DEVELOPING PRIORITIES FOR STREET IMPROVEMENT PROGRAMS IN URBAN AREAS

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•SUPPORT AND RENEWAL of established communities, expansion of growing cities, and development of new towns will continue to occupy the energies of engineers and planners both in the private sector and at all levels of government. The choice of public works projects that are to be included in maintenance, renewal, and construction programs must be made within a framework of conflicting goals and objectives and with severe limitations on available resources. Both public and private officials must select the appropriate mixture of community facilities and improvements, including water and sewer systems, recreation and open space, lighting, street pavements, sidewalks, and curbs. As an example of the kind of problem involved in these areas, the selection of a reconstruction program for the street system within an urban renewal project is presented in some detail. The principles and techniques developed in this study may also be applied in the other areas mentioned.

The selection of a reconstruction program for the street system within an urban renewal project presents unique problems. On the one hand, the street system should be compatible with the comprehensive urban plan and consistent with the overall arterial and highway network. On the other hand, street improvements should reflect the internal objectives of the project and result in an improved level of satisfaction for the community.

This paper describes the development and application of a rational method for evaluating alternative street-improvement programs in urban renewal areas. The methodology was developed in response to a need for a program of street reconstruction that would result in the assignment of priorities but would be based on a careful evaluation of all the relevant factors involved. A numerical rating of each street, curb, and sidewalk element is produced, which permits all components to be listed in order of importance. The rating that is obtained for each street section is compared to a desired level of improvement. The difference between actual and desired conditions is a numerical measure of the improvement that can be achieved. The value is weighted to reflect the relative importance of each street section, and priorities for improvements are established by determining the improvement-cost ratio for each street section.

PRIORITY RATING SYSTEMS

Priority rating systems for urban and rural streets or highways have been the subject of extensive research and application. A review of prior work, however (1 through 21), indicates that primary emphasis has been placed on regional networks such as statewide rural road systems or urban arterial highways. While the general approaches suggested in these studies are appropriate here, they are not directly transferable for application in urban renewal areas where considerations of travel time savings, vehicle operating costs, accidents, and other user costs are not the most relevant variables for measuring the impact of proposed improvements.

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Most urban renewal areas are characterized by local and collector streets, alleys, sidewalks, and curbs, usually in various states of disrepair and deterioration. The residential character of these areas requires that through traffic be reduced or eliminated and that the internal street network be designed to foster moderate vehicle speeds and pedestrian safety. Community interest and involvement are high, and specific needs are usually vocalized by various groups representing many points of view. Furthermore, street-improvement programs must be closely coordinated with other necessary public improvements such as sewer and waterline additions; electric, gas, and related utility relocation; and community recreational facilities, including acquisition of street rights-of-way for parks and malls. Accordingly, the selection of appropriate sections of street rights-of-way and the required investment for each should be based on a measure of effectiveness that describes the level of community satisfaction and compares this with the cost required to reach that level.

We use the term "improvement factor", I, to describe the numerical measure of effectiveness for a street, sidewalk, or curb improvement. Thus I_s is the amount of improvement achieved for a specific street section as the result of a proposed level of investment. The incremental cost, C, required in order to achieve a desired level of improvement yields an incremental improvement-cost ratio, ICR. Rank ordering of the values of ICR for each improvement produces a priority rating schedule that can be used as the basis for developing a street improvement program within a stipulated budget constraint.

The following sections describe the development of the methodology and its application to an urban redevelopment project in Pittsburgh. The paper concludes with a discussion of the results and suggestions for further modification and research.

METHODOLOGY

The increased use of urban roadways and their rapid deterioration looms as one of the major contemporary urban problems. The age of many urban streets, poor maintenance, or total disrespect places the urban street deficiency problem clearly into focus. Attempts to solve the problem through piecemeal efforts, spot improvements, or planning that reacts to immediate pressure seldom provide the best long-term solution. On the other hand, a methodological and systematic approach begins to introduce a degree of objectivity and direction toward an optimal solution. Accordingly, a systematic approach to roadway improvements is necessary as a contribution toward a healthy community. In order to effect this goal, careful examination is required of the existing facilities. Understanding of the extent and seriousness of the road deficiencies must precede establishment of priorities for mitigation of the observed deficiencies.

Basic to the evaluation procedure is the numerical rating allotted to a particular physical facility. In this analysis the pavement, curbs, and sidewalks are considered to be the three fundamental components of an urban residential street. Rating each of these components separately permits a degree of importance to be attached to each element, and thus a graded ranking of adequacy is developed. This gradation is related to judgment concerning the importance of each component and, as such, serves as an evaluative measure ensuring realistic allocation of the numerical rating for each street element.

