# PEDESTRIAN INFRASTRUCTURES AND SUSTAINABLE MOBILITY IN DEVELOPING COUNTRIES: THE CASES OF BRAZIL AND MALAYSIA

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## ABSTRACT

The objective of this paper is to compare two methods for assessing the quality of pedestrian infrastructures, one developed in Brazil and another one in Malaysia. The analysis shows that the two cases differ in how they view pedestrian paths. The Brazilian case focuses more on the walkability aspects of the pedestrian path, while the Malaysian case view the pathway as purely an infrastructure for pedestrians to walk. In a different context, the Brazilian case analyzes the "*soft*" components, while the Malaysian case chooses to focus more on the "*hard*" components of a pedestrian path. In summary, the similarities and differences in the two cases present enormous opportunity for implementation and/or application. Depending on the needs of the analysts, the Brazilian case may be more suitable especially if walkability is an issue. However, if adequacy of pedestrian facilities is of importance, than the Malaysian case is more appropriate for application.

*Keywords: pedestrians, walkability, developing countries*

## 1 INTRODUCTION

Part of the quality of life problems faced by urban areas is caused by transportation-related aspects, such as: accessibility and mobility constraints, congestion, high accident rates, and the degradation of urban environment. Those aspects are a consequence of weak or inexistent policies towards sustainable mobility, particularly in developing countries. Only in the last few decades some developed countries started to tackle the problem in a consistent way, with a mobility planning focus instead of a transportation planning focus. Some European cities, for example, have only recently carried out studies to review and update concepts related to urban mobility in order to develop sustainable mobility plans. Those plans try to change the intra-urban accessibility levels with measures that range from more impedance to the movement of the private cars to incentives to the use of non-motorized modes.

In developing countries, the situation is quite different. Incentives for the use of non-motorized are rare, given that not even the basic infrastructure is ubiquitously provided. As a consequence, urban and transportation planners of developing countries are still struggling to maintain the basic available infrastructure in fair conditions, so that it does not force the users to adhere to the automobile. However, as the available resources for construction and maintenance are scarce, there is a strong need of assessment methods to evaluate the quality of the infrastructures. In the case of the automobile, those methods are widely available. For the infrastructure of non-motorized modes, unfortunately that is not the case. That is the reason why planners and researchers of developing countries are trying to develop methods to assess the quality of pedestrian infrastructures. We found two of those methods, one in Brazil and another one in Malaysia. The objective of this paper is to compare those two methods in order to look for differences and similarities that could help to build even more effective methods to be used also in other developing countries.

This paper is structured as follows. After this brief introduction, we present and discuss in section 2 some of the methods for assessing the quality of pedestrian infrastructures found in the literature. Next, in section 3, we briefly introduce the two methods developed in Brazil and in Malaysia. They are compared in section 4 and the results discussed in section 5, just prior to the conclusions.

# 2 ASSESSMENT OF THE QUALITY OF PEDESTRIAN INFRASTRUCTURES

Most countries in the world are experiencing an unparalleled growth in the use of private automobiles. According to Sarkar (1993), substantial effort has been done to protect and to give preference to the vehicular traffic, improving the overall street conditions in terms of comfort and convenience mainly to drivers. As a consequence, sidewalks and pedestrian paths are increasingly becoming non-regulated spaces when compared to the urban spaces for motorized modes. Particularly in developing countries, pedestrian paths are often narrow, with irregular surfaces and poor maintenance. In addition, sidewalks are repeatedly occupied by other activities, such as convenience stores, bars, restaurants, gas stations, etc.

Only in the last few decades the pedestrian facilities really started to be considered as alternatives to the motorized modes. Several methods were then created to evaluate the quality of pedestrian infrastructures (Botma, 1995; Carter *et al.*, 2006; Dixon, 1996; Ferreira and Sanches, 2001; Fruin, 1971a and b; Khisty, 1995; Sarkar, 1993; Sarkar, 1995; TRB, 1985; TRB, 2000). They consider different variables and evaluation criteria. As a consequence, there is a certain difficulty to define a standard method that can be applied everywhere.

