Evaluation of Pedestrian Facilities: Beyond the Level-of-Service Concept

C. JOTIN KHISTY

For designing and evaluating pedestrian facilities, the 1985 *Highway Capacity Manual* (HCM) provides guidelines similar to those for vehicular flow, using the concept of level of service. It also recommends that additional environmental factors that contribute to the walking experience and therefore to the perceived level of service, such as comfort, convenience, safety, security, and attractiveness, also be considered. However, no guidelines are given on how to measure or use these environmental factors for designing and assessing pedestrian facilities. There is no question that environmental factors are of paramount importance for designing and assessing such facilities, because pedestrians, unlike motor vehicles, have practically no control over most of these factors. A practical method of assessing pedestrian facilities is described that takes into account several environmental factors observed by independent groups who are familiar with the situation being assessed. Assessment of the environmental factors is accomplished through suitable performance measures, and these in turn provide the operating characteristics and the qualitative level of service of the facility being assessed as perceived by its users. This qualitative level of service can then supplement the quantitative level of service of the facility on the basis of flow, speed, and density units, as described in the HCM. The methodology described can be most useful in monitoring and comparing the performance of such facilities as well as in allocating the budget for changes and improvements. A practical application of the methodology is described using seven performance measures: attractiveness, comfort, convenience, safety, security, system coherence, and system continuity. The methodology is quick, easy, and inexpensive to use.

Traffic standards for pedestrian facilities have been developed over the last 20 years by several researchers on the basis of empirical studies of pedestrian movement. These standards define flow relationships in terms of various speed levels and average personal space, classified into various levels of service, ranging from Level-of-Service (LOS) A to F, with LOS A representing the threshold of unimpeded free flow (considered the best) and F at critical density or breakdown of movement continuity (considered the worst). The level of service determined in this way can be considered as the quantitative one.

The LOS concept was first developed by traffic engineers for vehicular capacity studies connected with street and highway design. It is a powerful quantitative tool for planning, designing, and assessing transportation facilities serving vehicular movement. It was therefore not surprising that engineers and planners adopted the LOS concept for designing pedestrian facilities also. Pedestrian capacity analysis is a relatively new area of study, beginning with Fruin's Pedestrian Planning and Design in 1971 (*1*). In recent years the 1985 *Highway Capacity Manual* (HCM) has provided guidelines for designing walkways, crosswalks, and street corners using the LOS concept (*2*).

The HCM acknowledges that pedestrian facilities are far more complex to design as compared with vehicle facilities, although the LOS concept is used in both cases. Although the quantitative measures of flow, density, and speed affect such convenience factors as the ability to select walking speeds, bypass slower pedestrians, and avoid conflicts, the HCM makes it abundantly clear that additional environmental factors, such as comfort, convenience, safety, security, and the economy of the walking system, should be taken into account because these factors contribute to the walking experience and ultimately to the perceived level of service. However, no guidelines are given on how to measure or make use of these environmental factors in designing or assessing pedestrian facilities.

These environmental factors can have an important effect on a pedestrian's perception of the overall quality of the street environment. Whereas automobile drivers sitting comfortably in their vehicles have reasonable control over most of these factors mentioned, pedestrians, without the protection of the metal shell, have virtually no control. It is for this reason that the qualitative environmental factors appear to be as important as the quantitative flow, speed, and density factors in planning, designing, and evaluating pedestrian facilities. A practical method of taking into account environmental factors, and thus determining the qualitative level of service of a facility, is described on an individual link-by-link basis or at an overall systems level. Examples showing how the methodology is applied in a real-world situation are provided. It may be noted that it is not the intent of this paper to convey the notion that the qualitative level of service as described in this paper is a substitute for the quantitative LOS as explained in the HCM. On the contrary, both the quantitative and the qualitative levels of service clearly supplement each other.

