THE ESTABLISHMENT OF PRIORITIES FOR HIGHWAY IMPROVEMENT PROGRAMS

By Burton Marye, Jr

State Manager, Virginia Highway Planning Survey

SYNOPSIS

Methods of determining mathematical "ratings" or "indices" to guide in the selection of priorities of improvements are given and their limitations are discussed Major improvements to existing surfaced roads, exclusive of bridge and grade separation projects, are classed as (1) widening, (2) strengthening or reconstruction, and (3) relocation Separate priority indices for each of these improvements are determined

Under widening are included (a) widening to multiple lanes, and (b) widening of narrow 2-lane surfaces From an analyses of yearly traffic by hours and the times when the traffic volume was in excess of 300 vehicles per hour, the index for guidance in widening to multiple lanes is given as "the number of vehicles using the road in the course of a year during those times when the traffic volume was in excess of the number of vehicles per hour considered to be the maximum for a 2-lane road before widening For widening narrow 2-lane surfaces the index $\frac{t}{T_a}$ is given, in which "t" is the 24 hr. traffic on any given road section and "T_a" the average traffic on roads of the same width.

The index for strengthening and reconstruction is given as, $\frac{m}{M_a}$, in which "m" is the surface maintenance cost of any given road section, and "M_a" the State average cost for surfaces of the same type Surface types are grouped into a few general classes, and this classification should be determined by each State rather than on a national basis Wide diversity of surface types makes this necessary

Based on the fact that restricted sights become more hazardous and more objectionable as traffic increases, the index for relocation is, $Ir = \frac{s\,t}{S_a T_a}$, in which "s" is the number per mile of restricted sight distances under 500 ft. on any given road section, "S_a" the State average number per mile on the same system, "t", the annual average 24-hr traffic on the given road section, and "T_a", the average traffic on the same system

After establishing the indices for the three general classes of improvement they are considered individually and in combination with each other to determine both the type of improvement most desirable and its priority These methods, although subject to some criticism, offer appreciable benefit to highway officials by narrowing the field in which judgment alone needs to be exercised in determining the priorities for annual improvement programs

One of the most worthwhile services which planning surveys could render would be to devise some practicable method of assigning priorities to improvement projects so as to aid in the setting-up of annual construction programs

From the mass of data which has been accumulated by the planning surveys it would appear that the assignment of priorities by mathematical indices would be relatively simple—yet it is not a simple task. There are so many factors which influence the selection of the average improvement project that to attempt to assign exact mathematical "ratings" to each of them would be absurd Yet the very factors to which it is impossible to assign a mathematical rating are ofttimes those which, in the final analysis, govern the selection of the individual project.

Therefore, in any process of assigning mathematical ratings to guide in the

selection of priorities of improvement there is the danger, on the one hand, of considering so many factors as to make the final rating complex and cumbersome and, on the other hand, of considering so few factors that the rating would have a limited practical value.

It is my opinion that the process which would be of the most value would be to assign mathematical "ratings" or "indices" to only those factors for which such ratings are clearly practicable and which leaves other influential factors to be judged in the light of experience, common-sense and general policy.

Any process based on this reasoning would, therefore, preclude the assignment of any one final rating or index which would definitely determine the priority of any individual improvement project. The best that could be done would be to place the proposed projects in rather broad groups and to show by several indices the relative need for improvement based on such factors as traffic, the most important physical characteristics of the roads, and annual costs.

Such an evaluation would, of course leave much to be desired, but it would at least have the value of narrowing the field in which judgment need be exercised and of serving as a general guide to those vested with the final responsibility for the selection of annual improvement programs.

Major improvements to existent surfaced roads, exclusive of bridge and grade-separation projects, fall in three general classes as follows.

(1) Widening
(2) Strengthening or Reconstruction
(3) Relocation

It is suggested that separate priority indices be determined for each of these three classes of improvements rather than to attempt to compare the importance of one type with another by making one index applicable to all three.

WIDENING

Widening will generally fall in two classes; first, widening existent two and three-lane surfaces with additional lanes and, second, widening narrow two-lane surfaces to wider two-lane surfaces. Since no studies to date show which of these two classes of widening is the more important, it is proposed to establish separate indices for each and let their relative importance be judged in the light of experience and policy.

Widening to Multiple Lanes

While there are unquestionably several factors such as steep grades, restricted sight distances and types of vehicle, which contribute to congestion on two-lane roads, there is no gainsaying the fact that *volume of traffic* is the most important single factor and, in itself, is sufficient to cause congestion regardless of other contributing factors.

It is evident that, regardless of the specific volume considered sufficient by the several States to cause congestion, first consideration for widening should logically be given to that particular road, or portion of road, which, during a year's time, caused the most inconvenience to the most people. In other words, first consideration should be given to that road on which, during a year's time, the greatest number of people traveled during those periods when the traffic volume was above that considered the limit for a two-lane road.

If, for illustration, 300 vehicles per hour is considered the maximum which should be carried by a two-lane road before widening to three lanes then the index for widening would be:

"The number of vehicles using the road in the course of a year during those times when the traffic volume was in excess of 300 vehicles per hour." For the sake of convenience in establishing a mathematical index, "number of vehicles" could best be expressed in thousands.