The categorization of the street components that are used in this study varies from very poor to excellent. With respect to cartway pavement, six categories have been selected for physical classification. They are defined as follows:

1. Very poor—Characterized by very pronounced alligator cracking, potholes, and patches. Very often the roadway is heaved and wavy. Such deterioration is in most cases indicative of base failure. Such a cartway necessarily provides a very rough ride.
2. Poor—Characterized approximately the same as a very poor cartway but to a lesser degree. Alligator cracking is less obvious, potholes are fewer, and horizontal and transverse cracking is more evident. The ride is not smooth.
3. Fair—Considered to be satisfactory. Basically the ride is smooth. Horizontal and transverse cracking is the major deficiency. Slight alligator cracking (hairline

cracks not yet separating the asphalt) can be noticed. Often square patchwork indicates some type of major repair work.

4. Good-fair—Characterized by a smooth cartway. Minor horizontal and transverse cracking is noticed. The crackings are straight and evenly spaced, which indicates a joint in the subsurface.

5. Good—Considered better than most roads found in either the city or the suburbs and can be compared to a recently completed resurfacing job. Little or no cracking can be found.

6. Excellent—Characterized by a newly constructed cartway. This classification is included merely to complete the numerical scale used in evaluation.

A similar breakdown is used to categorize street curbing. The ratings range from very poor to excellent. They are defined as follows:

1. Very poor—Characterized by absent and sunken sections and distinct misalignment. The edges are rounded, broken, and cracked. Curb reveal is 0 to 2 in.

2. Poor—Characterized by cracking and misalignment. Curb reveal is 2 to 4 in.

3. Fair—Considered acceptable in most cases, depending on the amount of reveal. The material is basically intact and not adversely aligned. Brakes and cracking are evident but present no problems. The overall appearance is satisfactory. Curb reveal is 4 to 6 in.

4. Good—Characterized as very acceptable with little or no cracking. Curb is level with proper alignment. Curb reveal is 6 to 8 in.

5. Excellent—Viewed as newly constructed curbing.

Evaluation of sidewalk sufficiency is not only concerned with the composition of the walkway but also considers the functional elements of the sidewalk as well. Five categories are used ranging from very poor to excellent as follows:

1. Very poor—Characterized often as impassable, overgrown with weeds, broken, uneven, discontinuous, and heaving.

2. Poor—Noted for its wavy character, dominant cracks, and advanced deterioration.

3. Fair—Characterized by beginning deterioration and presence of slight cracks and breaks. With a little maintenance and replacement, the condition can be deemed fully acceptable. The surface is relatively level.

4. Good—Considered to be very acceptable. The walking surface is level and free from discontinuities and breaks. Minor cracking is sparse.

5. Excellent—Viewed as a newly constructed sidewalk.

The descriptive categories of possible conditions for a cartway, curb, and sidewalk have been related by a numerical index that reflects the condition of the street components. Two factors are considered in the selection. First, the index must have a sufficient numerical spread to adequately delineate the observed deficiencies; and, second, the weight attached to each of the components should reflect their relative importance to the community.

Efforts to determine the relative importance of cartway, sidewalk, and curbing to community residents will probably continue for some time. As a first approximation, it is assumed that the relative importance of the cartway and the sidewalk-curb system is reflected in the cost and width of the two systems. Because a typical cartway is 24 ft wide and costs \$30 per foot, whereas a typical sidewalk-curb system is 16 ft wide (8 ft on each side of street) and costs \$28 per foot, the ratio of the numerical rating factors assigned to these systems is 24×30 to 16×28 or 1.6:1.0. For simplicity, a ratio of 2:1 has been adopted.

The maximum rating to be assigned to a perfect or newly constructed street is next determined. Sensitivity to the condition of each component is a criterion for the ordinal scale selected. Accordingly, a numerical range that distinguishes the individual differences among the facilities is used. The range from 0 to 450 meets the criterion and is also divisible by three and multiples thereof. Thus, 300 points are assignable to the cartway, and, for the sake of convenience (and tempered by the belief that the curbs contribute little to the utility of the walkway), it is appropriate to distribute the remaining points such that an excellent sidewalk is rated 100 and an excellent curbing is rated 50, of which 25 is allocated for physical condition and 25 for the amount of curb reveal.

