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Footpaths Design on Renovation of City Centres – A Model of Assessment

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Abstract

Nowadays, many cities are committed on improving the attractiveness of their historical centers through its renovation. When renovating city centres, one of the most important issues to take into account is the mobility in these central areas and the use of soft transport modes, so as to improve not only its attractiveness, but also its sustainability. In order to achieve this purpose, the walkability of the city centre should be promoted. The main purpose of this work is to present a set of indicators which can assess the footpaths design in the context of renovation of historical city centres, focusing on the walkability of these urban areas. The assessment of those issues allows the creation of different scenarios and reflects, as early as in the preliminary design phase, the overall quality of the proposed solution for the footpaths.

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Keywords: walkability; soft modes; footpaths assessment; city centres renovation; urban environment.

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1. Introduction

Planning and developing the renovation and revitalization of historical city centres is a complex task, which demands integration across various fields of design and knowledge. A key concern in the renovation of city centres is the sustainability of the design solutions, and a central issue in this case regards the minimization of road traffic in these core areas. In this context, the option for soft mobility modes, such walking or cycling, is almost imperative nowadays. Thus, a walkable city centre significantly improves sustainable mobility, contributing for the reductions in air and noise pollution and greenhouse gas emissions, and also increasing the attraction as commercial, cultural and leisure destination. To achieve this purpose, the permeability of the city centre should be worked, allowing the pedestrians to move easily around the historical centre.

Promote a walkable city centre depends on how well the footpaths connections work and coexist with the other mobility modes and public transport, giving pedestrians the better choice in how to make their journeys. The geometrical design of the footpaths should also not be neglected, although in a historical city centre such characteristics are strongly conditioned by the existing urban morphology. For this reason, the assessment of those issues in a design phase is quite relevant for the perception of the overall quality of the proposed solution for the footpaths (Badenhorst, 2016; National Transport Authority, 2015; Silva et al, 2016; Silva and Monteiro, 2016).

Nomenclature

W	Width Weighted by the Length (m);
w_i	width of the footpath *i* (m);
l_i	length of the footpath *i* (m);
Swd	Width score (-);
PP	Percentage of Pedestrian Streets (%);
lp_j	length of the footpath *j* corresponding to a car-free street (m);
Spp	Pedestrian Streets score (-);
S	Slope Weighted by the Length (%);
s_i	slope of the footpath *i* (%);
Ssl	Slope score (-);
LI	Length Gauged by Intersections (m);
NI	total number of intersections with traffic roads for the total length of the footpaths (-);
Sgi	Footpaths Length Gauged by the Number of Intersections score (-);
D	Maximum Distance to the Nearest Public Transport Stop (m);
Spt	Connection With Public Transport score (-);
S_{AFD}	Assessment of Footpaths Design on Renovation of City Centres score (-).

2. The Assessment of Footpaths

The assessment approach to the footpaths design focuses on the walkability of the city centre, and is based on the network geometrical features, regarding the longitudinal profile and the footpath cross-section, on the intensity of the intersections with the traffic roads, and on the easy the pedestrian network is connected with the public transports, the latter being relevant in that it encourages the access of pedestrians to the city centre.

Accordingly, as shown in the Figure 1, the assessment of the criterion *Footpaths* is then carried out by using five indicators, which can be measured and evaluated: i) *width*; ii) *pedestrian streets/car-free zones*; iii) *slope*; iv) *footpaths length gauged by the number of intersections*; v) *connection with public transport*. The first, the third and the fourth indicators - *width*, *slope* and *footpaths length gauged by the number of intersections* - are related to the ease of use of the footpaths. The second is an indicator that values de pedestrian-only streets. The last one is an indicator of ease of access to public transport. The measurement of the indicators is carried out by using a transformation function which gives a score, with a value ranging on a scale from 0 to 1. These indicators are then combined according to a weighted linear procedure, resulting in a synthetic score for the assessment of the *Footpaths*, which reflects the quality of the proposed design solution.