As a concrete example, Tables 1 and 2 show the yearly traffic, by hours, on each of two important Virginia highways, namely U. S. Route 58 west of Suffolk and U. S. Route 11 north of Staunton.

It will be noted from these tables that although the average 24-hour traffic on Route 58 is slightly greater than that on Route 11, the latter shows 96 hours of the year during which the hourly traffic exceeds 300, whereas the former shows only 32 hours during which the traffic exceeds that figure. Moreover, on No. 11 a total of 32,289 vehicles use the road during those periods when the hourly volume exceeds 300, whereas on No. 58 only 10,894 use the road during those periods.

TABLE 1

YEARLY TRAFFIC, BY HOURS, ON U S. 58 WEST OF SUFFOLK

Traffic Volume Groups	Hours per year each group		Vehicles per year in each group	
	Number	Percent	Number	Percent
0- 99	4618	52 72	178,686	21 01
100-149	1741	19 87	220,235	25 90
150-199	1885	21 52	325,622	38 29
200-249	408	4 66	89,098	10 48
250-299	76	0 87	25,905	3 04
300-349	20	0 23	6,291	0 74
350-399	12	0 13	4,603	0 54
Total	8760	100 00	850,440	100 00

Average annual 24-hour traffic: 2,330

Therefore, Route 11 would receive a higher priority rating for widening than Route 58, the proposed index for each road being:

$$\text{For Route 11.}\ \frac{32,289}{1000} = 32.3$$

$$\text{For Route 58}\ \frac{10,894}{1000} = 10.9$$

After such comparative indices had been established, it would of course be necessary to examine other possible contributing factors such as relative proportion of heavy commercial traffic, steep grades, et cetera before it was finally determined that Route 11 should be widened before Route 58.

Widening of Narrow 2-lane Surfaces

If there were any studies showing conclusively the maximum permissible volume of traffic for 2-lane surfaces of different widths, then the ideal priority index could be established by dividing the traffic on any road section by the maximum permitted for that width. Unfortunately, however, the maximum traffic deemed advisable for 2-lane roads of different widths is still largely a matter of personal opinion and, for the time being at least, a more workable index could be established by dividing the traffic on any given road section by the State average traffic carried by all roads of that same width. If such a method were adopted it would be necessary that the actual State averages for the different widths be relatively consistent and that, for example, the average traffic found on all 14-ft. surfaces did not exceed that on 16-ft. surfaces To be of value the averages should increase as width increases.

TABLE 2

YEARLY TRAFFIC, BY HOURS, ON U S 11 NORTH OF STAUNTON

Traffic Volume Groups	Hours per year each group		Vehicles per year in each group	
	Number	Percent	Number	Percent
0- 99	4950	56 50	252,431	30 12
100-149	2266	25 87	279,468	33 34
150-199	1015	11 59	172,584	20 59
200-249	329	3 76	72,866	8 69
250-299	104	1 19	28,509	3 40
300-349	72	0 82	23,131	2 76
350-399	16	0 18	5,950	0 72
400-449	8	0 09	3,208	0 38
Total	8760	100 00	838,147	100.00

Average annual 24-hour traffic. 2,296.

In Virginia, the average traffic does increase as the widths increase In 1938 the 24-hour average for the several widths was as follows.

Width of Surface	Average Traffic
20 feet	653
18 "	560
16 "	458
14 "	220

The index for any section of road could be expressed.

$$\frac{t}{T_a}$$

in which "t" is the 24-hour traffic on any given road section and "T_a" the average traffic on roads of the same width. This method of determining priorities, while admittedly leaving much to be desired, would at least have the obvious advantage of giving high priority ratings to those narrow roads carrying high volumes of traffic

The examples in Table 3 illustrate how this formula would indicate the relative need for widening of several Virginia roads

Note how the indices in Table 3 accentuate the need for widening on the section of Route 65.

STRENGTHENING OR RECONSTRUCTION

The need for a higher type surface, strengthening of surface or surface reconstruction, is caused, as we all know, more by weight of traffic than by volume of traffic Nevertheless, from our own studies at least, it has been found well nigh impossible to determine just what weights or frequencies of different weights consistently show the same need for such improvement While it is true that on an average those surfaces of the same type show a greater maintenance cost and a greater need for strengthening as the frequency of heavy axle weights increase, no average frequency of such weights has been found which, when applied to an individual road section, will be at all indicative of the needs of that particular section This is because there are other obviously important factors besides either volume or weight of traffic which, in the final analysis, govern the durability of any type of surface. These factors include age, condition, nature of sub-grade and drainage, and will often explain why a certain section of low type road carrying relatively heavy traffic will remain in better condition and be maintained more cheaply than a higher type pavement carrying less volume and lighter weights.

It is therefore thought that any index for strengthening based solely on frequency of weights is apt to be misleading and, if followed, would perhaps result in improvement where such improvement was not necessary.

