Planning and Measuring Highway Progress

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• FEDERAL Highway Administrator Tallamy at the November 2, 1960 meeting of the Southeastern Association of State Highway Officials and again on November 28, 1960 at the AASHO meeting in Detroit stated, "Most of our current highway troubles can be traced to the raising of the Interstate System estimate from $27 to $40 billion." He pointed out that this drastic increase in the estimate gave the program's critics the opportunity to raise questions about the qualifications of highway administrators and about the capability of the existing Federal-state relationship to do the job.

Tallamy declared that the problem of estimating the cost of the Interstate System has been solved. Contrary to forecasts of an increase to $50 billion or more, the new estimate is in reasonably close agreement with the last. Standards are now well defined and estimating procedures are being employed which give assurance that the new estimates will reflect closely the actual cost of doing the job at the current price level.

Therefore, the problem of planning and measuring progress on the Interstate System is fairly well solved. Reappraisals will be made on a consistent basis as the program moves forward. There will be clearly defined measures of what has been done, what remains to be done, and the associated costs.

The Interstate System is extremely important, but it represents just 41,000 miles of the 3,000,000-mile total system of roads and streets. In his report to AASHO, Tallamy gave some idea of the magnitude of the program on other portions of the Federal-aid systems: "We have completed construction contracts on more than 106,000 miles of ABC roads. . . . On September 30, construction contracts involving more than 24,000 additional miles were under way. . . ." These are important roads although not parts of the Interstate System; in total, the remainder of the Federal-aid systems represents almost 20 times the mileage on the Interstate System. In traffic service they will provide approximately two and a half times the total service estimated for the Interstate System in 1975.

Therefore, it seems that some basic questions should now be asked about these other important parts of the Federal-aid systems; for example: "Do we have clearly defined measures of what needs to be done and the cost associated therewith?" "Are we heading for the same kind of trouble, estimate-wise, as created by the jump in the Interstate System estimate from $27 billion to $40 billion?"

In 1947, AASHO initiated the development of an estimate of needs on the Federal-aid systems for the guidance of Congress in writing the Federal-Aid Highway Act of 1948. New estimates were made in 1949, 1951, and 1953 for the same purpose.

In 1948 Congress asked for an estimate on the Interstate System. Again in 1954, Congress requested that an estimate be developed and submitted by the Secretary of Commerce. This latter estimate was developed by the Bureau of Public Roads in cooperation with the state highway departments and submitted to Congress on March 25, 1955. Each

TABLE 1

NATIONAL NEEDS ESTIMATES—FEDERAL-AID SYSTEM

Year	Needs Estimate ($ millions)				
	Interstate	Primary	Secondary	Urban	Total
1947	—	—	—	—	[1] 23,109
1948 [2]	11,266	—	—	—	—
1949	—	—	—	—	28,866
1951	—	15,266	8,459	8,282	32,007
1953	—	15,995	9,073	9,884	34,951
1954 [3]	—	32,276	14,867	20,623	67,766
1954 [3]	23,253	[4] 19,740	14,867	[4] 9,906	67,776
1956 [5]	39,511	—	—	—	—
1956 [6]	[7] 41,000	[4] 30,924	24,869	[4] 15,848	112,641

Note: Estimates for 1947, 1949, 1951 and 1953 assembled by AASHO.

[1] Adjusted to include estimates for six states not reporting. The 1949 totals reported for these states were added to the 1947 total for 42 states.
[2] "Highway Needs of the National Defense," in accordance with the Federal-Aid Highway Act of 1948.
[3] "Section 13" estimate, required by Federal-Aid Highway Act of 1954. Interstate did not include urban circumferential and feeder routes.
[4] Excluding Interstate System.
[5] "Section 108(d)" estimate, required by Federal-Aid Highway Act of 1956. Did not include mileage added under increase from 40,000 to 41,000 miles.
[6] So-called "210" report submitted to Congress. Estimates show an appreciable increase over 1954 values.
[7] Cost to complete as of Jan. 1, 1960, 41,000-mile system, including funds obligated prior to that date.

of these estimates from 1947 to 1955, except the one in 1948, covered all Federal-aid highway systems.

