plication the analysis provided a comprehensive overview of the pattern by which specific facilities contribute to problems, guided the specification of improvements, and lent itself readily to the justification of proposed improvements in terms of trip interchanges and activity clusters being served. Areas requiring further work include the following:

1. The evolution, from future subarea studies, of suitable benchmarks against which to compare the subareawide diagnostics, so that these measures may be used to set priority subareas for funding and to specify subareawide strategies;
2. Development of more rigorous guidelines for what constitutes a problem zone or zone pair—the heuristic rules used in this paper call for further examination; and
3. Development of more rigorous guidelines for formulation of distinct objectives and packaging of individual projects into alternatives for addressing these objectives.

ACKNOWLEDGMENT

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Priority Programming for Highway Reconstruction

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An adequacy rating procedure was developed for use in priority programming for highway reconstruction. The procedure makes use of 15 roadway and traffic elements to rate highway sections in urban and rural areas based on a 100-point scale. Condition elements (35 points) include a subjective rating of highway foundation, pavement surface, drainage, and maintenance economy. Safety elements (35 points) are stopping-sight distance, highway alignment, skid resistance, accident experience, and traffic-control devices. Service elements (30 points) include shoulder width, passing opportunity, rideability, surface width, volume-capacity ratio, and average speed. Some of the advantages of the new procedure include computerized analysis of all input data and detailed output summaries. All highway sections are referenced by milepoints, reference points, and federal-aid route numbers. The procedure incorporates the 1978 design standards. New adequacy concepts include the use of the rate-quality control method for accident analysis, a formal rating scheme for traffic-control devices, and a rating of lane width based on design level of service. Other advantages include measured skid numbers and a roadway-condition rating guide for subjective evaluations of six different roadway elements.

Virtually every state has a systematic procedure for periodic evaluation of highway sections for improvement programming. The procedure, known as adequacy ratings (or sufficiency ratings), was first developed and implemented by the Arizona Highway Department in 1946 (1). The rating of highway sections is generally based on a 100-point scale, where 100 points applies to a new section.

The adequacy rating includes the evaluation of several highway and traffic elements, which may be classified as condition, safety, or service. Condition elements usually require subjective evaluation and may include foundation, surface, shoulder, and drainage. Safety elements may include more objective information, such as surface width, accident information, stopping-sight distance (SSD), alignment, and skid resistance. Service elements may refer to such descriptors as rideability, passing opportunity, shoulder width, traffic speed, or volume-capacity (V/C) ratio.

A nationwide survey was published in March 1973 of the most commonly used variables considered in adequacy rating of highways (2). The point values most often used were 40 for condition, 30 for safety, and 30 for service. More than 80 different highway and traffic elements were found to be in use in the United States in adequacy ratings. The 16 most common elements were recommended for use with either 5 or 10 points assigned to each. No distinction was made between ratings for rural and urban highways (2).

Adequacy rating of highways in Kentucky was developed primarily for the purpose of locating deficient highway sections on the state-maintained system. In using adequacy rating techniques, highway sections are assigned numerical ratings to indicate their relation to established design standards. Priorities for construction or reconstruction are then based, in part, on the adequacy rating (3).

Approximately 16 000 km (10 000 miles) of state primary and secondary routes are included in Kentucky's adequacy rating program. Because the adequacy rating methods and procedures were last revised in 1963, an in-depth evaluation was made of the procedure. The purpose was to incorporate the latest engineering principles, design standards, and computer techniques. In 1976, Kentucky developed a new adequacy rating procedure to more effectively rate sections of highway. Because of operational differences between urban and rural areas, the new procedure incorporates some descriptors that best suit the location. The procedure was developed to improve accuracy and reliability of the adequacy ratings and to help ensure optimal expenditure of safety-improvement funds.

Table 1. Recommended adequacy rating elements.

Element	Rural Points	Urban Points
Condition		
Foundation	10	10
Pavement surface	10	10
Drainage	8	8
Maintenance economy	7	7
Safety		
Stopping-sight distance	8	-
Alignment	8	-
Skid resistance	7	-
Accident experience	12	20
Traffic-control devices	-	15
Service		
Shoulder width and condition	7	-
Passing opportunity	8	-
Rideability	5	-
Surface width	10	10
Volume-capacity ratio	-	12
Average speed	-	8
Total	100	100

CONDITION ELEMENTS

Subjective evaluation of many highway and traffic elements was made to determine those best suited for use in Kentucky. The variables used in other states and those currently used in Kentucky for rural and urban highways were considered. All elements are given in Table 1 along with corresponding point values. The condition elements include foundation (10 points), pave-

Table 2. Roadway-condition rating guide.