The methods proposed by Fruin (1971a) and TRB (1985), for instance, used the car concept of level of service (LOS) to evaluate the LOS of sidewalks. Fruin (1971b) was actually a pioneer in the type of assessment method that takes into account parameters such as human anatomy, field of view, comfortable separation between individuals, displacements up and down stairs, and the psychological perception of the urban space. The work was the basis for the guide added later on to the Highway Capacity Manual for the design of pedestrian pathways. In such a context, two methods were introduced in the 1990s. The first one was produced by Sarkar (1995) and tried to look for safe urban intersections and sidewalks for groups of pedestrians seen as 'vulnerable' users. The other method was developed by Dixon (1996) for the assessment of pedestrian facilities along urban streets. Differently from the Highway Capacity Manual, which focused on volume and capacity, both approaches looked at qualitative measures to describe subjective variables such as: security, safety, comfort, convenience, continuity, system coherence, and attractiveness.

The works of Khisty (1995) and Ferreira and Sanches (2001) also considered qualitative aspects of the pedestrian infrastructures, but from the users' point of view. The variables in that case were: visual attractiveness, comfort, system continuity, safety, and security. One advantage of those methods is that they take into account the calibration of the parameters considered in the performance measures. Unfortunately, the calibration phase demands excessive time and money to really grasp the users' opinions, particularly if they want to consider groups of users with mobility constrains, instead of a standard user. They also fail to consider the exposure of the pedestrian to the traffic when crossing the street or when deviating from the normal trajectory to avoid impedances in the walkway. In cities of developing countries that is a quite common situation. These are some of the reasons why specific methods, like the two cases discussed in this paper, are currently under development in developing countries.

# 3 THE SELECTED APPROACHES

In this section we describe the two methods studied, in order to gather the elements needed for the comparison carried out in the next section.

## 3.1 The Brazilian Approach

The Brazilian approach presented here was based on the method originally proposed by Dixon (1996) for assessing the level of service for pedestrians. Dixon's pedestrian LOS is based on a point system. Criteria fall under six categories: pedestrian facility provided (maximum 10 points), path conflicts (4), amenities (2), motor vehicle LOS (2), maintenance problems (2) and provision for multiple modes (1). LOS A, for example, is defined as 17 to 21 points.

In the Brazilian case, some elements of evaluation were adapted or even included to meet the local conditions. That was done taking into account the work of Sarkar (1995) and also after field observation carried out in the city of São Carlos, Brazil (Yuassa *et al.*, 2008).That was needed because, in general, most Latin American cities do not have a solid urban planning tradition. That results in pedestrian infrastructures that are not really planned for pedestrians' movements. They are quite often just parts of the streets that were not used to build the infrastructure for cars. As a consequence, we had to consider that some elements of evaluation could have negative values in order to mirror those negative aspects faced by the pedestrians when using the pathway, particularly when they are exposed to the cars passing by. The risk of being hit by a car is then a consequence of changes in the regular trajectory for avoiding impedances, such as potholes, inappropriate urban furniture and trees in wrong places. As they can assume negative values, they can reduce the overall rating of a particular infrastructure under evaluation.

The assessment method was based on eight evaluation categories, as shown in Table 1. The following elements were directly taken from the work of Dixon (1996): *amenities* and *maintenance problems*. While the elements *pedestrian paths* and *conflicts* were partially adapted, *pavement material*, *security perception*, *comfort*, and *traffic volume in the adjacent car lane* were introduced in the method. The categories, the criteria and the associated scores are also shown in Table 1. When compared to the work of Dixon (1996), there were no changes in the evaluation criteria considered for the category *amenities.* For the category *maintenance problems*, the condition *frequent or serious maintenance problems* was added to the list of possible conditions, with a value of -2 (instead of -1, as in Dixon's work, for the condition *major or frequent problems*).

The adapted categories *pedestrian paths* and *conflicts* were considered as follows. The category *pedestrian paths* is supposed to be assessed based on the predominant characteristic of the link under evaluation. Therefore, minor defects in the path do not reduce the points if they do not significantly affect the circulation of the pedestrians. The scoring system suggested by Dixon was reviewed here to be more compatible with the Brazilian reality, and some values were even reduced to half their original values. In the category *conflicts*, the original Dixon's criterion *less than 22 driveways and side streets per 1.61 km* was not considered due to the time and effort it demands for data collection.

In the new categories, *pavement material* tries to capture some safety aspects associated to the material used in the infrastructure. This is one of the conditions that may force the user to leave the path and to use the car lane nearby in order to avoid wet, slippery of even flooded parts of the walkway. That was the reason why those conditions receive negative values in the Brazilian work. The category *security perception* shows how people may feel if they walk in a desert or in a busy environment, and it was based on the work of Sarkar (1995). *Comfort* is essentially related to barriers along the way and *traffic volume in the adjacent car lane* essentially reflects difficulties for crossing the streets. The maximum value that can be obtained is 23. Negative values are also possible if the segment under analysis is really bad.