Congress, of course, makes authorizations of funds for each of the Federal-aid systems. For so-called ABC roads, these authorizations have been made by legislation every two years. The preparation and submission to Congress of estimates of needs obviously have been considered obligatory by the agencies who are expending the funds and who are responsible for the development and maintenance of the roads on which the funds are expended. In a very real sense, the regular reporting of "needs" estimates represents the highway administrators report of progress.

The estimates from 1947 to 1955 are summarized in Table 1 which illustrates the drastic change in concept that resulted from setting up the Interstate System as a high standard, high priority project. The change in concept had a significant effect on the estimates for all Federal-aid systems—not just the Interstate. Even with the Interstate System taken out of the primary system, the estimate for that system increased from $15,995 million in 1953 to $19,740 million in 1954. The secondary system estimate increased from $9,073 million to $14,867 million.

Just as was the case with the Interstate System, there are some good reasons why there have been tremendous increases in the estimates for the ABC Federal-aid systems. But, in view of the reaction to the sharp increase in cost on the Interstate System, it appears essential that the ABC estimating process be set up on a more stable basis so a similarly unfavorable reaction may not develop in connection with ABC estimates.

With this thought in mind, a check list of items is suggested for use as a guide by each highway department for a more consistent estimating process. This is, of course, equally important for the planning of the state's program as for national estimating. The check list includes the following five items:

1. Is the procedure for determining improvement needs a continuing planning function? In the past, estimating of needs on a national basis almost always has been undertaken

on a crash program basis. Some states have organized their own planning processes to provide regular reappraisals, which involve a relatively simple updating of records. Encouragement of this process and development of a plan for coordinating the individual state efforts nationally would give the desired estimates as a routine process rather than through a crash program.

2. Does the improvement needs evaluation give totals by each road system and area that has financial significance? For national purposes it is necessary that the estimate be broken down by Federal-aid systems and for urban extensions of those systems. For state purposes the estimate should also be broken down to fit such other system classifications or area units which may be a basis for apportioning funds. Unnecessary details in the estimating process should be avoided. Some of the difficulties in the past may have been occasioned by estimate refinements of questionable value.

3. Is the needs estimate based on providing a level of service that reflects (a) legislative action, and/or (b) administrative policy decision? In the case of the Interstate System, because of the legislative requirement for establishment and application of a specific standard, there have been both legislative action and administrative policy decision. The administrative policy decision, which actually determined the standards, was made by the Secretary of Commerce and the state highway departments. At this time, except for the Interstate System, it is assumed decisions will be made as administrative policy although it is conceivable that legislative actions in some states may set some guide lines.

Examples of administrative determinations are provided by Vermont and North Carolina. Governor Stafford of Vermont directed a letter to Highway Commissioner Poeter on February 4, 1960 with instructions as follows:

> This letter will serve to request of the Highway Department that it prepare a report and forward the same to me, as near July 1 as is feasible, covering the Highway Department plans for highway construction during the next 12 years. It would be appreciated if the report contain, among other things, the following information:
>
> 1. A listing of needed improvements on the major primary, secondary and urban routes to bring the entire state system to at least 70 percent sufficiency rating by 1971, including estimated costs of all projects.
> 2. A projection of how much of this total improvement can be built and financed on the basis of the present rate of progress assuming that the present rate of Federal allocations in all categories, including the Interstate is continued.
>
> This report, when received, will be made available to the public generally and to any persons who may be in a position to have some responsibility when the next General Assembly convenes in January 1961.

In this case the Governor set a service level of 70 on the sufficiency rating scale.