Condition	Excellent	Good	Fair	Poor
Base	Base (as distinguished from surface) is considered to be in very satisfactory condition. Rare situations of imperfect smoothness but no evidence of base failure.	Occasional evidence of minor base failure, fully correctable by spot repairs. Extensive reworking not absolutely necessary.	Frequent evidence of base failure, correctable only by heavy maintenance. Road should be considered for reconstruction. Traffic speeds reduced somewhat.	Severe base failure throughout subsection, extreme washboard condition. Road must be reconstructed. Traffic speeds reduced substantially.
Surface	Surface (as distinguished from base) is considered to be in very satisfactory condition. Pavement smoothness very satisfactory. No surface failure.	Occasional spots of surface failure, spalling, or roughness, correctable to a satisfactory extent through maintenance and minor patching. Resurfacing not absolutely necessary.	Frequent spots of surface failure and spalling. Rough surface in need of heavy maintenance. Should be considered for resurfacing. Traffic speeds reduced somewhat.	Severe surface failure throughout subsection. Road must be resurfaced or rebuilt due to surface condition. Traffic speeds reduced substantially.
Drainage	Road surface drains satisfactorily during heavy rains; no ponding, no flooding.	Occasional ponding during heavy rains but drains quickly thereafter, no restriction to traffic operation, no flooding.	Substantial ponding during heavy and light rains. Some reduction to traffic speeds due to ponding. Should be corrected to avoid damage to pavement. Occasional flooding.	Excessive ponding to the extent that traffic on occasion must traverse ponds over 50.8- or 76.2-mm deep. Correction necessary to avoid base damage, frequent flooding.
Ditch drainage or urban drainage facilities	Ditch drainage (or urban drainage facilities) are completely adequate under conditions of heavy rainfall. No corrections needed other than normal light maintenance.	Ditch drainage (or urban drainage facilities) generally adequate except under conditions of very heavy rainfall. Frequent light maintenance required. No need for substantial improvement.	Ditch drainage (or urban drainage facilities) only partially adequate. Excessive maintenance required. Consideration should be given to substantially improve and extend ditches or other facilities.	Ditch drainage (or urban drainage facilities) completely inadequate, not correctable through maintenance methods. Drainage facilities must be provided.
Maintenance economy	No expenditures, other than strictly routine. Patching rarely required.	Some expenditures, but not excessive. Some patching required annually or at intervals. Resurfacing would help but not absolutely necessary.	Considerable expenditures of money and material. Considerable patching required annually or continually. Road should be considered for resurfacing or reconstruction.	Excessive expenditures. Great amount of patching required annually or continually. Road cannot be adequately repaired, must be rebuilt.
Rideability	No driver strain whatsoever under normal conditions. Crown, superelevations, and transitions provide for excellent operation of vehicles. No undue hazards or side-entrance friction. Smooth riding condition. No width or clearance restrictions.	Moderate driver strain due to minor geometric deficiencies, occasional side-entrance friction, and hazard. Good riding comfort. Operations or driver strain alone do not justify major improvements.	Considerable driver strain due to geometric deficiencies or side-entrance friction. Vehicle operation affected. May be some riding discomfort. Some improvements should be considered to improve quality.	Severe driver strain due to geometric deficiencies, side-entrance friction, maneuvering vehicle. Substantial riding discomfort. Improvements fully justified on this factor alone.

Note: 1 mm = 0.04 in.

Table 3. Points for condition rating.

	Excellent			Good			Fair			Poor		
Condition	H	M	L	H	M	L	H	M	L	H	M	L
Base	10	10	9	8	7	6	4	3	2	1	0	0
Pavement surface	10	10	9	8	7	6	4	3	2	1	0	0
Drainage	8	8	7	7	6	5	3	2	2	1	0	0
Maintenance economy												
Standard pavement	7	6	5	5	4	4	3	3	2	1	1	0
Substandard pavement	7	5	4	3	2	2	1	1	0	0	0	0
Rideability	5	5	5	4	4	3	2	1	1	0	0	0

Note: H = high, M = medium, L = low.

ment surface (10 points), drainage (8 points), and maintenance economy (7 points). The rating procedure and point allocation for condition elements are the same for rural and urban roads.

The condition elements are rated based on a subjective evaluation by planning personnel in each of Kentucky's 12 highway districts. Each of the condition elements is rated as excellent, good, fair, or poor. There are three possible levels (high, medium, and low) for each, or 12 possible ratings. A guide with word descriptions was developed for use by field personnel to describe what is excellent, good, fair, and poor (Table 2). The relation between rating and point value for foundation and surface condition was determined to be S-shaped. A similar relation was found for drainage condition (eight-point maximum). Maintenance economy refers to the needed annual expense each year in maintenance costs. Curves for standard and substandard pavement types were developed based on a seven-point maximum. A summary of point values for all subjective elements is given in Table 3.

SAFETY ELEMENTS

Rural Highways

For rural highways, the safety descriptors selected were SSD, alignment (vertical and horizontal), skid resistance, and accident experience. The rating for SSD is based on a maximum of eight points and is calculated by the formula:

$$\text{Rating} = 8 - N/L \tag{1}$$

Where N = number of SSD restrictions and L = section length.

Sight distance restrictions are based on traffic speed conditions for various types of highways as given in Kentucky's Basic Geometric Design Criteria (4). For example, for 65 km/h (40 mph) design speed, the minimum SSD is 83 m (275 ft). Design speeds of 80 km/h (50 mph) and 97 km/h (60 mph) correspond to SSD restrictions of 105 and 143 m (350 and 475 ft), respectively. On an 8-km (5-mile) section with 10-SSD restrictions, the rating would be six out of eight points.

The rating for highway alignment may receive a maximum of eight points. Vertical and horizontal alignment may each receive up to four points based on the following formula:

$$\text{Rating} = 4 - N/L \tag{2}$$

Curvature limits for various volume ranges and design speeds are given in terms of maximum degrees of curvature allowed, as listed in Kentucky's highway design standards. Allowable curvature ranges from 4° to 25°, depending on design speed and traffic volume. For the vertical alignment rating, if two deficient vertical curves exist in a 1.6-km (1-mile) section, the vertical alignment rating would be two points out of four.

In rural areas, skid resistance of the pavement was selected as a safety element and assigned a maximum of seven rating points. For survey and inventory purposes, skid tests are made at 65 km/h left wheel only, with two skid trailers meeting ASTM E 274 standards. Procedures also comply with ASTM E 274. Survey testing is limited to the period between July 1 and November 30. Frequency of repeated surveys or inventories may involve testing every two years (5, 6).