The point system that evolved, as given in Table 1, delineates a base on which to rate existing physical conditions. The numerical rating for a street element is assigned after careful inspection of the element. This rating is subsequently modified, based on the frequency of particular deficiencies.

TABLE 1

EVALUATION INDEX FOR URBAN STREET FACILITIES

Condition	Cartway	Curb		Sidewalk
		Condition	Reveal	
Very poor	0 to 50	0 to 5	0 to 6	0 to 19
Poor	51 to 100	6 to 10	7 to 12	20 to 39
Fair	101 to 150	11 to 16	13 to 18	40 to 69
Good to fair	151 to 210	–	–	–
Good	211 to 270	17 to 22	19 to 24	70 to 95
Excellent	271 to 300	23 to 25	25	96 to 100

The advantage of using a numerical rating is that the rating is made relative to a standard; by computing the algebraic difference, a relative level of the deficiency can be derived. In most cases the standard is a totally sufficient or new physical facility. Deviation from the standard places the degree of deficiency of the facility into perspective. Furthermore, upgrading to a physical condition slightly less than totally sufficient is also a feasible alternative. In this case the algebraic difference again points up the degree of deficiency but in relation to a lower standard. Major importance is attributed not to the standard chosen in the development of the rating system but to the proposed level of improvement. The difference between the present rating and the proposed rating or incremental improvement remains the key in the development of priorities.

A further factor in the development of priorities is the significance of each particular facility to the community. Ideally an importance factor would be assigned to each facility to reflect community goals and objectives. If a community favored improvement of elements associated with residential streets rather than arterials, for example, higher factors would be assigned to the former. In the absence of specific statements of community objectives, it can be assumed that importance factors should be proportional to frequency of use by either pedestrians or vehicular passengers or preferably both. A weighting of this type attempts to make distinct the most beneficial improvements by raising the numerical value of the incremental improvement and influencing the priority rankings. The product of the incremental improvement and the importance factor is the weighted improvement factor.

The attainment of a priority listing is facilitated by the consideration of the economics of each improvement. Every degree of physical improvement has a cost associated with it. This cost is evasive unless it is viewed as cost per unit of improvement. In this sense the improvement-cost ratio provides a sound foundation for the development of priority rankings. Arrangement in order of decreasing improvement-cost ratios allows the maximization of community benefit at minimum cost.

In summary, the approach discussed here is to categorize the existing facilities, develop a numerical index of the deficiencies, establish the importance of the proposed improvements, and determine priorities for each facility that maximize community benefit. Mathematically, the model takes the form

$$\text{Priority index} = \frac{R_I - R_E}{C} W = \frac{IW}{C}$$

where

R_I = numerical rating of the improved condition of the facility;
R_E = numerical rating of the existing condition of the facility;
W = numerical weighting factor representing the relative importance of the facility;
C = incremental cost to effect the proposed improvement; and
I = numerical measure of incremental improvement, $R_I - R_E$.

The process can be illustrated in the flow chart shown in Figure 1.