If the scale proposed by Dixon is translated to the range found in the present case, values between 20 and 23 would be LOS A, between 15 and 19 would be LOS B, between 10 and 14 would be LOS C, between 5 and 9 would be LOS D, between 0 and 4 would be LOS E, and negative values would be LOS F. To better understand the concept behind that classification, the definitions presented by Dixon are quite useful. Her definition, for the LOS F, for example, was: “These roadways are inadequate for pedestrian use. These roadways do not provide any continuous pedestrian facilities and are characterized by high levels of motor-vehicle use and automobile-oriented development. These roadways are designed primarily for high-volume motor-vehicle traffic with frequent turning conflicts and high speeds.”

Table I - Elements for the evaluation of pedestrian infrastructures proposed in Brazil

| Categories | Criteria | Points |
|---|---|---|
| *Amenities* (maximum = 2) | Benches or adequate lighting for the pedestrians | 0.5 |
| | Pathway shadowed by trees | 0.5 |
| | Buffer strip of at least 1 meter between the pathway and the curb | 1 |
| *Maintenance* (maximum = 2) | Frequent or serious maintenance problems | -2 |
| | Occasional or irrelevant maintenance problems | 0 |
| | No maintenance problems | 2 |
| *Pedestrian paths* (maximum = 7) | Unavailable or discontinuous | 0 |
| | Continuous on one side of the street | 2 |
| | Continuous on both sides of the street | 3 |
| | Effective width larger than 1.53 meters | 2 |
| | Isolated from the car lanes | 2 |
| *Conflicts* (maximum = 3) | Less than 40 seconds of delay in the traffic signals | 0.5 |
| | Devices to reduce conversions or conflicts with cars | 0.5 |
| | Street crossings narrower than 18.3 meters | 0.5 |
| | Car speed limits up to 56 km/h | 0.5 |
| | Existence of median strips (to help crossing large streets or roads) | 1 |
| *Pavement material* (maximum = 2) | Unpaved (grass or bare soil) | -2 |
| | Inadequate material (slippery) | -1 |
| | Appropriate material (regular and non-slippery pavement) | 2 |
| *Security perception* (maximum = 3) | No busy locations along the way | 0 |
| | Nearby locations that attract people at least during part of the day | 1 |
| | Nearby locations that attract people night and day | 2 |
| | Surrounded by buildings with windows/doors facing the street | 1 |
| | Surrounded by buildings without windows/doors facing the street | 0 |
| | No buildings along the way | -1 |
| *Comfort* (maximum = 2) | No ramps for crossing the street | -1 |
| | Small steps along the path | 1 |
| | Flat surface or small gradient (2 to 5 %) | 2 |
| | Intermediate gradient (6 to 9 %) | -1 |
| | Several steps or stairs or large gradient (> 10 %) | -2 |
| *Traffic volume in the adjacent car lane* (maximum = 2) | High | -2 |
| | Intermediate | 0 |
| | Low | 2 |
| **Maximum value** | | **23** |

### 3.2 The Malaysian Approach

This method developed in Malaysia to rate pedestrian facilities utilizes an index called the *P*-index. The index uses the familiar 5-star rating format where the higher the number of stars, the better the quality of a particular pedestrian facility. For this purpose, a good pedestrian pathway is defined as "a paved, unobstructed walkway that provides continuous safe access to land uses." The computation of the *P*-Index is dependent upon a set of four indicators - mobility (*M*), safety (*S*), facility (*F*) and accessibility (*A*) - that form the premise of a good pedestrian pathway. The functional relationship between the *P*-index and these indicators is described below:

$$P = f(M, S, F, A) \tag{1}$$

Where:

*P* = *P*-index
*M* = mobility indicator
*S* = safety indicator
*F* = facility indicator
*A* = accessibility indicator

If the functional relationship between *P* and the four factors is assumed to be a linear one, then, Eq. (1) will take the following weighted average form:

$$P = b_1 M + b_2 S + b_3 F + b_4 A \tag{2}$$

Where:

$$\sum_{i=1}^{4} b_i = 1.0, \quad 0 \leq b_i \leq 1.0 \tag{3}$$

If, however, $b_1 = b_2 = b_3 = b_4 = b = 0.25$, then Eq. (2) is reduced to:

$$P = 0.25(M + S + F + A) \tag{4}$$

Upon computing the *P*-index value, the quality of the pedestrian facility can be translated based on the star-rating shown in Table 2.