In North Carolina, the service level has been determined by policy decisions of the state highway commission. On primary highways the adequacy level is established by setting an average operating speed. Road sections which provide less than the service level operating speed are considered inadequate. For secondary roads, the service level is established by minimum requirements of roadway width, pavement type and bridge capacity (*1*).

Other states are also doing new things in developing service level criteria. Pennsylvania has an ambitious project under way which is aimed at appraising needs and alternative approaches to satisfying the needs which may ultimately give an economic determination of service level (*2*). Regardless of how the service level is established, it represents an essential first step in the estimating process. It would appear that it is a subject for research to encourage exploration of a variety of alterna-

tives. What is needed is a method which will do the job satisfactorily in the states and be adaptable to the formulation of reasonably consistent national estimates.

4. Does the needs evaluation clearly define existing requirements —the backlog—in miles and dollars? One of the problems associated with reconciling some needs estimates has been that they represented a forecast of requirements over some future time period with no indication of what the current needs are. The current "needs" (backlog) are extremely significant and become more significant as successive estimates are developed. Comparison of such estimates will show clearly the degree to which progress is being made in overcoming the needs.

5. Does the procedure provide forecasts of road improvement requirements to counter obsolescence (miles and dollars)? This is most significant so that there is a clear indication of what must be done just to hold the line against increasing traffic volumes and structural deterioration. It is, of course, an essential addition in forecasting construction requirements to overcome highway deficiencies.

Specific applications will demonstrate that it is possible reasonably to fulfill the requirements of the check list from presently available state highway data. For example, Figure 1 is based on utilizing the sufficiency ratings which have been made on one state's highway system since 1950.

Utilizing sufficiency ratings may not provide the final answer to the problem of measuring need and highway progress. As previously indicated, exploration of various approaches ultimately may provide an economic measure as a better basis on which to plan improvements and measure progress. However, instead of simply waiting for a highly sophisticated system of measurement to be devised, it seems desirable to use what data are available, or readily obtainable at the present time, to make the best possible evaluations for immediate use. Perfections can be incorporated as they are developed.

It is significant that 38 states make periodic adequacy ratings according to a survey made by the Highway Research Board in June 1960 (HRB Research Correlation Service Circular 431, Nov. 1960).

The development of adequacy ratings by the state highway departments has been primarily for setting improvement priorities—to serve as a programing and improvement scheduling guide. The least adequate road sections receive the lowest ratings. These are the ones given particular attention in the formulation of improvement programs.

Although the ratings have received much less use in over-all program planning (for determination of the total needs backlog and measuring progress) it is clear that they have great potential for this purpose. The letter from Governor Stafford, previously quoted, illustrates this. The Governor instructed the highway department to develop an estimate based on getting all road sections to a rating of 70 or higher within a 12-year period.

In the state for which Figure 1 was prepared, the whole operation of forecasting needs and projecting a program was accomplished as a relatively simple statistical operation. The state will remain unnamed, as the program forecast was prepared by the state highway planners on a trial basis mainly for internal use and no attempt was made to break down the forecast by Federal-aid systems.

Sufficiency ratings have been made as a regular planning operation since 1950. This satisfies one of the desirable procedure elements. It is a continuing planning function providing