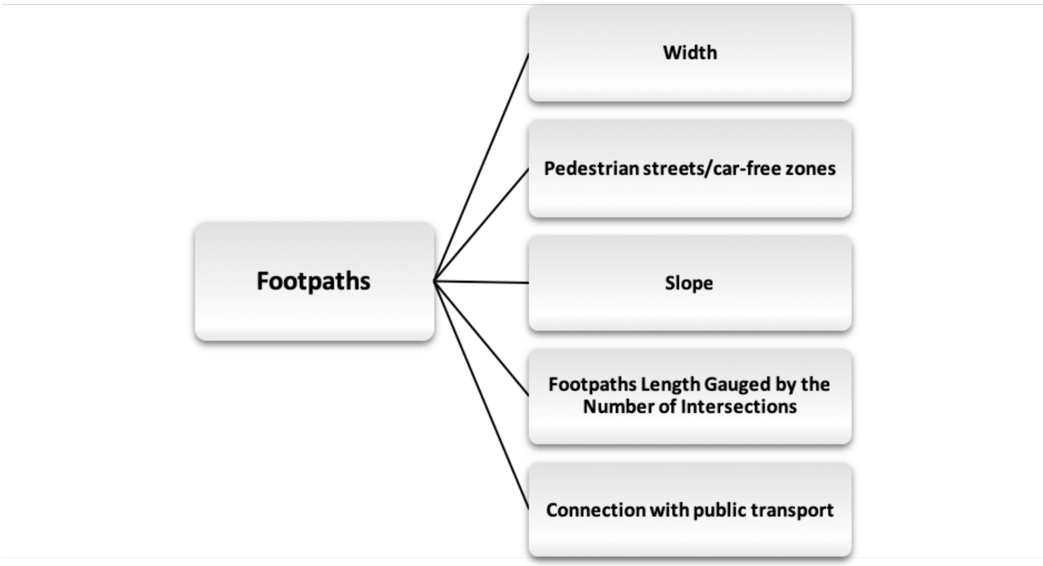

Fig. 1. Footpaths assessment indicators

3. The Width

The indicator *Width* evaluate the width of the footpaths, in order to ensure pedestrians to move easily around the city centre. A larger width allows a better distribution and flow of pedestrians, improving the walkability.

3.1. Width measurement

The width measure adopted for the footpaths is given by the *Width Weighted by the Length*, *W*, that is calculated through the Equation 1:

$$W = \frac{\sum_{i=1}^{n} w_i \times l_i}{\sum_{i=1}^{n} l_i} \tag{1}$$

where w_i is the width of the footpath i, and l_i is the length of the footpath i.

The *Width Weighted by the Length*, *W*, takes a value greater than 0 and increases with the footpaths width, in general, and the preponderance of wider tracks, in particular.

3.2. Width assessment

The indicator *Width* measures the performance of the design solutions according to the concept of width weighted by the length. This measurement is carried out by using a transformation function, which gives the indicator score *Swd*, with a value ranging on a scale from 0 to 1, as follows:

$$
\begin{aligned}
&Swd = 0 && \text{if } W \leq 1.5 \\
&Swd = 0.4\,W - 0.6 && \text{if } 1.5 < W < 4.0 \\
&Swd = 1 && \text{if } W \geq 4.0
\end{aligned}
\tag{2}
$$

This indicator assigns the higher score to a *Width Weighted by the Length, W*, equal or greater than 4.0 m. On the other hand, the indicator assigns a score equal to zero if $W \leq 1.5$ m (National Transport Authority, 2015; Lahart et al, 2013; Pedro, 2001).

4. The Pedestrian Streets

The *Pedestrian Streets/Car-Free Zones* indicator evaluate the extension of the car-free footpaths, in order to ensure pedestrians to move easily and safely around the city centre. A greater extent of such paths allows a more comfortable movement of pedestrians along the city centre.