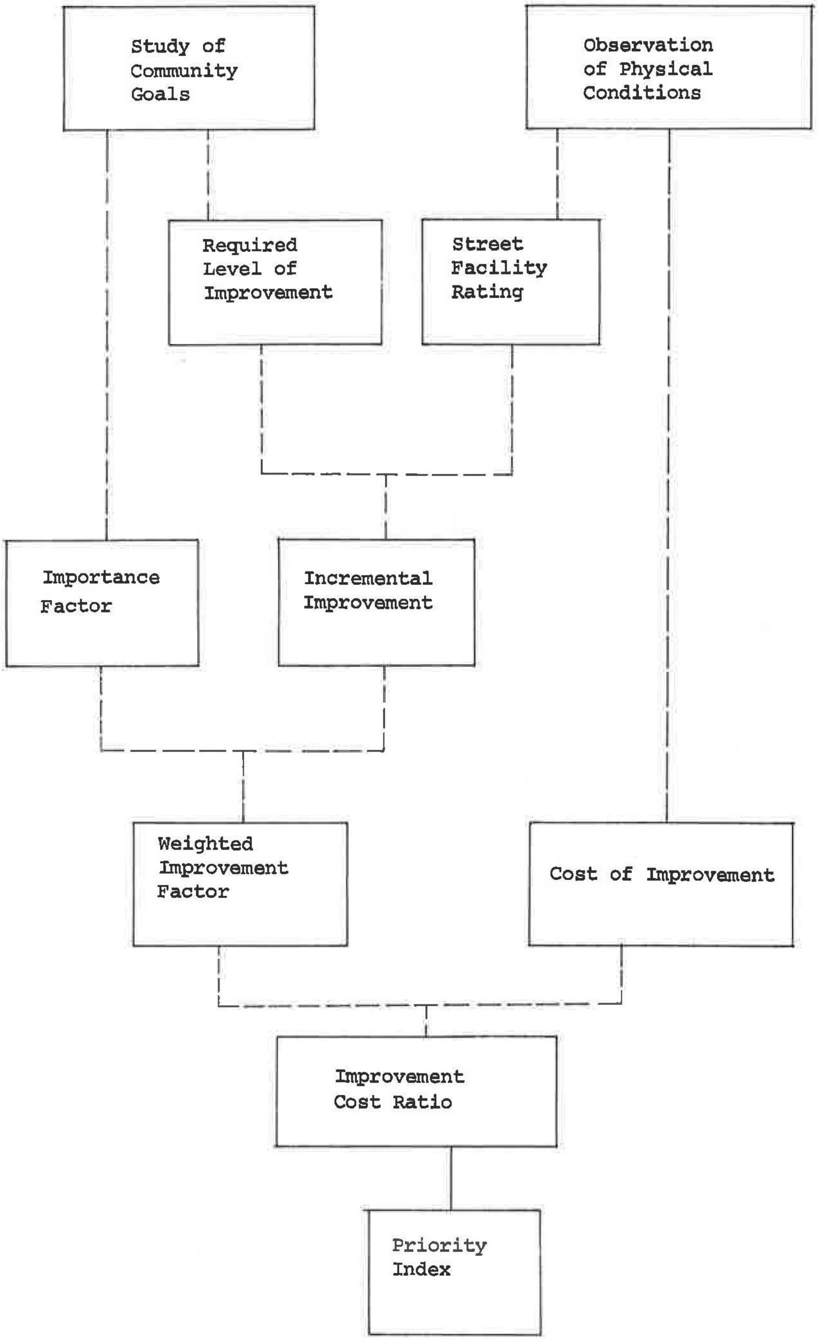

Figure 1. Development of priorities for street improvements.

APPLICATION

The application of the methodology for rating street-improvement projects is illustrated by reference to a specific urban redevelopment project: the Manchester Conservation Area in Pittsburgh, Pennsylvania. Manchester is a declining residential community located approximately 1.5 miles northeast of Pittsburgh's downtown area. The community, which was at one time a fashionable residential area of architecturally significant single-family homes, today is an area of low-income, multifamily dwellings. Manchester is predominantly black, and local groups have organized to plan its rebirth as a viable self-sufficient community. The conservation project for Manchester was to include reconstruction and rehabilitation of housing and the necessary public improvements (i. e., water, sewer, streets, and parks). Approximately 75 percent of the total budget was allocated to improving housing and the remainder to meeting public works needs, of which streets are a major part.

The first step in the development of a priority list for work proposed in the Manchester Area was the assignment of numerical ratings for the present condition of each of the various street elements (pavement, sidewalk, and curbing) of each definable street segment. Because the condition of various adjacent blocks in a given street was similar in many cases, it was possible to define segments consisting of more than one block. In all, 116 segments were considered although some of these were later combined to form larger subprojects.

A physical inventory of each street section provided the basic data for the study. Every section of sidewalk, curb, and cartway was classified into a general category ranging from very poor to excellent. In addition, a more precise numerical rating for each physical facility was developed from detailed field notes. The field notes provided information that could be used to modify the general rating and, thus, allow a more meaningful measure of a facility's condition. Specifically, they describe the deficiencies, including the number and size of cracks and potholes, the amount of curb reveal, the material makeup of the facilities, and other noteworthy characteristics.

The translation of the cartway classifications into a graded numerical scale consists of a procedure in which "quality points" are subtracted from the basic rating depending on the type of deficiencies observed. These deficiencies include horizontal and transverse cracking, alligator cracking, patches, potholes, sunken areas, and outdated material makeup such as brick or Belgian block. (In most cases, a brick or block cartway is heaved and uneven so that a need arises to compensate for it.) The degree of the deficiency is noted as (+) for highly deficient, (0) for moderately deficient, and (-) for slightly deficient. [With respect to potholes, for example, the maximum number found on a particular street was five, thus (+) indicated five potholes, (0) indicated three potholes, and (-) indicated one pothole.] The point value for each deficiency is given in Table 2.