COMPLEXITY OF ASSESSING PEDESTRIAN MOVEMENT

The deceptive simplicity of pedestrian movement on such facilities as streets, highways, malls, stairs, and ramps has led many reserchers to concentrate their attention almost exclusively on the flow-speed-density relationship for designing and evaluating pedestrian facilities. Several other researchers, mostly from the social sciences, have since identified major concerns with this practice of treating humans as vehicular units. Hill provides a comprehensive survey of the results of these investigations (*3*).

A particularly interesting conceptualization of pedestrian movement is presented by Goffman (*4*). He observes that vehicles using highways and streets are distinguished by the strength and thickness of their outer metal shells. Viewed in contrast, the pedestrian moving across and along streets is encased in a soft and exposed "shell," namely, his or her clothes and skin, and is thus amazingly vulnerable to injury and possible death. However, despite

Illinois Institute of Technology, Chicago, Ill. 60616.

the fact that pedestrians are often forced to share the road with motor vehicles, they possess some characteristics that are truly unique. Goffman notes that "pedestrians can twist, duck, bend and turn sharply and therefore, unlike motorists, can safely count on being able to extricate themselves in the last few milliseconds before impending impact." Should two pedestrians collide, he continues, damage is not likely to be significant, whereas collision between a pedestrian and a car is most likely to result in instant death.

The bottom line is that the built environment can be considered to consist of interrelated geographic, social, and cultural components that afford certain behaviors in consistent ways. Indeed, there is an invitational quality about a well-designed pedestrian facility, the characteristics of which go far beyond the flow-speed-density measurements. Saarinen (*5*) suggests that some facilities that form part of the built environment, such as freeways and railroad tracks, are designed more for the successful functioning of vehicles than for people. In contrast, factors such as convenience and comfort are paramount when malls, sidewalks, elevators, stairs, and transit stations are designed. He labels the former facilities as "anthropozemic" and the latter "anthropophilic." In anthropozemic settings, people and the vehicles they use have to adapt to the built, sterile, and nonhuman conditions provided; in anthropophilic settings, the built environment has to be designed to adapt to the needs of human beings. Figure 1 supports the reason why the design and evaluation of pedestrian facilities cannot be performed in the same manner as that for freeways or pipelines (*6*).

METHODOLOGY

As has been noted, the level of service is the overall measure of all service characteristics that affect users of a system. The HCM provides guidelines for evaluating level of service, based primarily on performance elements, such as flow, speed, and density. In addition it is necessary, as pointed out before, that qualitative elements, such as attractiveness, comfort, convenience, security, and safety, be taken into account. The combined effects of these two categories of performance measures—the quantitative and the qualitative—contribute to the level of service of a particular facility.

An evaluation methodology is developed for the assessment of the qualitative elements of facilities used by pedestrians by independent observers familiar with the situation. These facilities include those used exclusively by pedestrians as well as those used jointly with other modes of transportation, that is, Regions 2 and 3 in Figure 1.

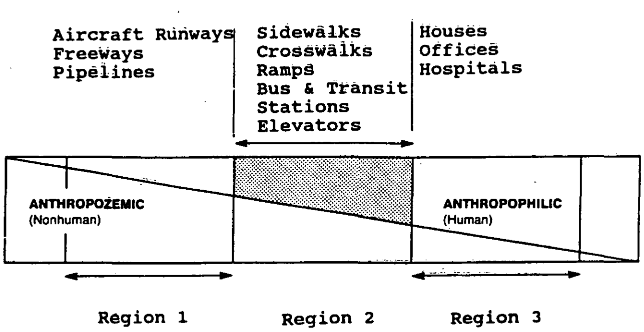

FIGURE 1 Anthropozemic and anthropophilic transportation facilities.

The basic input to the task of selecting potential performance measures (PMs) for assessing the environmental factors was derived from a literature review of traffic engineering and environmental psychology. Nearly 20 different PMs were extracted from this review and reduced by elmination (on the basis of duplication, relevance, and data availability) to 7. They are, in alphabetical order, attractiveness, comfort, convenience, safety, security, system coherence, and system continuity. The next two tasks were (*a*) to describe as accurately as possible what each PM represented and to measure them on a scale of A through F, with A representing the best and F the worst, and (*b*) to apply a weighting factor methodology that would rank order the perceived importance of the PMs for use in evaluation (*7*).