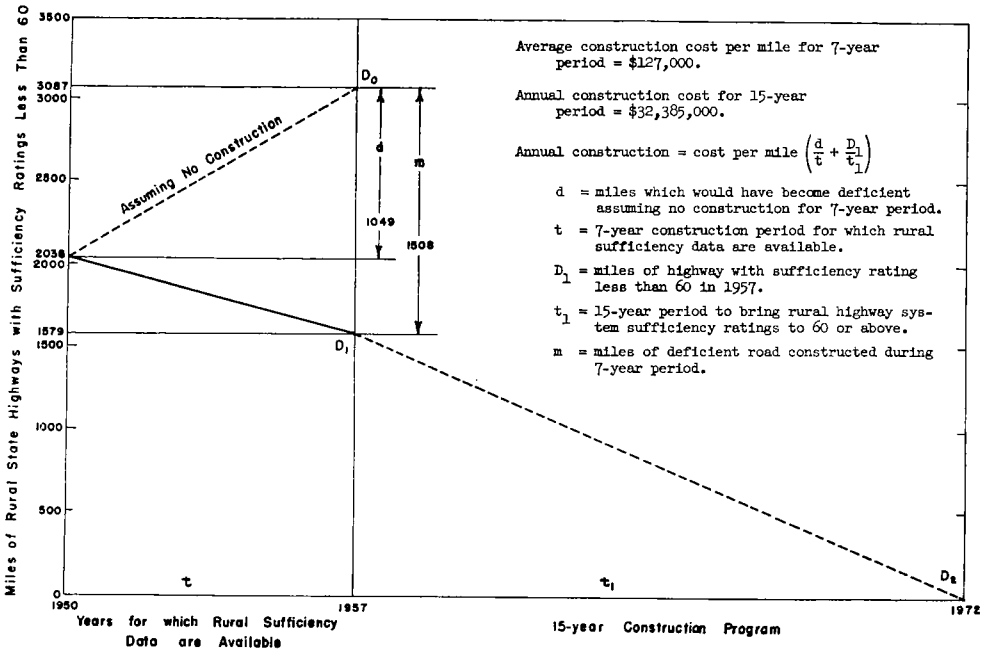

Figure 1. Financial planning of rural highway construction based on rural sufficiency rating data, 1950-1972.

current appraisals of the highway system.

For the purpose of this analysis, a rating of 60 was set as the service level below which the state highways are critically inadequate and should be planned for improvement. This might be some other value. One of the great values of this procedure is the readiness with which analyses can be made at any service level which administrative policy, legislative action, or public interest may dictate. They can be made at several levels to demonstrate clearly what the financial requirements of any higher service level may be. The adaptability of this approach to administrative policy or legislative action is important. It meets an important requirement for a satisfactory planning procedure.

Using the available records, and the 60 rating level, it was determined (Fig. 1) that there were 2,038 miles of rural highway critically deficient in 1950. There were 1,579 miles in this category in 1957. During the 1950-57 period, construction improvements had been accomplished on 1,508 miles of deficient roads, raising their adequacy rating above 60.

Using these figures (the miles critically deficient in 1950 and 1957 and the deficient mileage improved) it is possible readily to determine what would have been the situation had no critically deficient mileage been improved. There would have been 3,087 miles critically deficient in 1957. This provides a direct measure of obsolescence—3,087 minus 2,038 or 1,049 miles. Therefore, the rate of obsolescence is 1,049 miles over 7 years, or 150 miles a year. This is the mileage of improvement of critically deficient road sections required each year just to hold the line, without raising the service level of the highway system.