Table 2 - Interpretation of the *P*-index value

| ***P*-index value** | **Star Rating** | **Description** |
|---|---|---|
| 0 - 20 | ★ | Hostile towards pedestrians |
| 21 - 40 | ★★ | Unfavourable to pedestrians |
| 41 - 60 | ★★★ | Walkable |
| 61- 80 | ★★★★ | Supportive towards pedestrians |
| 81 - 100 | ★★★★★ | Very pedestrian friendly |

Each of the indicators - mobility (*M*), safety (*S*), facility (*F*) and accessibility (*A*) - is computed individually, as shown in Table 3.

Table 3 - Equations for the calculation of the mobility, safety, facility and accessibility factors of the *P*-index value

| Equations | Variables |
|---|---|
| (5) $M = \left( \frac{0.5D_C}{D} \right) \times 100$ | $D_C$ = total length of paved pedestrian pathway, calculated on both sides of roads (km)<br>$D$ = total length of roadway, calculated one-way (km) |
| (6) $S = \left( \frac{0.5D_{SP}}{D} \right) \times 100,\ 0 \le D_{SP} \le D_C$ | $D_{SP}$ = total length of spatially and physically separated paved pedestrian pathway, calculated on both sides of roads (km)<br>$D_C$ = total length of paved pedestrian pathway, calculated on both sides of roads (km)<br>$D$ = total length of roadway, calculated one-way (km) |
| (7) $F = \frac{\sum_{i=1}^{n} \left( 0.5B_i + 0.5R_i + Z_i \right)}{3n} \times 100$ | $B_i$ = bollard facility<br>$R_i$ = ramp facility<br>$Z_i$ = zebra crossing facility<br>and,<br>$B_i, R_i = \begin{cases} 2, \text{ if available on both sides} \\ 1, \text{ if available on one side} \\ 0, \text{ if absent} \end{cases}$<br>$Z_i = \begin{cases} 1, \text{ if available} \\ 0, \text{ if absent} \end{cases}$ |
| (8) $A = \frac{\sum_{j=1}^{k} L_j}{k} \times 100$ | $L_j$ = percent (%) of households within walking distance to land uses *j*, *j* = 1, 2, …, *k* |

The first of the four indicators, i.e., mobility (*M*), describes the provision of a paved, continuous pathway relative to the total length of roadways for the pedestrians to use. The second of the four indicators - i.e., safety (*S*) - describes how safe is the pathway for the pedestrians to use. For this purpose, a safe pathway is defined as that one providing both spatial and physical separations between the pedestrians and the motorized vehicles. The third indicator - facility (*F*) - identifies the provisions of appropriate minimum facilities for crosswalks. Here, minimum facilities that every crosswalk must have are (1) bollards on both sides of the crosswalk, (2) ramps on both sides of the crosswalks, and (3) a zebra marker. This indicator is important as crosswalks are points where potential conflicts between pedestrians and motorized vehicles take place. The last indicator - the accessibility (*A*) indicator - measures the closeness or proximity (i.e. within walking distance) of households to selected land uses. This indicator indirectly measures the attractiveness of walking in the study area. Table 4 describes the interpretation of the indicators with respect to the star ratings.

Table 4 - Interpretation of the indicator values

| **Indicator value** | **Star Rating** | **Interpretation of the *M*-indicator value** | **Interpretation of the *S*-indicator value** | **Interpretation of the *F*-indicator value** | **Interpretation of the *A*-indicator value** |
|---|---|---|---|---|---|
| 0 - 20 | ★ | Little or no mobility | Very unsafe for walking | Non-existence or negligible pedestrian facility | Land uses inaccessible by walking |
| 21 - 40 | ★★ | Inadequate mobility | Unsafe for walking | Inadequate pedestrian facility | Poor accessibility to land uses by walking |
| 41 - 60 | ★★★ | Fair mobility | Walk with caution | Moderate availability of pedestrian facilities | Moderate accessibility to land uses by walking |
| 61- 80 | ★★★★ | Good mobility | Safe to walk | Good pedestrian facilities | Good accessibility to land uses by walking |
| 81 - 100 | ★★★★★ | Excellent mobility | Excellent safety for pedestrians | Excellent pedestrian facilities | Excellent accessibility to land uses by walking |

# 4 COMPARING THE TWO APPROACHES

In analyzing the two approaches, the information in Table 1 for the Brazilian approach and the information in Table 3 for the Malaysian approach are compared. Several similarities between the two approaches were found. They are then summarized in Table 5.