Because of city maintenance programs, cartway resurfacing programs, and public concern and awareness over roads in disrepair, cartway deficiencies are obvious and can be singled out. This was not the case, however, for sidewalks and curbs where the accumulation of years of service, compounded by spot repair, made it nearly impossible to record the number of faults. Thus, for the evaluation of sidewalks and curbs it was found to be advantageous to use an average of the point spread for each general classification (Table 3).

To illustrate the use of this system, consider the evaluation of Bidwell Street from Liverpool to Pennsylvania (Table 4). The cartway was rated as very, very poor ("very, very" was used merely to stress the fact that the cartway was one of the worst). The rating yields a basic point value of 50, and the accompanying field notes (not shown in this table) indicated that each deficiency was

TABLE 2
DEFICIENCY SCALE FOR CARTWAYS IN MANCHESTER

Deficiency	Highly Deficient (+)	Moderately Deficient (0)	Slightly Deficient (-)
Alligator cracking	-10	-7	-4
Horizontal and transverse cracking	-10	-7	-4
Potholes	-20	-13	-6
Patches	-10	-7	-4
Sunken areas		-10	
Brick material		-10	
Block material		-15	

TABLE 3

EVALUATION VALUES FOR SIDEWALKS AND CURBS IN MANCHESTER

Facility	Very Poor	Poor	Fair	Good	Excellent
Sidewalk	10	30	50	88	98
Curb					
Condition	2	8	14	20	24
Reveal	3	10	16	22	—
	(0 to 2 in.)	(2 to 4 in.)	(4 to 6 in.)	(6 to 8 in.)	—

judged to be moderate, i. e. (0). The final rating is obtained as (50 - 34) = 16. The sidewalk shows a rating of 75 percent poor and 25 percent fair, resulting in a point rating of 35.

Finally, a fair-to-poor curb with a 3 to 6 in. reveal is assigned a rating of 25. The derivation of this figure is as follows: Poor to fair spans a range of 6 to 16 having an average of 11 points; reveal of 3 to 6 in. ranges from 10 to 18 with an average of 14 points. The rating of the entire section is 65 out of a possible 450.

The future serviceability of an upgraded facility is assigned a numerical rating, and the difference between the two ratings is termed incremental improvement. The assignment of several degrees of improvement to a particular facility implies that the facility can have alternative programs of improvement. Each of these alternatives is considered separately and finds its way into the priority listing. The Manchester analysis considers three alternatives for cartways: (a) sealing and patching on roads that need minimum work, (b) resurfacing, and (c) reconstruction. The decision to assign 270 quality points to a renovated cartway is arbitrary and based on the maximum rating of 300 points. Sidewalk-improvement programs consider two levels of improvement: (a) reconstruction to level 100, and (b) general upgrading of partial replacement and patching to 90. Similarly, curbs can be improved to a rating of 40 or 50.

After the incremental improvement is determined for each facility, the development of priorities hinges on the use of an improvement-cost ratio. The incremental improvement used in this ratio, taken to be a measure of benefit, must take into account the relative importance of the facility. Indicative of this importance is the use of the facility. Traffic counts taken for the Manchester area delineate those facilities most used. The traffic counts are used to group the area streets into six divisions—each corresponding to a particular traffic volume and design traffic number. The importance factors devised are nearly equal to the design traffic number used by The Asphalt Institute in roadway design. These and the importance factors are given in Table 5. The product of the incremental improvement and the importance factor yields the weighted improvement factor—the numerator of the improvement-cost ratio.

TABLE 4

TYPICAL RATING SHEET FOR STREET COMPONENTS IN MANCHESTER

Street	From-To	Section (ft)	Right-of-Way (ft)	Cartway			Sidewalk			Curb			Rating		
				Width (ft)	Material	Condition	Width (ft)	Material (percent)	Condition	Reveal (in.)	Material	Condition	Cartway	Sidewalk	Curb
Abdell	Bidwell-Allegheny	270	35	22.5	A	Very poor	5.5	50 C 25 C 25 B	Good Fair Poor	0 to 4	G	Fair	30	43 13 7	14 6
Adams	Manhattan-Boundary	610	60	36	A	Fair	10N 10.5S	40 C 40 B 20 A	Fair to poor Fair to poor Good	1 to 2	G	Poor	143	16 16 18	8 4
Beech	Riggo-Allegheny	140	20	20	B A/B	Poor	—	—	—	—	—	—	83	0	0
Beymer	Bidwell-End			—	—	—	—	—	—	—	—	—	—	—	—
Bidwell	Liverpool-Pennsylvania	340	40	24.5	A	Very, very poor	8	75 B 25 A	Poor Fair	3 to 6	G	Fair to poor	16	23 12	11 14