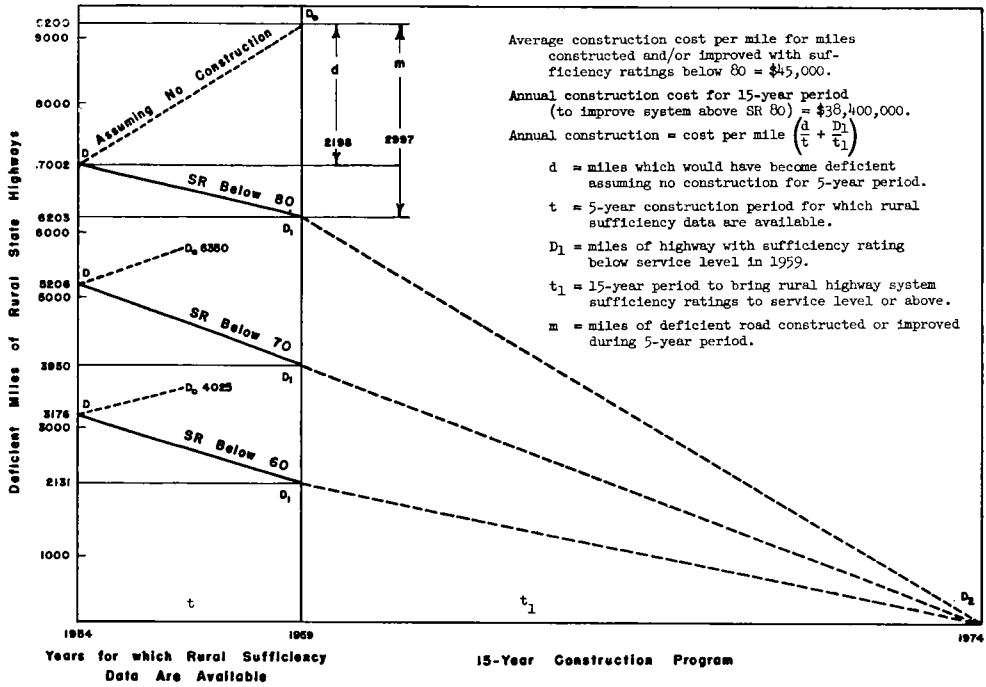

Figure 2. Rural highway programing on different service levels—state highway system less Interstate.

Because of the factors which are incorporated in the sufficiency ratings, the obsolescence value resulting from this projection takes account of (a) structural deterioration, (b) traffic increases and obsolescence resulting therefrom, and (c) upgrading of standards for new construction.

The latter may need a word of explanation. As visualized at present, it would not be necessary to adjust the chart of sufficiency rating progress for changes in highway standards which might occur periodically. Sufficiency ratings for any given year would be based on current standards. Thus, a trend of changing standards over a period of years, if any, simply would be reflected in the slope of line depicting deficient miles.

With one further value added to those shown, the average cost per mile for construction, it is possible to develop estimates and forecasts. In this case the average cost per mile for the 7-yr period was $127,000. This figure was not adjusted to current price levels as would be desirable.

What is the backlog of urgent needs? The current mileage of roads rating less than 60 is 1,579. The cost for improvement at $127,000 a mile is $200,533,000. What expenditures are required simply to counter obsolescence? This is 150 miles a year at $127,000, or $19,050,000.

What average annual expenditures are required to provide improvements to eliminate needs backlog and keep ahead of obsolescence in 15 years, from 1957 to 1972? It will take first the $19,050,000 to counter obsolescence and then one-fifteenth of the backlog of $200,533,000, giving a total of approximately $32,400,000 a year.

Alternative calculations can be made for different program periods. A 10-yr program period, for example, would require $19,050,000 and one-tenth of $200,533,000 or an annual construction expenditure of about $39,100,000. Progress can be readily appraised as the program moves forward.

To provide further indication of the usefulness of results that can be obtained from this kind of analysis, Figure 2 has been developed from information supplied by the planning branch of another state highway department. Figure 2 includes a family of sufficiency rating progress curves showing what the experience has been in overcoming deficiencies at different service levels. The average construction cost per mile is given to improve highways with sufficiency ratings below 80. From the data on miles constructed in this category, the obsolescence (d) has been worked out, and a projection of annual cost made for the 15-yr period to raise the entire state highway system (excluding Interstate) to a sufficiency rating of 80 or better.

Similar calculations have been made for the two progress curves at ratings of 70 and 60. In each case, the average cost per mile of improving the highways is different. This is because of the amount of money spent on roads which already rate over 60—due in part to a fund distribution formula which requires some expenditures in areas with few if any low rating roads. From the expenditure data, it is apparent that the roads with a higher rating generally receive a betterment type of construction rather than complete reconstruction and that substantially more miles are purchased for an equivalent expenditure than where complete reconstruction might be needed. Thus, in this state's experience, the average cost per mile to improve all roads rating below 80 is less than that required to improve all roads rating below 70, and, similarly, the average cost below 70 is less than that below 60. These average costs are as follows: (a) For improving roads rating below 80—$45,000 per mile; (b) for improving roads rating below 70—$50,000 per mile; and (c) for improving roads rating below 60—$62,000 per mile.

