA reported that 75 to 90 percent of RRR projects contained exceptions. In prairie and desert states with newer highways, the percentage was far lower (0 to 30 percent).

What began as an interim measure lasted longer than expected, because selecting separate RRR geometric design standards proved to be complex and controversial. Safety and design issues were raised, involving a large number of geometric features affecting different types of highways operating in rural and urban settings. Underlying the question of standards was the need to use federal RRR funds in the most cost-effective manner for the nation as a whole. Controversy was introduced by the different perspectives of safety organizations and state highway organizations.

It was not until June 1982 that the FHWA issued new regulations addressing RRR standards. During the intervening 6 years, the FHWA considered a number of alternative policies and reversed itself with respect to preferred action. Alternatives included:

1. Continue to use new construction geometric design standards with exceptions permitted on a case-by-case basis.
2. Adopt RRR standards developed by AASHTO. In November 1976, shortly after the initiation of the federal RRR program, AASHTO recommended geometric standards for RRR projects. Referred to as the "Purple Book," the AASHTO standards are quantitative design *guidelines* concerning pavement and shoulder widths, cross slopes, superelevation, bridge width, and clear zones.[1] They are considerably less stringent than the new construction standards.
3. Adopt RRR standards developed by the FHWA. In August 1978, the FHWA proposed RRR standards that had been developed internally. In general, the FHWA standards are somewhat more stringent than the AASHTO Purple Book standards, but they are similar in terms of scope and format.
4. Adopt a flexible approach under which states could develop and use their own RRR standards subject to FHWA approval.

This protracted rule-making process attracted comments from a variety of affected institutions and individuals, including safety-oriented organizations such as the Center for Auto Safety, the Insurance Institute for Highway Safety, and the National Transportation Safety Board. The safety organizations generally opposed any regulation that might lead to standards significantly less stringent than the new construction standards for RRR projects, and favored the first alternative described above as least objectionable. Although a large number of exceptions had been granted by the FHWA under the first alternative, explicit consideration of exceptions to geometric standards was required, which occasionally stimulated substantial geometric upgrading. While the safety organizations acknowledged the need for exceptions, both the AASHTO Purple Book standards and FHWA-proposed standards were viewed as being far too lax, permitting the RRR program to focus almost exclusively on road surface improvements and foreclosing the possibility of more stringent safety requirements. In addition, it was argued that reductions in standards for federally assisted RRR projects would

[1] *Geometric Design Guide for Resurfacing, Restoration, Rehabitation (RRR) of Highways and Streets,* American Association of State Highway and Transportation Officials, Washington, D.C., 1977.

violate legislative mandates concerning safety. The fourth alternative, permitting states to develop their own standards, also was not popular with the safety groups who feared that states would opt for, and the FHWA would approve, standards similar to the AASHTO Purple Book.

State highway organizations, on the other hand, initially supported the AASHTO Purple Book standards, but later indicated a general willingness to accept the more stringent RRR standards proposed by the FHWA. New construction standards were viewed by the states as inappropriate for RRR projects. It was believed that the new standards, if followed rigorously, would greatly increase project costs, thereby concentrating available funds on a small number of improvement projects. Such a policy, it was argued, would leave unattended many miles of federal-aid highways that were badly in need of pavement repair, which would meet neither safety nor repair objectives. It was also contended that if, on the other hand, widespread exceptions were to be permitted, needless administrative costs and delays would be incurred.

In June 1982 the FHWA settled on the fourth approach, permitting states to develop their own RRR standards subject to FHWA approval. By this time, some states had grown accustomed to using new construction standards, with case-by-case exemptions, and under the June 1982 rule, states were permitted to continue this practice as well.

A secondary system RRR project that included lane widening, addition of a shoulder, and new bridge-approach treatment.

SAFETY CONSIDERATIONS

In the debate and discussion of RRR standards, safety was considered from two different standpoints. First, concerns were raised about the effect of the standards on safety: Will accident rates increase if highways with existing geometric deficiencies are resurfaced with no other improvements? What changes in accident rates can be expected if different types of geometric improvements are made? What would be the nationwide consequences on safety and highway condition of alternative RRR standards when budgetary resources are fixed? What would be the biggest safety payoff? Although such questions could not be answered fully, the FHWA considered in its RRR "Technical Analysis" the nationwide consequences of alternative standards, concluding that standards less stringent than those for new construction would be appropriate for RRR projects.[1] This analysis was criticized by the National Transportation Safety Board for possible methodological shortcomings. Overall, many safety and technical questions were left unresolved during the RRR rule-making process.