TABLE 5

IMPORTANCE FACTORS AND RELATED DATA FOR MANCHESTER

Street Type	Traffic Volume (vehicle/day)	Design Traffic Number	Importance Factor
Major carrier	5,000 to 7,500	20 to 40	30 to 40
Major access	3,500	15	20
Residential feeder	2,000	10	10
Residential	1,000	5	6
Minor	500	2	2
Alley	200	1	1

TABLE 6

TYPICAL COMPUTATION OF RATINGS AND IMPROVEMENT-COST RATIOS FOR PROJECTS PROPOSED FOR MANCHESTER AREA

Street Segment (1)	Facility (2)	Rating of Existing Facility (3)	Type of Improvement (4)	Rating of Improved Facility (5)	Improvement Factor (col. 5 - col. 3) (6)	Importance Factor (7)	Weighted Improvement Factor (col. 7 × col. 6) (8)	Unit Cost (dollars/ft) (9)	Improvement-Cost Ratio (col. 8 ÷ col. 9) (10)
14e	Cartway	93	Replacement	300	207	6	1,242	42.83	29
14e	Cartway	93	Seal and patch	270	167	6	1,002	9.03	111
14e	Sidewalk	54	Replacement	100	46	6	276	8.00	34
14e	Sidewalk	54	Patching	90	36	6	216	2.00	108
14e	Curb	13	Partial replacement	50	37	6	222	7.93	28
15a	Cartway	30	Replacement	300	270	1	270	16.90	16
15a	Sidewalk	0	Replacement	100	100	1	100	8.00	12

Given particular levels of improvement for each physical facility, the costs involved are easily obtained. Current construction costs for each improvement program based on readily obtainable unit prices are estimated.

An attempt is made to itemize realistically each facet of the improvement program for a particular facility. In reconstruction, the cost of grading, backfilling, and replacement were considered. Whenever appropriate, a percentage of the unit cost corresponding to the percentage replacement (for improvements other than total reconstruction) is used. The unit costs developed represent the last raw data required for the listing of improvements in order of priority. Table 6 gives a typical set of computations to obtain improvement-cost ratios.

Benefit-cost analyses of the type used here seek to maximize the return per dollar expended. The improvement-cost ratio details the benefit per dollar spent and, in so doing, forms the backbone of a priority ranking. A listing of each physical improvement in order of decreasing improvement-cost ratios defines a schedule for improvements that maximizes community benefit. This priority listing is invaluable when limited funds restrict complete revamping of an area.

The efficacy of the priority listing is enhanced by a cumulative cost figure adjacent to each element of the listing. This figure serves as an indication of the total amount expended to that point in the improvement schedule. When budgetary restraint is a factor, it further serves to suggest a break-off point for the improvement program. Because of the alternative improvements considered for some facilities, caution is exercised in the development of the cumulative cost. A need exists to subtract the cost of a prior improvement when a second alternative is reached. The priority ranking, thus, directs a program of improvement toward the maximization of benefit.

SUMMARY

The decision concerning the appropriate street-construction program for urban renewal projects depends in part on the benefits or improvements associated with each level of expenditure considered. Accordingly, a systematic method of selecting the projects to be associated with a given level of spending has been developed. The method assigns priority numbers to proposed improvements on the basis of the improvement-cost ratio of each. By selecting projects on the basis of the amount of improvement

per unit cost, the benefits to be realized at a given expenditure level are clearly understood.

Improvement factor is defined as the difference between the sufficiency rating corresponding to the present condition of a street element and the rating corresponding to the improved condition. Improvement factors are weighted by importance factors that reflect the relative importance of specific street elements. Weighted improvement factors and costs per foot are used in computing improvement-cost ratios. Aside from indicating which projects should be supported by a given amount of money, the priority list can be used to schedule the work in such a way that the return per dollar spent will be maximized even if funds are cut back.

The priority assignment procedure developed was illustrated by a description of its application to the Manchester Renewal Project in Pittsburgh. The results obtained in that study indicated that a rational method for establishing priorities can assist decision-makers and assure the community that the available funds are being judiciously allocated. The techniques and principles developed may also assist in setting priorities for maintenance and construction programs in smaller communities and new towns.

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