Geometric Design of Highway Shoulders

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● THE geometric aspects of highway shoulder design are those that the driver sees and feels as his vehicle operates either on the adjacent through traffic lane or the shoulder itself. Any discussion of these aspects overlaps other topics on this symposium, but to some extent this is necessary to emphasize the features that are strictly geometric.

It is the aim of the designer to provide a shoulder of such character and extent as to insure the efficiency, safety, and mobility of vehicle operations on the highway, both when all traffic flows smoothly and when an emergency condition arises. There are several geometric features involved; namely, the shoulder width, continuity, distinctiveness as compared with pavement and outer areas, direction and amount of cross slope, inclusion of curbs and drainage inlets, outer edge rounding, and the slopes beyond. On some highways there are other outer features such as sidewalks, guideposts or guardrails, walls or rock faces, and structure piers or abutments. Also the effect of a stopped vehicle on the shoulder is of concern.

In some form or another current design practices and standards are reasonably well crystallized as to "desirable" geometric features of shoulders. The shoulder should be continuous, with a usable width of 8 to 12 ft. It should be reasonably stable for occasional use in all types of weather and should obviously appear so to invite use in emergencies. It should have contrast in color and texture from that of the adjacent through traffic lane, but be sufficiently smooth to be free of hazard when a vehicle traveling at or near highway speed pulls over on it in an emergency. The cross slope should be sufficient to provide adequate pavement drainage, but not enough to discourage full width use by timid drivers coming to a stop; accepted values in the range of ¼- to 1-in. per ft accomplish this. Vertical elements such as steep curbs, rails and walls should be well set back; sloping curbs at the inner edge should be flat enough both in fact and appearance that drivers will mount them when necessary.

To a large extent these current geometric design conclusions were arrived at by experience and judgment rather than by studies and reports of detail research. Preferably, all of the desirable features should be included on all highways insofar as the desired traffic operation is concerned, but in view of the costs involved distinctions regularly are made for some types of highways and for some terrain and adjacent land development conditions. The shoulder element of width is reduced considerably on low order highways and even on major highways in rough terrain, and the elements of stability and contrast may be omitted altogether on low order highways. Since such conclusions regarding the warranted extent and character of shoulder improvement are items of engineering judgment they remain somewhat debatable. Research data that demonstrate the actual value of shoulders as compared with their cost increment would be highly useful to reach such conclusions. Such research largely falls under the subjects of other panelists but is the basis for solution of general geometric design problems concerning width and continuity of shoulders. The basic question is, "Under what traffic volumes and operating conditions are non-continuous and partial width shoulders adequate?" This question applies to all types of highways.

Most highway departments concur in conclusions that continuous, stable, and wide shoulders are proper parts of expressways, both rural and urban, and rural major highways. But, on sections of these where construction or right-of-way costs are extremely high, circumstances seem to force consideration of other alternatives, the traffic operational effects and accident rates of which are little known. One alternate is the construction of a continuous but partial width (some 4 to 7 ft) shoulder along expensive fills or as part of long viaducts. Another alternate is the virtual elimination of a continuous shoulder and instead provision of emergency parking bays at intervals. Or, there may be a combination of the two — a shoulder that is continuous but only of partial width, with full width bays at intervals. Will such arrangements suffice for the volume and speeds of traffic operating on expressways? Can traffic flow continue with safety when some vehicle makes an emergency stop? If traffic operations are satisfactory with such arrangements, what are minimum dimensions for partial shoulder, the bay length and tapers, or the spacing between bays? A few examples of such treatment are now constructed and research studies should be started on them.

A stabilized shoulder 8 to 12 ft wide and continuous along an expressway is needed to prevent blocking of all lanes when a vehicle must stop on the roadway. Some engineers now report concern about use of this smooth and reasonably wide area as an additional traffic lane during periods of peak flow on heavily traveled routes, thus nullifying it as an emergency area. As a result they are asking how to design the shoulder area to be smooth enough for use in an emergency but yet of a type or pattern to discourage use as an extra lane. They are considering, and trying to a limited extent, transverse scoring, added planks or corrugations, or roughened surfaces of some sort. Here is a new field for research, as yet wide open. Is there sufficient demonstration of such malpractice in lane operation to make it of concern on expressways generally? Or, does it occur only in special cases with high traffic overload? If it is a general problem, then what are some three-dimensional forms of stable shoulder surfacing that will at least discourage, if not prevent, use of the shoulder as a lane and at the same time not impair drainage functions? Obviously, experimentation is needed.

This problem is a part of the broader one of how to make the stabilized shoulder truly contrast with the travel lane, both day and night, good weather and bad, and still be within reason on maintenance costs. The known contrasts of light vs dark surfaces, or either vs a turf shoulder area, are not feasible or acceptable generally. A drainage arrangement with flat curbs or shallow or rolled gutter sections on the inside of shoulder are means for this distinction. A distinctive shoulder pavement stripe may be developed. Chip courses on shoulder surface may be possible of development in a more permanently contrasting form than so far used. And, effectively stabilized turf surfaces have promise in certain climatic conditions. No doubt a number of acceptable answers will evolve, but as yet there are more questions than answers on these features. Experimentation and study along these lines should be accelerated.

On divided highways the advantage of a left or median shoulder is being recognized in some areas. With two through traffic lanes in each direction the left shoulder offers advantages of safety space, edge delineation and maintenance operations. On 6- and 8-lane facilities it may be of much greater importance as emergency stopping area. During periods of peak flow a stalling vehicle in the left lane or lanes has little possibility of being able to reach the normal shoulder on the right. This opens a new field of questions so far unanswered, in this case probably involving extra width in the median design. Are left shoulders functional parts of the cross-section? Should they be only a part or all of the width used on right shoulders? What are suitable curb and drainage arrangements? Should they be carried through underpasses?

Problems also arise on means of distinction along continuous stabilized shoulders at the ends of acceleration and deceleration lanes. Questions of shoulder width also involve the size and placement of principal direction and destination signs with letters legible to high-speed traffic.

The above types of studies require data on nearly all phases of engineering shown in this symposium. Traffic studies giving data on accidents, volumes, speeds, placement, and general driver behavior are essential. Particularly lacking are studies on vehicle breakdowns, frequency and extent of use of shoulders, and resultant effects on traffic operation and capacity. Drainage, soil and surfacing design also are involved. Maintenance and financing aspects also enter heavily. A combined approach appears to be the only way in which answers to these geometric problems can be determined.

In an effort to break down the large field of geometric design research into correlated pieces that might be studied, the committee has prepared and the Highway Research Board has distributed a series of research problem statements, one of which is on the geometric design of highway shoulders (No. 13 in Special Report 12, HRB). The committee is endeavoring to bring into a research report stage any useful studies and to assist any individuals or groups that may display an interest in doing related research on any phase of geometric design. Thus far the only research noted on shoulders is that organized and reported by other HRB committees.