Skid resistance has been assessed in terms of skid number (SN) groupings. SNs above 39 are considered to be skid resistant; 33-39 is considered marginal; 26-32 is slippery (5, 6).

For use in adequacy ratings, a relationship was derived between SN and adequacy points. An SN of 25 or less was assigned zero points and an SN of 41 or more was assigned the seven-point maximum. A linear relationship was assumed between these SN values. For example, SNs of 31 and 35 would correspond to three and five points, respectively (5, 6).

Accident experience as a rating element of rural highway sections has received much attention within the Kentucky Bureau of Highways in recent years. A new method for identification of hazardous rural spots and sections is being implemented in Kentucky (7). One of the criteria used for evaluation of highways based on accident data involves the rate-quality control method.

Average statewide accident rates for highways of similar characteristics are needed to use the rate-quality control formula. The formula is based on the assumption that accident occurrences on an annual basis are approximated by the Poisson distribution (7):

$$CR = \lambda + k\sqrt{\lambda/m} + \tfrac{1}{2}m \tag{3}$$

where

CR = critical accident rate for a particular highway section in accidents per 1 million vehicle-kilometers,
λ = overall, average accident rate for sections of like characteristics in accidents per 1 million vehicle-kilometers,
m = number of 1 million vehicle-kilometers on a highway section in a one-year period, and
k = probability factor determined by the level of significance desired for the equation.

The value of k is determined by the level of probability that an accident rate above λ is abnormal, that is, large enough so that a high accident rate cannot be reasonably attributed to random occurrences (7). Examples of k values for various probability levels (P) are

P	k
0.995	2.576
0.975	1.960
0.950	1.645
0.925	1.440
0.900	1.282

Values of statewide average accident rates (λ) were determined for five types of Kentucky roads for 1971, 1972, and 1973 (8):

λ(two and three lane) = 3.84 accidents/1 million vehicle-km,
λ(four lane, undivided) = 5.01 accidents/1 million vehicle-km,
λ(four lane, divided) = 2.50 accidents/1 million vehicle-km, and
λ(Interstate and parkway) = 1.34 accidents/1 million vehicle-km.

The critical rate curves for two-lane and three-lane roads are given in Figure 1 and were prepared to illustrate the use of the formula. Each curve represents a highway section length of 1.6 to 32.2 km (1 to 20 miles). To apply the method, the accident rate for a one-year period is found by use of the formula:

$$R = (A)(1\,000\,000)/(365)(AADT)(L) \tag{4}$$

where

R = accident rate of the section,
A = number of accidents in one year, and
AADT = average annual daily traffic on the section.

This accident rate is compared with the critical accident level as given in Figure 1 for any AADT and section length. The actual rate is then divided by the critical rate to give the critical rate factor (CRF). Sections whose rates exceed their critical values have a CRF above 1.0, which signifies a very hazardous section.

Figure 1. Critical rate curves for rural two-lane and three-lane highway sections.

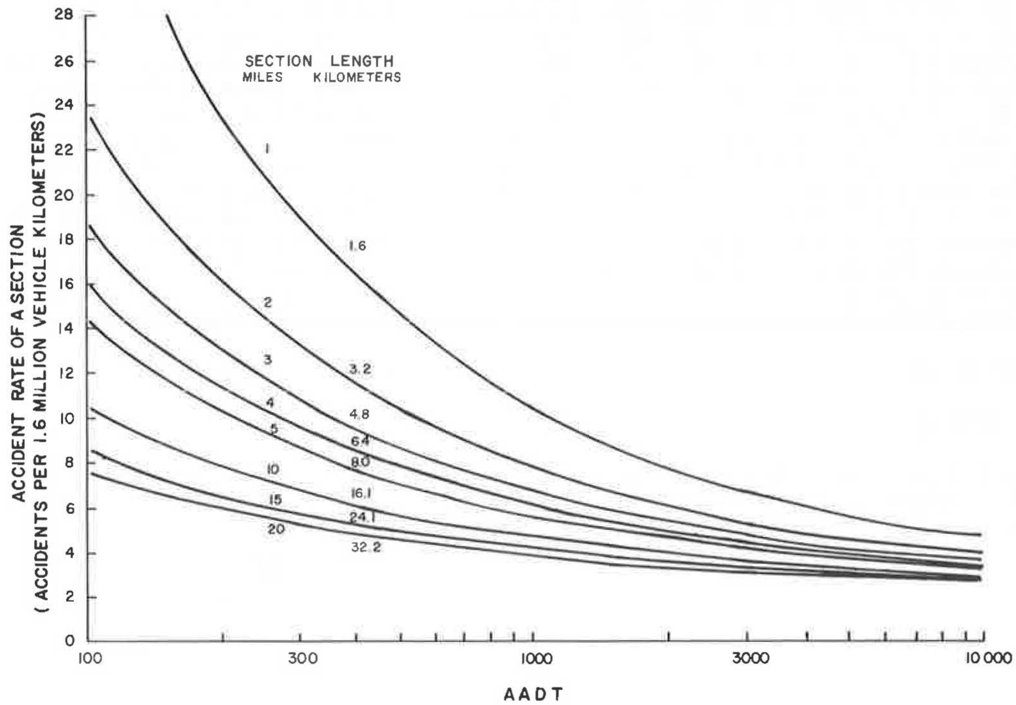


Table 4. Accident rate for arterial-collector locations.