Calculations of obsolescence at the three levels may be made from the data given in Figure 2. Annual costs for a 15-yr program are as follows:

$$\text{Annual cost} = \text{Average cost per mile} \left(\frac{d}{t} + \frac{D_1}{t_1} \right)$$

in which d/t is the obsolescence factor and D_1/t_1 is the backlog increment.

To Elim. Def. Below	$\frac{d}{t}$	$\frac{D_1}{t_1}$	Avg. Cost per Mi. ($)	Annual Cost ($)
60	$\frac{849}{5}$	$\frac{2131}{15}$	62,000	19,300,000
70	$\frac{1144}{5}$	$\frac{3950}{15}$	50,000	24,600,000
80	$\frac{2198}{5}$	$\frac{6203}{15}$	45,000	38,400,000

The 15-yr totals of these annual expenditures, corresponding to a needs estimate at each level, are shown on the A curve of Figure 3. Incidentally, the construction cost per mile figures have been adjusted to current price levels so program amounts are at present values. The 15-yr programs are $290 million; $370 million; and $576 million, respectively.

In the foregoing approach there is the assumption that the state will concentrate construction expenditures below the service level in each alternative program. That is, in eliminating deficiencies below rating

of 60 all expenditures will be on sections rating less than 60. Similarly, for the alternative directed toward eliminating all deficiencies below 70, construction expenditures will be made only on sections rating less than 70.

In actuality this could be reasonably approached although there may have to be some expenditures—emergencies, connecting links, etc.—which will involve sections rating above the selected service level.

For the present state, however, there is now a sizable expenditure of construction funds on sections rating from 60 to 80. As implied earlier this results primarily from the program distribution formula which requires expenditures in areas with few low rating roads. If it is assumed this programing procedure is to be continued, alternative forecasts of 15-yr programs can be made to reflect such continuation.

The approach would be to take all previous construction expenditures, regardless of the adequacy of the road on which they were spent, and consider that these purchased only the mileage below the desired service level. For example, the total 1954-59 construction expenditures, at present values on rural state highways excluding Interstate, has been $135,341,000. The only significant mileage raised has been from below sufficiency rating 60—1,894 mi. This gives an average effective cost per mile of raising deficient mileage of $135,341,000/1,894 mi., or approximately $71,500 per mi. This compares with the $62,000 per mi. when only the amount spent below the 60 rating was considered to have purchased the mileage raised below 60, as in the first analysis.

The 15-yr program amounts worked out on the second basis are shown on the B curve of Figure 3. An interpretation of the difference between the curves—for example, $44,000,00 at a 60 rating—might be

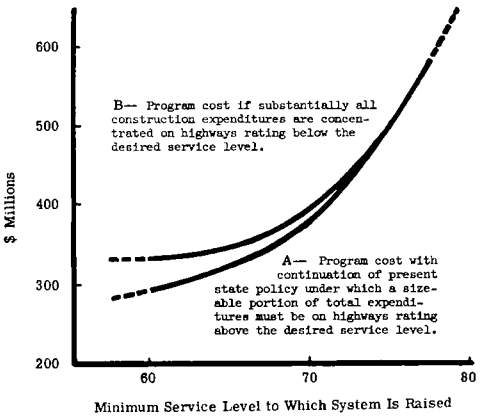

Figure 3. Fifteen-year program costs, rural state highways (less Interstate).

that this is the amount which could be saved in 15 years if the state were able to concentrate its expenditures below the desirable service level on the assumption that attaining this service level is the goal for this period of time.