Second, there was debate over the role that safety should play as an objective of the RRR program. The FHWA adopted the position that safety was an essential consideration of the RRR program, but secondary to preserving and extending the service life of highways. Safety groups, on the other hand, argued that statutory language already existed that made safety a primary objective of all federal-aid highway programs including RRR. The House Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation held hearings on RRR standards in the fall of 1981, and the safety/repair issue repeatedly surfaced in the testimony. Ultimately, this led to a provision in the Surface Transportation Act of 1982 that stated that the objective of the RRR program is ". . . to preserve and extend the service life of highways and enhance highway safety." Nevertheless, Congressional deliberations revealed substantial ambiguity on how much of a change, if any, was required by this provision. Subsequently, the FHWA modified its June 1982 rule on RRR standards to echo this restatement of program objectives. Reflecting the legislative ambiguity, the FHWA changed the policy statement in the preamble to the rule, but made no changes to the procedures themselves.

These changes to statutory language and rules have not resolved the problem of the cost-safety trade-off within the RRR program. To address "safety/cost-effectiveness," an additional provision was included in the Surface Transportation Assistance Act of 1982 that directed the National Research Council

[1] RRR *Alternative Evaluations for Non-Interstate Rural Arterial and Collector Highway Systems,* Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1979.

Culvert headwalls are a common roadside hazard. The problem has been mitigated in some RRR projects by extending the culverts, installing guardrails, or using special delineation treatments.

Widening lanes and shoulders in mountainous terrain is often costly, particularly where rock cutting is involved.

(NRC) to conduct a study ". . . to determine the most appropriate minimum standards to apply to resurfacing, restoration, and rehabilitation projects. . . ."

STUDY PROGRESS

Through the Transportation Research Board (TRB), the NRC appointed a 17-member committee to conduct the study. Cochaired by Peter G. Koltnow, President of the Highway Users Federation for Safety and Mobility, and Herbert H. Richardson, Associate Dean of Engineering at the Massachusetts Institute of Technology, the full TRB Committee for the Study of Geometric Design Standards for Highway Improvements (committee membership was listed in *TRNews*, November-December 1983) has met three times since September 1983, and the subcommittees have met twice. The committee developed a detailed work plan and began directing initial staff and consultant activities.

Included in the initial study activities are field visits to a number of state highway agencies aimed at understanding the real-world context of the federal-aid RRR program, the extent and nature of projects undertaken, the selection and design process of RRR projects, the differing needs of the states for RRR work, constraints on the states in making geometric improvements, and state use of federal RRR funds. Thus far, TRB staff have conducted RRR reviews in Arizona and Virginia. When completed, the field reviews should provide the study committee with valuable insight and perspective concerning the RRR process.

Another study activity seeks to define the "most probable" relationships between different roadway features and highway safety. Although an understanding of these relationships is imperfect, it is nevertheless necessary to assess the incremental safety benefits that result from upgrading specific geometric features. As part of this work, safety researchers have been selected to conduct critical reviews of prior research for 10 roadway features; and requests for proposals have been issued for two new research projects addressing pavement edgedrop and roadside features.

On the basis of the results of the initial study activities, the committee will define RRR alternatives and evaluate these alternatives with respect to a variety of impact categories including safety, cost, highway condition, administrative burden, environmental consequences, and legal implications. Alternatives will include not only minimum design values but also other aspects of the RRR process that might be improved: project programming procedures, exception procedures and guidelines, design practices, and the use of highway safety data. The evaluation process will involve a combination of project level and system level analyses, with the latter likely to entail detailed case studies in several states.

Ultimately, the TRB Committee for the Study of Geometric Design Standards for Highway Improvements will develop and report its recommendations to the U.S. Congress and the U.S. Secretary of Transportation. These recommendations may include minimum design values and/or standard practices regarding other aspects of the overall RRR process.