Population	AADT Mid-Blocks	AADT Inter-Sections	Accidents Per Location Mid-Blocks	Accidents Per Location Inter-Sections	Accident Rate Per Million/Vehicles Mid-Blocks	Accident Rate Per Million/Vehicles Inter-Sections
Over 200 000	11 781	23 562	5.0	10.2	1.16	1.19
50 001 - 200 000	8 990	17 980	4.1	6.6	1.25	1.01
20 001 - 50 000	6 520	13 040	2.7	4.5	1.13	0.95
10 001 - 20 000	5 800	11 600	1.5	2.4	0.71	0.57
5 001 - 10 000	4 811	9 622	1.0	1.9	0.57	0.54
2 500 - 5 000	4 002	8 004	0.8	1.2	0.55	0.41

Table 5. Evaluation of traffic-control devices.

Criterion	Excellent	Good	Fair	Poor
Standardization	All existing traffic-control devices meet regulations in the MUTCD. Signal heads and indication displays are sufficient. Sign colors and symbols are correct. Proper sign distances exist. Color and type of pavement markings are correct and visible.	Most traffic-control devices meet MUTCD regulations. Signal heads and indication displays are sufficient in nearly all cases. Most signs and markings are correct. A few sign distances may be too short. Pavement markings are generally adequate.	Many traffic-control devices do not meet MUTCD regulations. Several signal heads and indication displays are inadequate. Sign colors and symbols are incorrect in many cases. Inadequate signing distances are often the case. Pavement markings are quite worn.	Traffic-control devices were installed with no regard to the MUTCD. Signal heads and indication displays are totally inadequate. Signs often are in conflict and unclear, and signing distances are inadequate. Pavement markings are misleading, incorrect, or worn.
Effectiveness	Existing traffic control devices convey sufficient information to the driver. No additional signs are needed. Destinations are clear. Regulations and warnings are adequately signed and marked. Traffic flows freely through signalized intersections.	Most traffic-control devices convey sufficient information to the driver. A few additional signs may be needed. Destinations are clear in most cases. Regulations and warnings are usually adequate. Traffic flows through signalized intersections with occasional congestion.	Many traffic-control devices do not convey sufficient information. Several additional signs are needed. Unclear destination signs exist. Regulations and warnings are often inadequate. Traffic flow is often congested through signalized intersections.	Traffic-control devices are unclear. More signing is needed, destinations are unclear, and regulations and warnings are unclear or conflicting. Traffic is greatly congested through the signalized intersections.
Maintenance	Signs and pavement markings are clearly visible, clean, and straight. All signal and streetlight bulbs are burning and lens faces are clean. Delineators are all in place and in good shape.	Signs are slightly weathered or dirty. Pavement markings are slightly worn or dirty. One or two bulbs in signals or streetlights may need to be replaced. Some delineators are missing, but they are still adequate for nighttime visibility.	Signs and pavement markings will soon need to be replaced. Several bulbs in signals or streetlights need to be replaced. Many signal faces need to be cleaned. No delineators exist and nighttime driving may be difficult.	Signs are weathered or dirty and need to be replaced. Several signal and streetlight bulbs need to be replaced. Delineators and pavement markers are mostly worn away or missing.

Curves for four lanes, divided and undivided, were also developed in a similar manner but are not given here. Values for λ were substituted into the formula with various AADT and section lengths to develop each set of curves. A probability level of 0.995 was used for all curves. Short sections must have a higher accident rate than long sections to have similar CRFs.

One use of the rate-quality control formula is to compare the degree of hazard of one section to another, regardless of length or highway type. For example, consider the data for two highway sections (1 km = 0.6 mile):

Factor	Section 1, Four Lane, Divided	Section 2, Two Lane
Section length	3.2 km	6.1 km
AADT	18 523	8391
Annual number of accidents (A)	24	27
Statewide average rate (λ)	2.50	3.84
Annual traffic exposure (m)	21.63	18.62
Accident rate (R)	2.83	3.72
Critical accident rate (CR)	3.95	5.78
CRF	0.72	0.64

Although section 1 had the lower accident rate, it had a greater CRF and is therefore more hazardous. Neither section is considered critical, since their CRFs are less than 1.00.

To apply this procedure to the adequacy rating of highways, a linear relation was developed between adequacy points and CRF. A point value of 0 (worst condition) represents a critical location for all sections with a CRF of 1.0 or greater. A point value of 12 (safest condition) was given to sections with a 0 CRF, which occurs when there are no accidents on a section in a one-year period (an accident rate of 0). A CRF of 0.50 (half of the critical level) corresponds to 6 points, and so on.