One of the advantages of using the procedure outlined to make a needs determination is the ease of improving estimating accuracy with each year's experience. To a certain extent, results are self-correcting since there is a new take-off point of deficient miles each time sufficiency ratings are made.

Furthermore, with a few years of historic record the obsolescence rate and average improvement costs per mile can be projected into the program period instead of taking current average values, as have been used in the foregoing discussion. For example, the 7-yr average obsolescence rate in Figure 1 is 150 mi. Review of the trend might indicate, however, that the current rate is about 153 mi. and a projection for 15 years should be about 158. For average construction costs, the 7-yr average is $127,000 a mile; a projection of the trend of this item might indicate that an appropriate 15-yr forecast value would be $140,000.

Using such projected values of obsolescence and cost per mile—both of which will be statistically determined from highway records—the program projections can be expected to be reasonable approximations which will become increasingly accurate as the program moves forward.

Because of this self-correcting feature and because of the relative nature of adequacy ratings, it should be recognized that the results of this procedure are not dependent on precise accuracy of rating formulas. As long as a consistent rating method is used, the projections and measurements of progress in overcoming deficient miles also should be consistent.

In connection with this and with the procedure, the answers to some questions frequently asked may clarify the application further. How can this procedure take account of new routes or new locations? To the extent these new routes are required by the inadequacy of existing highways, the ratings and forecasts take full account of such situations. The only area where this procedure does not provide a valid forecast is where highway standards are drastically changed. The gradual upgrading of standards is taken into account and reflected in the suggested procedure. But where drastic changes are made at one time, such as was the effect of the initiation of the Interstate System, then the suggested procedure would not be valid.

However, since the Interstate System needs forecasting is being handled satisfactorily as a separately committed program there is no need to include it in the other forecasting. Furthermore, if a state were to undertake an expanded freeway program in addition to the Interstate System (for example, California, Connecticut, and Michigan), estimates and forecasts for these can be handled effectively in the same manner as for the Interstate System.

How can the adequacy rating forecasts from all the individual states be correlated into a national estimate and forecast? This can be done by application of one or more rating formulas to selected sections in every state. Based on this sampling operation it can be determined what the equivalent adequacy levels are on each state's rating scale. It might develop that one state's projection would have to be made at 63 to conform to 60 in another state, 69 in another, 58 in another, etc.

Another question concerns the application of this method to urban portions of the highway system. The answer is that although most road rating has been for rural highways there are a number of states that have made urban highway ratings. It is not necessary that the method be the same as used on rural highways. To repeat, what is necessary is a consistent method of determining an acceptable service level for urban highways and of reckoning the deficient miles below this service level—then, the same analysis can be applied.

Finally, how can a program analysis of this type proceed when adequacy ratings of the highway systems have not been made previously? First, it will be necessary to make a current adequacy rating survey. With numerical ratings established for all road sections it will be possible immediately to determine the backlog of needs at any service level which might be selected. By getting an average construction cost it will be possible to estimate the cost for overcoming the backlog.

The factor missing, as a state initiates this kind of an approach, will be the rate of obsolescence. However, it appears that this rate will have a great deal of consistency from state to state. An assumed value can be used at the start based on what has developed in states which have a rating procedure that has been in use over a period of years.

With this procedure adopted and kept up to date as it can be relatively simply, with encouragement of research to perfect improvements in the techniques, but, with a recognition that reasonable forecasts with existing formulas can and must be made now, this kind of procedure can provide much that is needed to do a solid job of planning and measuring highway development. The need to compile a crash estimate every few years is removed by the use of this approach and the kind of answers the highway administrators need are provided continuously—the kind of answers that can have real significance to the legislature and the public.

REFERENCES

1. NORTH CAROLINA STATE HIGHWAY COMMISSION, "An Analysis of Long-Range Highway Needs" (1960).
2. GARDNER, E. H., "The Congestion Approach to Rational Programming." HRB Bull. 249 (1960).