Performance Measures

A brief description of the seven PMs follows:

1. *Attractiveness*: This PM encompasses much more than aesthetic design. The PM goes far beyond the manifest or instrumental functions of safety, convenience, and comfort by considering latent functions, such as pleasure, delight, interest, and exploration.
2. *Comfort*: Such factors as weather protection, climate control, properly designed shelters, condition of walking surface, cleanliness of terminals, and provision of adequate seating arrangements can be considered to provide comfort. One could even include such factors as odor, ventilation, noise, vibration, and crowding.
3. *Convenience*: Walking distances connected with attributes such as pathway directness, grades, sidewalk ramp locations, directional signing, activity maps and directories, convenient connections between frequently used locations, and other features making walking easy and uncomplicated are qualities of convenience. Sidewalk obstructions and circuitous trip linkages are considered a source of inconvenience to pedestrians. Properly ramped curb cuts for the handicapped and tactile trails for the blind are considered assets.
4. *Safety*: The reduction of pedestrian-vehicle conflicts can be considered a basic factor promoting safety. Ease of movement in walking, even in vehicle-free areas such as malls, passageways, sidewalks, stairs, elevators, ramps, and escalators, is considered part of safety. Particularly in heavily trafficked street networks, the provision of properly designed control devices, providing adequate time and space separation from vehicular movement is an essential part of safety.
5. *Security*: The ability to provide pedestrian facilities that provide clear observation by the public and the police through unobstructed lines of sight, good lighting, absence of concealed areas, and television surveillance is considered a measure of good performance. The pedestrian should feel reasonably safe and secure, commensurate with the neighborhood and level of street activity prevailing.
6. *System Coherence*: Mental imagery and selectivity play a major role in perceiving and understanding the world of time and space. For instance, an able-bodied pedestrian using an unfamiliar street system would generally be looking impatiently for primary orientation and direction in reaching his or her destination rather

than admiring the aesthetics of the setting, particularly if it was getting dark and the street lighting was not adequate. There is a strong correlation between activity systems and the cognitive images people have of the physical environment. Distortion in imagery reflects and affects the perceptions people have of such things as the location of shops, parks, and other facilities. Even the perception of the distance of facilities is affected by such things as the geometry of paths. A path that is circuitous or full of junctions is perceived to be longer than one of the same length that is straight.

7. *System Continuity*: A well-designed pedestrian system may have all the attributes alluded to in the PMs mentioned earlier but lack an essential feature of continuity and connectivity. Continuity is particularly important for multimodal facilities connected to pedestrian paths that unify the system efficiently.

The next step was to prioritize the seven PMs and to assign weights to each. This was done by applying a weighting-factor methodology.

Weighting Factors

The constant-sum, paired-comparison method is a systematic approach for determining the relative importance of each of a large number of factors, using group consensus. Thus, not only is a ranking of factors by importance obtained, but also the relative importance or weight of each factor with respect to all other factors is found. As an example, Figure 2 shows a simple matrix that indicates all possible pair comparisons (A versus B, A versus C, A versus D, B versus A, and so on). Each respondent is asked to distribute a constant bundle of values (in this case, 10) between each pair of factors. If a respondent believes that Factor A is far more important than Factor B, a score of 10 for Factor A and a score of 0 for Factor B are noted in the cell (Row 1, Column 2). If, on the other hand, the respondent believes that Factor A is about equal to Factor C, the score would be 5 for A and 5 for C (Row 1, Column 3). The bottom left portion of the matrix is simply the mirror image of the top right portion.

The scores for the factors listed on the left side of the matrix are then summed for each row (e.g., the bottom portion of row A is 10 + 5 + 6 = 21). The sum of rows is taken (21 + 5 + 18 + 16 = 60) and used to normalize each of the row sums as shown in Figure 2. For a group response, the mean and standard deviations of the values may be determined to obtain the consensus or profile of the group. In this hypothetical case, Factors A, C, D, and B carry weights of 0.4, 0.35, 0.20, and 0.15, respectively, in descending order of importance. The mean and standard deviation of the group response can be plotted as shown in Figure 3, which provides a feel for the group's priorities.