Urban Highways and Streets

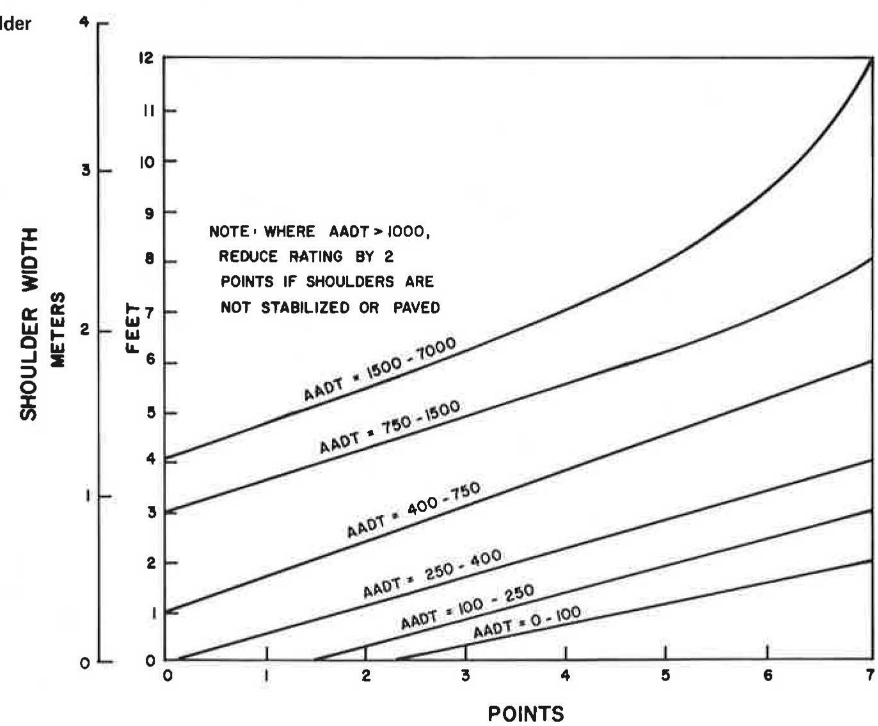
Although four different elements were selected for use in the evaluation of the safety of rural highways, only accident experience and traffic-control devices were chosen for urban safety rating. Skid-resistance data are often difficult or impossible to collect in urban areas due to low vehicle speed, high traffic volumes, and stop-and-go driving conditions. The evaluation of SSD and vertical and horizontal alignment is not applicable to city streets because of urban street networks and generally low vehicle speeds.

Accident experience was assigned 20 points because of the importance of this element. The method for the evaluation of accident experience for the adequacy rating uses the rate-quality control formula in a slightly different way than for rural highways. Urban streets, intersections, and midblocks are defined within each urban section. All rates are expressed in terms of accidents per million vehicles instead of accidents per million vehicle-kilometers. At intersections, volumes and accidents on both intersecting streets are used.

If locations in every city were considered under the same criteria, virtually no locations in small and medium cities would be identified as hazardous. Therefore, the rating procedure for cities was weighted according to population. Cities of over 2500 population were divided into six categories, as shown in Table 4. Average statewide accident rates were calculated for each city group for intersections and midblocks. Midblock average rates ranged from 0.55 to 1.25 accidents/1 million vehicles. Intersection rates ranged from 0.41 to 1.19 accidents/1 million vehicles. These values were calculated from 1974 accident data and volume counts (Table 4) (9).

Using the statewide average accident rates and the rate-quality control formula, a set of curves for critical rate were drawn for midblocks and intersections. They were based on a probability level (P) of 0.995 (k = 2.576) and give the critical accident rate for locations of a

Figure 2. Point values for rating shoulder width and condition.



given city group and AADT. There are 44 approved urban areas that fall under Kentucky's adequacy rating program.

To apply the procedure, CRFs are calculated and averaged for all intersections and midblocks within a study section. A linear relation was developed between CRF and rating points, as for rural roads. However, a maximum of 20 points is assigned for CRFs of 0 (accident rate of 0).

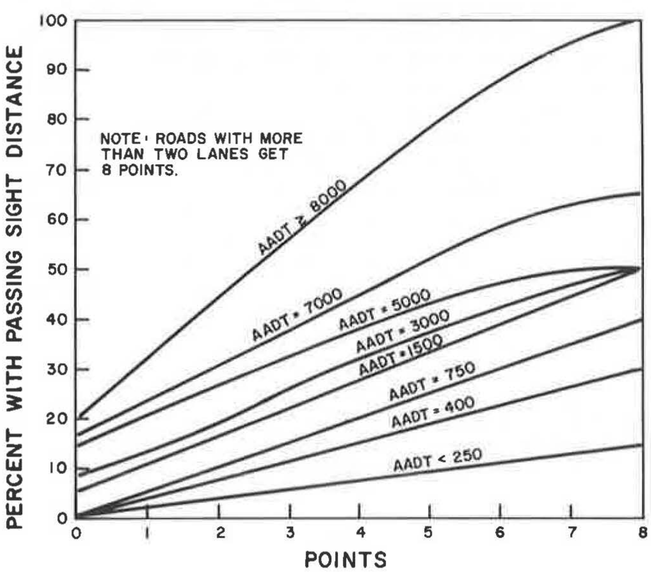
The condition and effectiveness of traffic-control devices are important in determination of the adequacy of an urban section. A maximum of 15 points was allotted to this element. A method was developed that consists of rating the standardization, effectiveness, and maintenance of signs, signals, and markings as shown in Table 5. Detailed definitions of condition evaluation are given for each of the three categories. The point allocation for each category is 5, 4, 2, and 0 points for excellent, good, fair, and poor ratings, respectively.

The standardization of a device is based on its compliance with the Manual on Uniform Traffic Control Devices (MUTCD) (10). Such items considered are sign color and symbols; proper sign location; color, type, and visibility of pavement markings; and adequacy of size and indications on traffic signals.

The effectiveness of traffic-control devices is the second category. This pertains to the clarity of information that is given to the driver related to destinations, upcoming dangers, and regulations (i.e., speed limits, stop signs, and no passing). The effectiveness of the traffic signals to promote smooth traffic movement through the intersection is also considered. Inappropriate signal timing, inconspicuous or small signal heads, or lack of coordination between adjacent signals would result in poor ratings in this category.

The maintenance of traffic-control devices requires that all signs and pavement markings be clearly visible, clean, and straight. All signal and streetlight bulbs should be burning and lens faces be clean. Pavement delineators should all be in place and in good condition. Weathered or worn-out traffic-control devices can create hazardous conditions to the out-of-state motorist, particularly in the rain or at night.