4.1. Pedestrian Streets measurement

The pedestrian streets measure adopted for the footpaths is given by the *Percentage of Pedestrian Streets* in the total footpaths network, *PP*, that is calculated through the Equation 3:

$$PP = \frac{\sum_{j=1}^{n} lp_j}{\sum_{i=1}^{n} l_i} \times 100 \tag{3}$$

where l_i is the length of the footpath *i*, and lp_j is the length of the footpath *j* corresponding to a car-free street.
The *Percentage of Pedestrian Streets*, *PP*, ranges over the interval from 0 to 100 %, and increases with the preponderance of car-free streets.

4.2. Pedestrian Streets assessment

The indicator *Pedestrian Streets/Car-Free Zones* measures the performance of the design solutions according to the concept of percentage of car-free streets in the total footpaths. This measurement is carried out by using a transformation function, which gives the indicator score *Spp*, with a value ranging on a scale from 0 to 1, as follows:

$$Spp = (1/100)\,PP \qquad \text{for } 0 \leq PP \leq 100 \tag{4}$$

This indicator assigns the higher score to a *Percentage of Pedestrian Streets* in the total footpaths network, *PP*, equal to 100%, and a score equal to zero if $PP = 0\%$. These values correspond, respectively, to a network in which all the branches are car-free zones, and to a network in which in all its branches coexist pedestrians and vehicles traffic.

5. The Slope

The *Slope* indicator evaluate the slope of the footpaths, in order to ensure pedestrians to move easily around the city centre. A smooth slope allows a better flow of pedestrians, improving the walkability.

5.1. Slope measurement

The slope measure adopted for the footpaths is given by the *Slope Weighted by the Length*, *S*, that is calculated through the Equation 5:

$$S = \frac{\sum_{i=1}^{n} s_i \times l_i}{\sum_{i=1}^{n} l_i} \tag{5}$$

where s_i is the slope of the footpath i, and l_i is the length of the footpath i.

The *Slope Weighted by the Length*, S, takes a value greater than 0 and increases with the footpaths slope, in general, and the preponderance of tracks with greater slopes, in particular

5.2. Slope assessment

The indicator *Slope* measures the performance of the design solutions according to the concept of slope weighted by the length. This measurement is carried out by using a transformation function, which gives the indicator score *Ssl*, with a value ranging on a scale from 0 to 1, as follows:

$$\begin{aligned} &Ssl = 1 && \text{if } S \leq 2.0 \\ &Ssl = -0.125\, S + 1.25 && \text{if } 2.0 < S < 10.0 \\ &Ssl = 0 && \text{if } S \geq 10 \end{aligned} \tag{6}$$

This indicator assigns the higher score to a *Slope Weighted by the Length, S*, equal or smaller than 2%. On the other hand, the indicator assigns a score equal to zero if $S \geq 10\%$ (Pedro, 2001; Chiara et al, 1995).

6. The Footpaths Length Gauged by the Number of Intersections

The *Footpaths Length Gauged by the Number of Intersections* indicator measures the frequency of intersections with traffic roads for the total length of the footpaths, in order to ensure pedestrian to move easily and safely around the city centre. Less intersections allows a better flow of pedestrians, improving the walkability, the safety and the attractiveness of the city centre.

6.1. Footpaths Length Gauged by the Number of Intersections measurement

The footpaths length gauged by the number of intersections measure adopted is given by the *Length Gauged by Intersections*, *LI*, that is calculated through the Equation 7:

$$LI = \frac{\sum_{i=1}^{n} l_i}{NI + 1} \tag{7}$$

where l_i is the length of the footpath i. and *NI* is the total number of intersections with traffic roads for the total length of the footpaths.

The *Length Gauged by Intersections*, *LI*, ranges from a minimum value of 0 to a maximum value corresponding to the total length of the footpaths, increasing with the decrease in number of intersections.