APPLICATION OF METHODOLOGY

The Illinois Institute of Technology (IIT) campus was chosen as the setting for applying the methodology described in the previous section because the campus provides some interesting features. The 120-acre main campus is located in Chicago, about 3 mi south of the Downtown Loop, and is accessible by car and by public transportation (bus and train). The master plan of the main campus and the architecture of many of its 50 buildings were developed by Ludwig Mies van der Rohe, one of the century's most influential architects and city planners, and for 20 years the chairman of IIT's Department of Architecture. The bulk of the campus is located between 31st and 35th streets, running east to west, and between the Metra rail lines and Michigan Avenue, running north-south. South State Street, a four-lane divided highway running north to south, cuts the campus into two halves, with the parking lots located in the western half. The average daily traffic throughout the day is moderate except during the morning and evening peak hours. Six hundred survey forms were distributed to students, staff, and faculty during the spring and early summer of 1993 to apply the constant-sum, paired-comparison methodology, as described next.

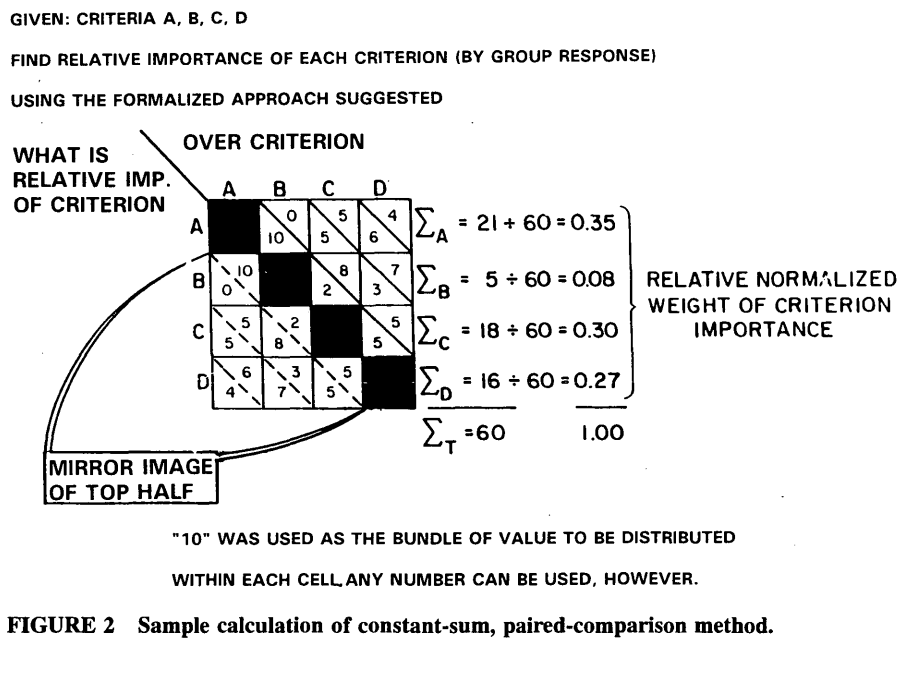

FIGURE 2 Sample calculation of constant-sum, paired-comparison method.

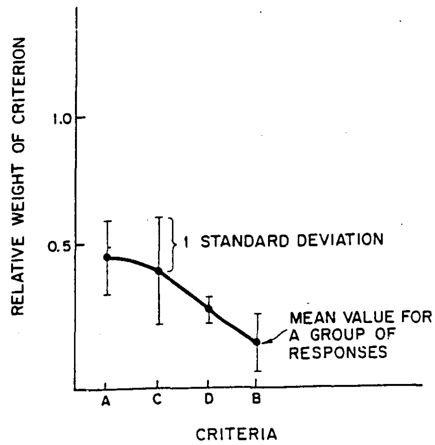

FIGURE 3 Conceptual plot of group of respondents.