Figure 3. Point values for rating passing opportunity on two-lane roads.



SERVICE ELEMENTS

Rural Highways

The width and condition of the highway shoulder are important for adequate capacity and refuge for emergency stops. A relationship was developed between shoulder width and adequacy points based on AADT, as shown in Figure 2. Small values of AADT provide the most points for various shoulder widths. For example, for AADT ranges of 0 to 100, adequacy values range from two points for no shoulder to seven points for shoulder widths of 1 m (2 ft) or more. For AADT values of 1500 to 7000, shoulders of 1.2 m (4 ft) are assigned zero points, and seven points are given only for shoulders of 3.8 m (12 ft) and above. For roads over 1000 AADT, two points are deducted if shoulders are not paved or stabilized.

Figure 4. Point values for rating pavement width on two-lane roads.

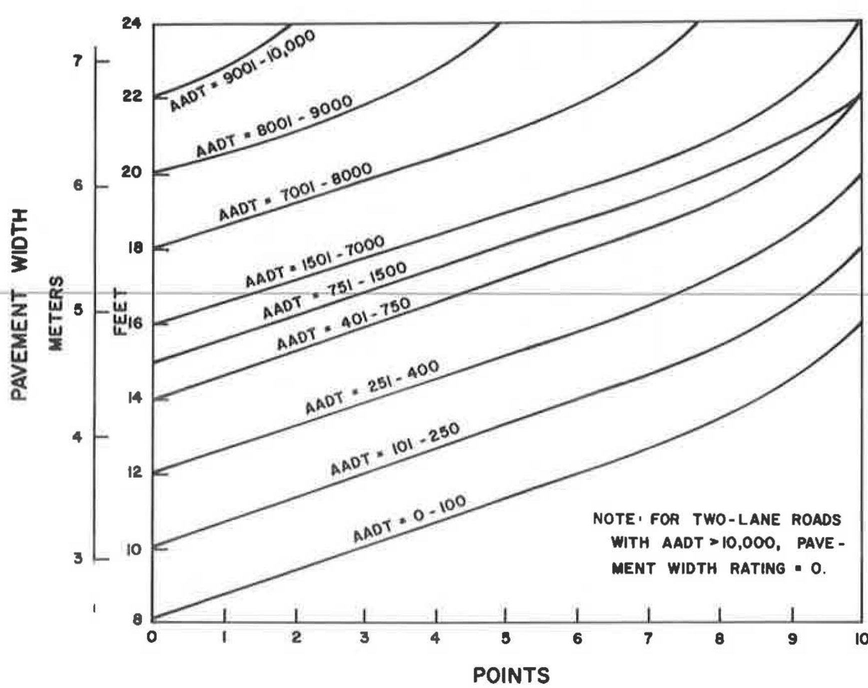


Figure 5. Point values for rating lane width on urban streets.

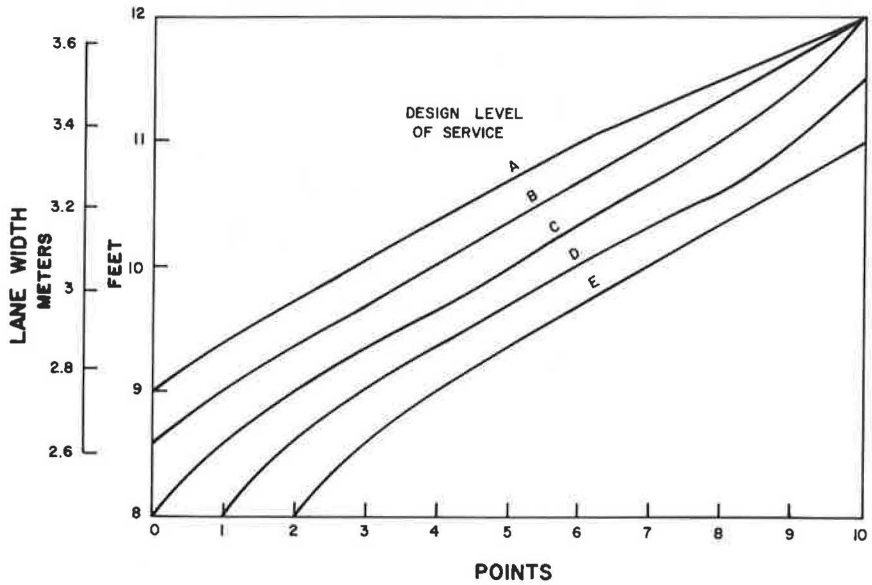
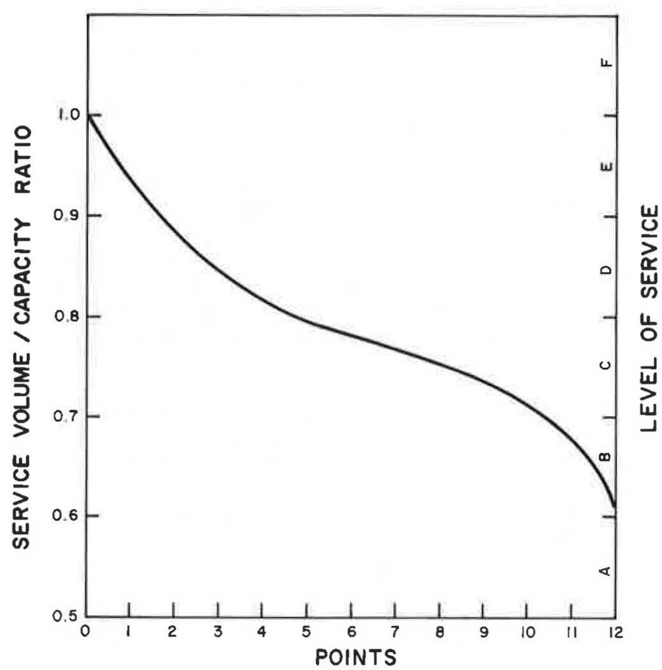


Figure 6. Point values for rating volume/capacity ratio on urban streets.



