or two exceptions, will not rate the road sections in the same relative order.

Each of the formulas studied was tailored to fit the conditions existing in a particular state. As such it is not surprising that the formulas do not give the same composite ratings or rate sections in the same relative order where applied to conditions in any one state. In addition, the application of the various formulas to but four test sections certainly does not clearly establish the validity of any of the formulas. However, certain tentative conclusions are indicated: (1) there is a significant difference in the ratings derived by the use of the different formulas which make state comparisons of ratings of doubtful validity, (2) the major difference between the formulas is in the method of computing the condition of structural adequacy rating, (3) the formulas do not place the road sections rated in the same relative position with respect to sufficiency, and (4) there is closer agreement between the sufficiency ratings than there is between the deficiency ratings.

Possible Areas of Improvement in Rating Procedures

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THE RATING of highway sections with respect to their sufficiency is not new or unique. For many years states have developed their construction programs on the basis of the personal knowledge of their administrative staff of the need for improvement on the various portions of their state highway system. Such a method of program development, while unscientific, informal, and surely not free from personal bias, has been founded on an appraisal of the relative sufficiency of the many routes that comprise the system. Thus it must be realized that highway sections can and have been rated in the past for sufficiency whether formally or informally, casually or periodically.

Sufficiency-rating formulas have been devised and procedures developed, however, to provide a method whereby the rating of highway sections could be as unprejudiced, objective, and uniform as possible. To obtain this end, it is essential that no factor or element be used which cannot be precisely defined and adequately measured.

From one point of view, the act of rating is one of comparing individual highway sections, with respect to certain elements which have been selected as significant, with a hypothetical highway section. This hypothetical section meets certain geometric standards previously selected and established. These standards are essential, and they should be as objective and consistent as possible. Where they are not, the ratings obtained will be of low reliability, since the personal bias of the individuals rating the elements may produce considerable variation in the final rating values.

It is admittedly difficult, for example, to establish objective standards for the element "consistency"; consequently it becomes necessary to rate this element on the basis of a subjective evaluation. The personal judgment required to do this reduces the reliability of the rating. This may likewise be true of standards for such other elements as "sway in cross section," "roughness," or "surface driving condition." It is noted that some states do not use these elements, and it is suggested that the procedure might have greater acceptability if these elements, for which objective standards are not obtainable, be eliminated.

The standards used for the condition or structural adequacy rating appear to vary considerably as to objectivity. Here is a factor that purports to measure the structural adequacy of a roadway and yet in many instances the standard used is the one to which the roadway was originally designed and constructed. Standards for structural adequacy can best be established

on the basis of service to present-day traffic with consideration given to climatic conditions. Such standards, based on current design requirements should include those for such items as shoulders, drainage and base in addition to surface standards.

To adequately evaluate maintenance economy, it would be desirable to use standards established from properly classified maintenance-cost data which have been acquired over a long period of time.

For making the field ratings some states have advocated the use of only one field party to cover an entire system and thus attempt to minimize the personal equation. It is no doubt necessary to adopt such safeguards where personal judgment enters into the rating procedure, but it should be recognized that the use of a single party endeavors to standardize personal bias over the system to be rated rather than to eliminate it. A more satisfactory approach would be the use of rating factors or elements that can be objectively measured and the elimination of elements the measurement of which depends on subjective appraisal. The guiding principle should be that objective measurements are superior in every way to judgments, and therefore, unit measurements should be used wherever possible.

It is self-evident that elements for which objective standards cannot be established, cannot be objectively measured. Some of these elements have already been mentioned. It has been noted, however, that while objective standards have been established for "sight distance," "stopping sight distance," and "passing opportunity," in some instances a subjective evaluation is made of these elements. Critical features surveys can be made involving the actual measurement of sight distances, which are plotted in the form of sight distance profiles. Using standards for both stopping sight distance and passing sight distance, it is possible with such profiles to measure precisely the degree of restriction for each of these elements.

It is difficult to understand how "passing opportunity" can be objectively measured without relating available passing sight distance to the volume of traffic using the highway during some selected peak hour, such as the thirtieth-highest hour. In other words, highway sections with adequate passing sight distance provide passing opportunity only to the extent that the volume of traffic permits passing maneuvers to be performed. It thus appears that neither passing sight distance nor passing opportunity is an element which can be used to measure objectively relative sufficiency, unless a variation in standards as wide as the variation in traffic volumes is employed. On the other hand, available passing sight distance can be used to compute practical hourly capacities which, when related to the thirtieth highest hourly volumes, provide an objective means of rating the relative sufficiency of highway sections with respect to traffic capacity. New York has made use of capacity ratings in its procedure.

Accident rate, although in only limited use, is an element which can be objectively ascertained and probably should be more widely used. Some sections with a good safety rating have a high accident rate, possibly because factors such as access points, land use, and the like are not considered in the formula. The use of accident rates, of course, is limited by the extent to which accurate accident data are available. The use of accident experience over a period of several years would seem most desirable.

In states where there is considerable variation in traffic on a system, some adjustment of the basic sufficiency rating seems necessary in order that the traffic carried by the highway section may influence the priority rating of the section. The formula devised by Arizona has had wide use by other states. Some experimentation with it has been attempted. For example, the value of the constant in the denominator has been changed by some states in order to obtain a wider range of adjustment. Such experimentation appears desirable, especially where the priority ratings established by the traffic adjustment are at variance with what experience and judgment seems to indicate.

In some states there is moderately wide variation in the relationship between annual daily traffic and the thirtieth-highest annual hourly volumes. In Minnesota these hourly flows vary from 12 to 26 percent of the annual daily traffic, depending on geographic location. With such a variation, it can be seen that an annual daily volume

of 2,500 vehicles means a design-hour volume of 300 vehicles at one location and 650 at another. This suggests that design-hour traffic volumes should be used in setting up the basic standards and in making the traffic adjustment to the basic sufficiency rating.

Any attempt to rate highway sections by an empirical formula is subject to argument. The very nature of the empirical approach, since it is less than scientific, requires that resultant ratings be tested as to conformance with ratings obtained by other means. The selection of factors and elements, their relative weighting, and the traffic adjustment method must all be adopted on a trial basis. The whole sufficiency-rating procedure must then be tested for validity. Does it actually measure relative sufficiency? How well does it do the job?

The test must be made by comparing the rated sufficiency of various highway sections with an evaluation of their actual performance as traffic carrying facilities. Do the rated sections stand in the same relationship to one another as they do when the relative sufficiency of their performance is evaluated on the basis of experience and judgment? If they do not, a review of the elements employed, their relative weighting and the traffic adjustment method is required. Perfect validity is practically impossible to achieve, but reasonable validity is not only possible but indispensable to insure the successful use of any sufficiency-rating procedure.

In closing, it should be pointed out that there are other factors to be considered in programming construction improvements that perhaps might be included in a rating procedure. Among these are economic considerations, such as cost, benefits, and earnings. Such relatively unexplored areas of improvement present a challenge to all of us for further analysis and experimentation.