RESULTS

Before applying the weighting-factor methodology, it was necessary to measure the seven PMs on a 5-point scale from LOS A = 5 (the best) to LOS F = 0 (the worst), as shown in Table 1. On the basis of a preliminary survey, this type of scaling and assignment of points not only coincided with the setup of having six levels of service as used in the HCM, but also seemed to be a pragmatic way of measuring the feeling of satisfaction or dissatisfaction expressed by the public while using the facility in question.

The application of the constant-sum, paired-comparison methodology to the seven selected PMs was taken up next and yielded the results shown in Table 2, which were based on responses from 320 valid survey forms received from the 600 distributed regular users of the IIT pedestrian system. An examination of the ranking and weighting indicated that the results were logical and consistent with the perceived values of the population. It is, of course, possible to do a more extensive survey on a broader systemwide basis and revise the weights and ranking as deemed necessary.

The results of the survey provided the level of service for 15 different routes and segments of routes on the IIT campus. For the purposes of this paper, however, the results for only two routes are given. The first results are for the path from the western half of the campus to the eastern half of the campus, where the parking lots are located. Although the security aspect of the lots is more than adequate (with the provision of police surveillance and well-lighted paths), users have to cross a four-lane divided street, with moderate traffic during most of the day, but with no pedestrian signals or markings. Particularly during inclement weather, the use of this route is unsatisfactory, because the vibration and intense noise of frequent trains on the elevated tracks just above the parking lots are most disconcerting. Also, the puddles of water on the street as well as in the parking lots are bad. The overall grand total score of 2.32 as shown in Table 3 truly reflects LOS D.

The second route results were for the sidewalks on the main campus, which are very well maintained and on which walking is a pleasure. Security may be a problem after dusk, but police surveillance is adequate for the most part. A total score of 4.35 as indicated in Table 4 shows that the level of service is better than B.

A summary of the procedure developed and applied is as follows:

Step 1: Choose a set of PMs with the help of a committee of people familiar with the site under investigation. It does not matter at this stage if the set is large; 7 to 10 is a reasonable number.

Step 2: Apply the constant-sum, paired-comparison method to determine the relative weight of each factor. For a group response, determine the size of the group by applying standard statistical methods. Determine the mean and standard deviation of the PMs.

TABLE 1 Measurement of PMs on 5-Point Scale

LOS A	greater or equal to	85% satisfied	= 5 points
LOS B	greater or equal to	60% satisfied	= 4 points
LOS C	greater or equal to	45% satisfied	= 3 points
LOS D	greater or equal to	30% satisfied	= 2 points
LOS E	greater or equal to	15% satisfied	= 1 point
LOS E	less than	15% satisfied	= 0 points

TABLE 2 Rank and Weight of PMs

Rank	Performance Measure	Mean	Std Dev	% Wt:
1	Security	0.354	0.120	35
2	Safety	0.241	0.108	24
3	Comfort	0.101	0.032	10
4	Convenience	0.092	0.049	9
5	Attractiveness	0.080	0.048	8
6	System Coherence	0.071	0.029	7
7	System Continuity	0.061	0.027	6
		1.000		100

TABLE 3 Route from IIT West Campus to Parking Lots on East Campus

Performance Measure	% Satisfied	LOS	Points	Wt	Total
Attractiveness	21	E	1	0.08	0.08
Comfort	22	E	1	0.10	0.10
Convenience	33	D	2	0.09	0.18
Safety	16	E	1	0.24	0.24
Security	61	B	4	0.35	0.35
System Coherence	42	D	2	0.07	0.14
System Continuity	48	C	3	0.06	0.18
		Grand total			2.32

The overall environmental LOS is slightly better than a D

Step 3: Examine the results of Step 2 and list candidate PMs by priority and weights. If necessary, reduce the number of PMs if any of the weights are too low in comparison with the ones with higher weights.

Step 4: Adopt a 5-point scale for the six levels of service.