Another service element that was included for rural roads was passing opportunity (Figure 3). It is based on AADT and the percentage of passing-sight distance (PSD) on two-lane roads. Again, lower-volume roads are given more points than high-volume roads. For AADT values below 250, the maximum, eight points, is assigned for roads with a PSD of only 15 percent. Roads with AADTs above 8000 must have 100 percent PSD to obtain the eight-point maximum. Roads larger than two lanes get the maximum eight points, regardless of volume.

Rideability is a rural service element that is related to the road roughness and is a subjective rating made while driving over the section. The rideability rating is based on an S-curve, as was shown for foundation and surface condition, and carries a five-point maximum (Table 3).

Surface width is the most important service element (10-point maximum). Pavement widths of 2.5 to 7.2 m (8 to 24 ft) for two-lane roads were plotted against adequacy points as a function of AADT in Figure 4. A total of nine different volume ranges up to 10 000 were used for determining points. For two-lane roads with AADT values over 10 000, 0 points were assigned. For multilane, rural roads, another figure (not given here) was developed based on median width.

Urban Highways and Streets

As discussed previously, there are differences in driving conditions between urban and rural roads. On rural roads, desirable attributes include the opportunity to pass, adequate pavement width, wide shoulders, and a smooth pavement surface. On urban streets, the emphasis is on maintenance of acceptable speeds, avoidance of congested conditions, and an acceptable street width. The three service elements for urban areas include pavement width, V/C ratio, and average speed.

The relation between lane width and adequacy points on urban streets bears no resemblance to the curve for rural highways. The relationship was developed from level of service information provided in the Highway Capacity Manual (11). Up to 10 adequacy points are assigned to lane widths from 2.4 to 3.6 m (8 to 12 ft), as shown in Figure 5. Five different curves corresponding to levels of service A to E are provided. Kentucky's current design level of service is C for urban areas. Since design levels of service change, the figure provides for any such changes. As design level of service is lowered (such as from C to D), more adequacy points would be assigned for a given lane width.

The second service element for urban areas is the V/C ratio during peak traffic periods, which is worth up to 12 adequacy points (Figure 6). Again, information from the Highway Capacity Manual was used in the allocation of points (11). The S-shaped curve gives a high rating to V/C values below 0.7 (corresponding to levels of service A and B). Between 0.7 and 0.8, the points drop from about 10 to 4. When the volume equals or exceeds capacity (level of service E or F), no points are given.

Average traffic speed is the final urban service element and is based on eight points maximum (Figure 7). For business and downtown streets, speeds over 39 km/h (24 mph) correspond to the maximum eight points,

Figure 7. Point values for rating average speed of traffic on urban streets.

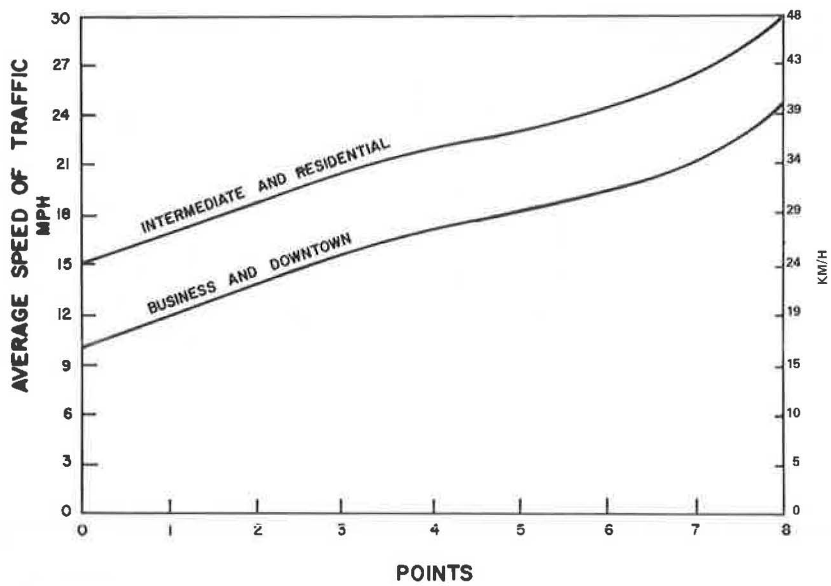


Figure 8. Example of computer output of adequacy ratings.