Of all the factors which indicate the

TABLE 3

Route	From	To	Present Width	Ave 24 Hr Traffic	Index $\frac{(t)}{(T_a)}$
42	Dayton	Bridgewater	18	1295	2 31
33	Gordonsville	Ruckersville	18	677	1 21
211	Page Co Line	New Market	16	1220	2 66
460	Alexanders Corner	Int Rt 58	16	547	1 19
65	Pennington Gap	Int Rt. 636	14	1419	6 45
231	Gordonsville	Madison Co Line	14	233	1 06

need for strengthening, that of maintenance or annual cost lends itself most readily to comparison and should be most decisive inasmuch as such costs are usually caused by a combination of all other factors

The ideal index based on cost would be "the maintenance cost on any given section of road divided by the maximum maintenance cost which should be incurred on that particular surface type before reconstruction to a higher type." An objection to such an index is the extreme difficulty of determining, with any degree of accuracy, the maximum maintenance costs which are justifiable for each of the several surface types.

A much more simple index, and one which would not be subject to personal opinion would be: "the maintenance costs on any given road section divided by the State average maintenance costs for that particular surface type on the same system."

It is true that such an index would not reflect maintenance costs per vehicle mile nor per ton mile, but it should be borne in mind that regardless of how little or how much traffic a low type surface carries, a maintenance cost on any section which is excessive and above the average for all roads of that same type, is certainly a strong indication that the road should be strengthened. Moreover, such an index would do more than indicate the need for reconstruction from the standpoint of economic maintenance, for it will generally be found that roads upon which the maintenance costs are excessive are those which are more frequently in poor riding condition and upon which vehicles are subject to more wear and tear and more frequent delay.

It is therefore suggested that the index for strengthening be expressed as follows.

$$\frac{m}{M_a}$$

in which "m" is the surface maintenance cost of any given road section and "M_a" the State average costs for surfaces of the same type.

Surface types should preferably be grouped into as few general classifications as possible, and the exact classifications should be determined in each State rather than on a nation-wide basis. This is necessary because of the wide diversity of surface types.

RELOCATION

The need for relocation (not the building of an additional road) is determined by alignment, grade and sight distance in relation to traffic. Inasmuch as the frequencies of curvature and steep grades are almost always reflected by the number of restricted sight distances, it should be possible to establish an index based on the two factors of sight distance and traffic volume.

In view of other more pressing needs, and since many miles of high type pavement have been built in the past few years with sight distances of between 500 and 1000 ft., it is believed that the need for more immediate relocation could feasibly be based on the number of restricted sights less than 500 ft. rather than the number less than 1000 ft.

As it is of course obvious that restricted sights become more hazardous and more objectionable as traffic increases, the suggested index for relocation is as follows:

$$I_r = \frac{st}{S_a T_a}$$

in which "s" is the number per mile of restricted sight distances under 500 ft. on any given road section, "S_a" the State average number per mile on the same system, "t" the annual average 24-hour traffic on the given road section, and "T_a" the average traffic on the same system.

A comparison of two sections of high-

way, based on restricted sight distance and traffic is shown as follows.

(1) Route 59 between Fremont and Van Sant

$$s = 6\ 64 \qquad t = 658$$
$$S_a = 3.99 \qquad T_a = 784$$
$$Ir = \frac{6.64 \times 658}{3.99 \times 784} = 1.397$$

(2) Route 60 between Amherst and Buena Vista

$$s = 4.05 \qquad t = 571$$
$$S_a = 3.99 \qquad T_a = 784$$
$$Ir = \frac{4.05 \times 571}{3.99 \times 784} = 0.739$$

In this comparison, case No. 1 has a relatively high priority, whereas the index for case No. 2, being less than unity (1.0), indicates that this particular section of road need not be considered for relocation at this time.

Although the foregoing index would not in all cases recognize long sustained grades, such long grades, particularly in mountainous terrain, are usually accompanied by frequent curvature which would be reflected by restricted sights At any rate, special conditions could be given special consideration.

After the indices for the three general classes of improvement have been established they should be considered individually and in combination with each other. This is necessary in order to determine both the type of improvement most desirable and its priority.

To illustrate: index No. 1 for a certain road section may be very high but indices 2 and 3 below the State averages. This would indicate that the road need only be considered for widening. However, if either index 2 or index 3 is also very high, the road should be considered for complete reconstruction to a greater width.

Similarly, if index 2 is very high but indices 1 and 3 below the State averages the road need only be considered for strengthening on the same alignment and to the same width. However, if index 1 is also high, consideration should be given to both strengthening and widening.

In the case of relocations, all three indices should be given close study and consideration It would be entirely logical to give a higher final priority rating for relocation to a road being found also deficient in width and strength than to a road which was adequate in one or both of these respects.

Of course there are other important factors to be considered, among which are right-of-way restrictions and costs, construction costs and the general importance of a route as a whole. However, as aforestated, it is felt that such factors can be best left to judgment and administrative policy.

As has been evident throughout this discussion, the methods of determining and presenting the several indices for improvement are simply offered as suggestions. It is recognized that they are subject to criticism and that further study will most assuredly bring further refinement and increased accuracy. Nevertheless, it is also felt that the methods have a certain amount of logic and that the tabulation of priority indices based upon them would be of appreciable benefit to highway officials until such time as better indices may be determined.