6.2. Footpaths Length Gauged by the Number of Intersections assessment

The indicator *Footpaths Length Gauged by the Number of Intersections* measures the performance of the design solutions for the footpaths according to the concept of frequency of intersections with traffic roads. This measurement is carried out by using a transformation function which gives the indicator score *Sgi*, with a value ranging on a scale of 0 to 1, as follows:

$$\begin{aligned} Sgi &= 0 && \text{if } LI \leq 100 \\ Sgi &= (1/300)\ LI - 1/3 && \text{if } 100 < LI < 400 \\ Sgi &= 1 && \text{if } LI \geq 400 \end{aligned} \tag{8}$$

This indicator assigns a score equal to zero to a *Footpaths Length, LI*, equal or smaller than 100 m. On the other hand, the indicator assigns the higher score if $LI \geq 400$ m (Aultman-Hall et al, 1997).

7. The Connection With Public Transport

The *Connection With Public Transport* indicator measures the ease of access to public transport in the city centre in terms of walking distance. A shorter distance encourages the access of pedestrians to the city centre.

7.1. Connection With Public Transport measurement

The connection with public transport measure adopted is given by the *Maximum Distance to the Nearest Public Transport Stop, D.* The distance *D* is measured in straight line from the less favorable point of the footpaths network to the nearest public transport stop.

7.2. Connection With Public Transport assessment

The indicator *Connection With Public Transport* measures the performance of the design solutions for the footpaths according to the concept of walking distance to the nearest public transport. This measurement is carried out by using a transformation function which gives the indicator score *Spt*, with a value ranging on a scale of 0 to 1, as follows:

$$\begin{aligned} Spt &= 1 && \text{if } D \leq 150 \\ Spt &= -(1/600)\ D + 1.25 && \text{if } 150 < D < 750 \\ Spt &= 0 && \text{if } D \geq 750 \end{aligned} \tag{9}$$

This indicator assigns the higher score to a *Maximum Distance to the Nearest Public Transport Stop*, *D*, equal or smaller than 150 m. On the other hand, the indicator assigns a score equal to zero if $D \geq 750$ m (Costa, 2008).

8. The Footpaths assessment

The calculation of the final score for the assessment of the criterion *Footpaths*, S_{AFD} , is carried out through an aggregation equation using a Weighted Linear Combination (WLC) procedure, set for the previous 5 indicators: *Width*, *Pedestrian Streets/Car-Free Zones*, *Slope*, *Footpaths Length Gauged by the Number of Intersections*, and *Connection With Public Transport*. For this purpose, similar weights of 0.20 are assumed for the 5 indicators, meaning that all are assigned the same importance.

Finally, the final score to the *Assessment of Footpaths Design on Renovation of City Centres*, S_{AFD}, with a value ranging on a scale of 0 to 1, is set according to the equation bellow:

$$S_{AFD} = 0.20 \times S_{wd} + 0.20 \times S_{pp} + 0.20 \times S_{sl} + 0.20 \times S_{gi} + 0.20 \times S_{pt} \quad (10)$$

9. Conclusions

Promote a walkable city centre depends on how well the footpaths connections work and coexist with the other soft mobility modes and public transports, giving pedestrians the better choice in how to make their journeys. In this context, the geometrical design of the footpaths should be a central concern, although in a historical city centre such characteristics are strongly conditioned by the existing urban morphology.

The model assesses the footpaths focusing on the walkability of the city centre and is based on the pedestrian network geometrical features (longitudinal profile and footpath cross-section), on the intensity of the intersections with the traffic roads, and on the easy the pedestrian network is connected with the public transports. These indicators are combined according to a weighted linear procedure, resulting in a synthetic score for the assessment of the pedestrian network.

The assessment of these issues in a preliminary design phase is quite relevant for the perception of the overall quality of the proposed solution for the footpaths, contributing to improve the design quality of the pedestrian network and avoid major errors. Such assessment can lead to significant functional and economic benefits. It is intended to apply the model in the nearby future to de city centre of Viana do Castelo, in Portugal.

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