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CODE              ELEMENT                       POINTS

  A   FOUNDATION CONDITION (R, U )                10
  B   SURFACE CONDITION (R, U)                    10
  C   DRAINAGE CONDITION (R, U)                    8
  D   MAINTENANCE ECONOMY (R, U)                   7
  E   STOPPING SIGHT DISTANCE (R)                  8
  F   ACCIDENT DATA (R, U)                     12 OR 20
  G   SKID RESISTANCE (R)                          7
  H   ALIGNMENT (R)                                8
  I   SHOULDER WIDTH AND CONDITION (R)             7
  J   PASSING OPPORTUNITY (R)                      8
  K   RIDEABILITY (R)                              5
  L   SURFACE WIDTH (R, U)                        10
  M   TRAFFIC CONTROL DEVICES (U)                 15
  N   VOLUME/CAPACITY RATIO (U)                   12
  P   AVERAGE OVERALL SPEED (U)                    8

RURAL HIGHWAY SECTION

  6(10)A  + 5(10)B + 4(8)C + 3(7)D = 18(35)CONDITION
  2(8)E + 10(12)F + 4(7)G + 5(8)H  = 21(35)SAFETY
  6(7)I + 8(8)J + 2(5)K + 7(10)L   = 23(30)SERVICE

                                     62(100)TOTAL

URBAN HIGHWAY SECTION

  4(10)A + 8(10)B + 6(8)C + 7(7)D = 25(35)CONDITION
  18(20)F + 13(15)M               = 31(35)SAFETY
  11(12)N + 5(8)P + 10(10)L       = 26(30)SERVICE

                                    82(100)TOTAL

   R = RURAL, U = URBAN
   NUMBER IN FIRST POSITION INDICATES THE RATING
   NUMBER IN ( ) INDICATES MAXIMUM POINTS
     ALLOCATED TO THE ELEMENT
   LETTER INDICATES THE ELEMENT (SEE ABOVE AND
     TABLE 1)
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while speeds of 16 km/h (10 mph) or less get no points. For intermediate and residential streets, average speeds of 48 km/h (30 mph) are necessary to receive eight points. Speeds of 24 km/h (15 mph) or below get no points.

OUTPUT FORMAT FOR ADEQUACY RATINGS

Computerization of all information appearing in the figures and tables was a major recommendation for improvement of accuracy and efficiency of the rating program. The only input into the computer program is the raw data collected for each highway section. The output consists of a listing of assigned and maximum points for each element of the section along with the final adequacy rating.

To facilitate the implementation of such a computer printout, each of the 15 highway elements was assigned a letter code (A to P), as shown in Figure 8. Examples of printouts for rural and urban highway sections include

1. Each element used (designated by letter code);
2. Assigned points for each element;
3. Maximum points for each element (number in parentheses);
4. Subtotal points for condition, safety, and service; and
5. Final adequacy rating.

The example for rural highways (Figure 8) shows that the section received 18 of the 35 condition points. The breakdown of the 18 points is 6 points for foundation, 5 points for surface, 4 points for drainage, and 3 points for maintenance. The section also shows 21 out of 35 points for safety and 23 out of 30 points for service. The final adequacy rating was 62.

The example of an urban highway section cited in Figure 8 shows a rating of 82. The point distributions show that most elements rated high except for the foundation element, which received only 4. A final adequacy rating of below 70 may indicate a need for highway improvement.

The capabilities for an additional computer printout, which would contain raw data used to compute adequacy points, were also recommended. Included would be such information as lane width, accident rate, AADT, SN, PSD, V/C ratio, average speed, annual maintenance cost, and a word description of all subjectively rated elements.

SUMMARY AND CONCLUSIONS

A number of advantages may be expected from the use of the adequacy rating techniques described in this report. Computerization of the procedures will permit the coding of numbers from forms without the need for tables, graphs, and charts. Traffic-control devices in urban areas can then be rated quickly and easily. The inclusion of accident and skid resistance data will be accomplished by merging computer tapes with those of the adequacy rating. The total cost of the rating program will be reduced; much of the work will be done more quickly and efficiently with the aid of the computer. Faster updates of adequacy ratings will be possible.

Improved reliability of the results can also be expected from the revised techniques. Conversion from tables, charts, and graphs will no longer be done by hand. Human error, therefore, will be reduced. Skid resistance will be a measured determination rather than a subjective rating. Several important elements, such as accident experience, traffic safety features, and traffic-control devices, add to the overall data base of the adequacy ratings and, therefore, improve reliability of the rating. Another improvement is the revision of the figures and tables to meet current design criteria in Kentucky. The revisions incorporate 1978 standards.

The revised procedure involves simple addition of numbers for each element to obtain the final adequacy rating. Maximum points and assigned points may be printed on the output format so that the specific deficiencies can be quickly noted. Another simplification is the use of mileposts, reference numbers, and federal-aid route numbers for each section. This will permit easier site identification. The revised technique uses only two classifications of highway instead of three, since intermediate highway sections are to be designated as either urban or rural.

The addition of accident experience, traffic efficiency measures, and traffic-control devices was judged to be important. Skid resistance data (measured values) will also be added to replace the subjective evaluations. The revision of the lane-width factor would allow for modification of the adequacy rating for urban sections if the design level of service were to be changed.

The recommended adequacy rating procedures in this paper are currently being implemented by the Kentucky Department of Transportation.

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Determination of Priorities for Incremental Development of the MARTA System

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The Urban Mass Transportation Administration has recently established a policy for the incremental development of fixed-guideway transit systems. This policy necessitates the evaluation of system components and the subsequent assignment of priorities to system components. The Metropolitan Atlanta Rapid Transit Authority undertook a comparative analysis study to determine the most appropriate order of construction for its "referendum" rail system. This paper reviews the study methodologies and final results. The referendum system, excluding that currently under construction, was divided into 13 operational segments (11 rail and two busway). Analytical information was compiled for each segment, including expected patronage, estimated construction and operating costs, annual revenue, travel time, and various nonquantifiable data. Three criteria were employed in the evaluation of segments: cost efficiency, travel utility, and an index representing nonquantifiable factors. The study was performed in a series of iterative analyses based on sequential decisions. The following conclusions are made: (a) the concept