A. Amenities
Only the provision of a buffer strip is common to both the cases. Benches, lighting and tree-covered path are present only in the Brazilian case.

B. Maintenance
The maintenance aspect of the pedestrian path is totally absent from the Malaysian case, while this aspect may determine the overall grading of a particular pedestrian path.

C. Pedestrian Path
Both the Brazilian and Malaysian cases agree that continuity of pathways is an important criterion in determining quality pedestrian pathways. However, in the Malaysian case, the continuity of the pedestrian pathways is measured as a factor of the total road length as part of the mobility indicator. Meanwhile, in the Brazilian case, different types of continuities carry different points. The Brazilian case considers the width of the pedestrian path and the

location of the path as criteria for quality path. In the Malaysian case, however, these two factors are absent.

D. Conflicts
Devices to reduce conflicts with the cars appear in both the cases. However, this is where the similarity ends. The Brazilian method further considers delay at traffic signal, road width, cars traveling speed and the existence of median strips as criteria for reducing conflicts. It is also pertinent to point out that, in the Brazilian case, only wide roads with median strips may obtain the maximum points of seven. A narrow road that does not provide a median strip, even though it is perfectly acceptable to do so, may never be able to obtain full points.

E. Pavement Material
Generally, pavement materials are not included explicitly in the Malaysia case. Instead, the pavement material is described implicitly as the Malaysian case defines a pedestrian pathway as a paved facility. Therefore, unpaved paths are never included in the computation for the Malaysian case.

F. Security Perception
Locations of nearby activities appear in both cases. However, the Brazilian case considers location as a factor that may influence security, while the Malaysian case views it as catalyst for pedestrianism.

G. Comfort
The availability of ramps, and their gradient, features prominently as a factor of pedestrian comfort in the Brazilian case. Nonetheless, for the Malaysian case, ramps are considered among the facilities at crosswalks, others being bollards and zebra markers.

H. Traffic Volume in the Adjacent Car Lane
As the Malaysian case is a measure of the provision of pathway, not a measure of walking quality, the criteria that measure the difficulty level of crossing a street is therefore missing. The Brazilian case, on the other hand, included traffic volume as a criterion as it focuses more on the quality of walking, unlike the Malaysian case.

Table 5 - Similarities between the Brazilian Case and the Malaysian Case

| **Brazilian Case** | **Malaysian Case** | | | |
|---|---|---|---|---|
| | *Mobility* | *Safety* | *Facility* | *Accessibility* |
| *Amenities* | | Buffer strips | | |
| *Maintenance* | | | | |
| *Pedestrian Path* | Continuity of pathways | | | |
| *Conflicts* | | | Devices to reduce conflicts with cars | |
| *Pavement material* | | | | |
| *Security perception* | | | | Nearby locations attracting pedestrian |
| *Comfort* | | | Ramps | |
| *Traffic volume in the adjacent car lane* | | | | |

# 5 CONCLUSIONS

The two cases differ in how they view pedestrian paths. The Brazilian case focuses more on the "*soft*" aspects of the pedestrian path, while the Malaysian case view the pathway as infrastructure for pedestrians, choosing to focus more on the "*hard*" components of a pedestrian path.

Examples of the differences in views can be seen from (1) criteria that are shared by both cases, and (2) from criteria that are missing from the cases. In the case of shared criteria, their treatments of these shared criteria are glaringly different. For example, the provision of buffer strips is considered as an amenity in the Brazilian case, but the buffer strips are taken as pedestrian facilities that must be provided. As the case of missing criteria, a good example would be the criteria of "maintenance" and "traffic volume in adjacent car lane". These two criteria appear in the Brazilian case as they are considered as important to determine the desirability to walk. However, these criteria do not feature in the Malaysian case as they are not relevant to the provision of pedestrian paths.

In summary, the similarities and differences in the two cases - the Brazilian and the Malaysian cases - present enormous opportunity for implementation and/or application. Depending on the needs of the analysts, the Brazilian case may be more suitable especially if walkability is an issue. However, if adequacy of pedestrian facilities is of importance then the Malaysian case is more appropriate for application.

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