Step 5: Choose routes (or segments of routes) that need to be evaluated, and administer a survey to persons who use the pedestrian system on a regular basis. On the basis of the percentage of respondents who are satisfied with the route (or segment of the route), (*a*) assign a level of service to each chosen PM, (*b*) assign a point value to each level of service (A = 5 through F = 0), (*c*) assign a weight to each PM from Step 3, (*d*) multiply the points by weights for each PM, (*e*) add the product of each PM to obtain a grand total, and (*f*) assign a level of service to this grand total.

USES, BENEFITS, AND CAVEATS

The evaluation of pedestrian facilities is now recognized as an important tool in improving the total transportation system. Used effectively, it can greatly enhance the efficiency and image of the system. Public involvement in selecting, priority ranking, and weighting PMs is a crucial part of the evaluation process, and therefore the potential uses and benefits of the methodology should be made known to those involved with the process.

There appear to be at least four primary applications of this methodology. First, the results can be used as a tool to guide decision makers in evaluating the quality of pedestrian facilities over and beyond the quantitative measures of flow, speed, and density, as elaborated in the HCM. Second, the results identify what can be considered an ideal route or benchmark with which other routes can be compared on the basis of either individual attributes or aggregate values. The third primary application is as a planning tool to develop future routes and overall perspectives for the system. The fourth application is for use in budgeting funds for route improvements. There are probably other uses as well.

The need for further refinement and verification of the research methodology described here is clearly indicated. The PMs must be used over a period of time to verify that they are methodologically appropriate and that the results they produce truly reflect the quality of pedestrian service being provided. The ranges of values proposed for the various measures must also be verified and refined, if needed.

It should be clearly understood that the level of service obtained by using PMs does not in any way invalidate the quantitative level of service calculated using the guidelines set forth in the HCM. In fact, the level of service obtained via the environmental factors and the PMs supplements the results obtained through the HCM.

TABLE 4 Sidewalks Anywhere on West Campus

Performance Measure	% satisfied	LOS	Points	Wt	Total
Attractiveness	83	B	4	0.08	0.32
Comfort	82	B	4	0.10	0.40
Convenience	95	A	5	0.09	0.45
Safety	90	A	5	0.24	1.20
Security	78	B	4	0.35	1.40
System Coherence	69	B	4	0.07	0.28
System Continuity	92	A	5	0.06	0.30

The overall total of 4.35 indicates that the LOS is better than a B

CONCLUSION

Major urban traffic generators produce considerable pedestrian activity and movement, and therefore an important factor is the planning, designing, operating, and evaluating of transportation systems. The HCM provides guidance in designing and evaluating pedestrian facilities based only on quantitative measures of pedestrian flow, walking speed, and flow density, resulting in six levels of service, similar to those for vehicular flow. However, it recommends that additional environmental factors that contribute to the walking experience, and therefore to the perceived level of service, be considered, but does not spell out a methodology of how to do so. This paper discusses the need to consider environmental factors over and beyond the quantitative measures of level of service provided by the HCM, and then sets out a methodology for evaluating pedestrian facilities. The IIT campus is used as an example of how the methodology is applied in a real-world situation.

REFERENCES

1. Fruin, J. *Pedestrian Planning and Design*. Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971.
2. *Special Report 209: Highway Capacity Manual*. TRB, National Research Council, Washington, D.C., 1985.
3. Hill, M. R. *Walking, Crossing Streets, and Choosing Pedestrian Routes: A Survey of Recent Insights from the Social/Behavioral Sciences*. University of Nebraska Studies: New Series 66. Lincoln, Nebr., 1984.
4. Goffman, E. *Relations in Public: Microstudies of the Public Order*. Basic Books, Inc., New York, 1971.
5. Saarinen, T. F. *Environmental Planning: Perceptions and Behavior*. Houghton Mifflin, Boston, 1976.
6. Izumi, K. Some Psycho-Social Considerations of Environmental Design. 1968.
7. Ferguson, G. A. *Statistical Analysis in Psychology and Education*, 3rd ed. McGraw-Hill Book Company, New York, 1971.

Publication of this paper sponsored by Committee on Pedestrians.