A MULTICRITERIA MODEL FOR EVALUATING CONFORMITY OF TRAVELLING CONDITIONS FOR PEDESTRIANS WITH MOBILITY CONSTRAINTS

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Abstract: - For people with mobility constraints, the conditions offered by pedestrian environments are crucial for their ability to remain independent and self-sufficient. Mobility is also a key factor to maintain people actively involved in the community. Taking into account only the physical characteristics of urban spaces, the goal of the present work is to analyse the factors that limit the circulation of people with mobility constraints and to map those conditions in central urban spaces. The assessment was performed in agreement with the standards specified in the Portuguese Law. A multi-criteria model was developed to evaluate the compliance of urban spaces with those standards. Its integration within a GIS platform was performed in order to implement a spatial analysis of the results. A case study was conducted in a central area of the city of Braga, Portugal. Maps showing levels of compliance with the standards were produced and the results are discussed.

Keywords: - Urban Planning, Planning Support Systems, Pedestrian Mobility, Circulation Map

1 Introduction

There are many reasons for walking: to visit a neighbour, to run errands, to shop, to get to a business meeting, to go to medical facilities, etc… Walking can also be a recreation activity and a way to gain health benefits, by simply enjoying being outside. It is also a way to travel independently, as pedestrians often must walk to transit or to reach another destination. For all these reasons, it is a public responsibility to provide a safe, secure, and comfortable system for all people who walk [1].

However, the necessary conditions to ensure that each walking trip is a pleasant and safe experience are sometimes forgotten. Tight *et al.* [2] referred that walking has perhaps been partly overlooked by those responsible for urban areas because it is ubiquitous and seen as a benign mode of transport. The disregard for the conditions of the walking environment happened also because when transportation planning began, the main goal was to achieve a fast increase of the use of the automobile. In this context, a scaling issue emerged as most transportation projects model and assess movement patterns at higher scales than those used for walking level studies [3].

So, mainly in urban areas, safety and comfort of pedestrians are nowadays a key issue for planners and city managers. Even more concern is required when considering mobility of impaired people. For those people, several obstacles become barriers which cannot be overtaken and thus significantly decrease their level of mobility. Despite the importance of this theme, the impact of the built environment on pedestrian mobility is an underdeveloped issue [4]. Sedlak *et al.* confirmed that "lately, very strong attention is paid to removing barriers which make movement of disabled people more difficult or even impossible" [5]. The attention on this theme has been evolving from a stage where no concerns about physically impaired people were taking into account, then through the first steps towards making the building environment accessible to all (after World War II, in order to meet the needs of war invalids) and to the present day, where accessibility is considered a right that everyone should have [6].

Furthermore, demographic trends worldwide have revealed significant increases in the number of older people in the population in the coming years. As there is a close link between age and disability, the longer people live the more likely they are to become disabled to some degree. The pedestrian environment is fundamental in enabling older and disabled people to retain independent mobility, and to reduce their need for costly support from the state, in more developed regions, or to alleviate poverty and isolation in some developing countries [7].

In Portugal, the authors of the Decree–Law 163/2006 [8], in short DL163/2006, state that the promotion of accessibility constitutes a basic element in people's quality of life, being an essential way for exercising the rights that are given to any member of a democratic society, contributing decisively to a bigger reinforcement of the social relationships, for a wider civic participation, and consequently, for a growing deepening of the solidarity in the social State where the rule of law prevails. On the other hand, an infrastructural environment accessible to everyone can be used as an indicator to show the level of development when assessing city management [9]. The DL163/2006 also refers that it is crucial to guarantee and protect the rights of people with special necessities. Those persons are confronted with environmental barriers that block their possibility of having an active and integral civic participation.

In this context, the present work proposes a spatial model for the analysis of the physical urban environment for pedestrians, classifying the urban space in terms of its compliance with the requirements defined for the urban circulation of pedestrians with mobility constraints. Furthermore, the study focuses on the physical characteristics of walking spaces in a global perspective, and does not analyse the network level of service or the characteristics of the pedestrians. This way, the study intends to improve the analysis of the characteristics of those areas as basic infrastructures for walking mobility, not necessarily to adequate the capacity of the sidewalks to the demand.

The adopted classification highlights qualities and weaknesses of the urban space for walking mobility. The analysis refers to the urban spaces with pedestrian circulation, such as pedestrian streets, sidewalks, squares and other open spaces. The proposed analysis only takes into account the physical characteristics of urban spaces according to the standards specified by Portuguese Law, [8], namely sidewalk dimensions, position of urban furniture, ramps, etc. The analysis of several criteria results in an index classification model, which assesses the level of compliance of the urban spaces of the case study. Through its integration in a GIS platform, maps are produced to reflect the conditions that mobility impaired pedestrians will face in the studied area.

2 Methodology

The implementation of the proposed spatial classification model was taken in several steps, which are explained in the following paragraphs.

The first step of the spatial classification model is the identification of a set of compliance items, related with the walkability conditions of public urban spaces for people with mobility constraints. In the present study, this feature was performed by analysing the Portuguese Law to gather the design criteria for public urban spaces, particularly the pathways for pedestrians, in order to provide good mobility conditions for all. The selected criteria adopted in the analysis model were structured so that the evaluation criteria (indicators) can be used in similar studies for other cities or countries.

The starting point to identify the criteria was the analysis of the Portuguese Law DL163/2006 (similar to laws adopted in other countries). The standards found in this law establish the accessibility design condition to public buildings and establishments, to public urban open spaces and to residential buildings. Also, the law defines accessibility as a part of a wider role of government instruments to establish a global and coherent system of rules, capable of providing equal opportunities of mobility to all persons [10]. The new law replaces the previous law (published in 1997), as referred in the document, due to "… insufficient solutions proposed by the previous law". This new law aims to establish a solution of continuity with the previous law, by amending the identified imperfections, improving the fiscal mechanisms and sanctioning efficiency, increasing the level of communication and responsibility of the involved agents, as well as by introducing new solutions in line with the verified evolution of social, technical and legislative aspects between the publication of the two laws.

From this analysis, two main groups of criteria were identified. Both groups were also divided in subgroups, containing specific criteria that will be used to feed the proposed classification model. The structure of groups and subgroups of criteria is listed in Table 1. The groups and subgroups are detailed by Rodrigues [11]. Since the focus of the study is the compliance assessment of urban spaces, the criteria defined in the law concerning indoor circulation were not considered.

Table 1: Group and subgroups of criteria to assess walkability conditions of urban spaces

Group	Subgroup
Public areas: Sidewalks and walkways	Accessible route Sidewalks and other pedestrian walkways Stairs Public Stairways Public Stairways between ramps Ramps Ramps in public spaces
Public areas: Crosswalks and pedestrian passages	Crosswalks (pedestrian crossings) Pedestrian overpasses or underpasses Other places of circulation and staying of pedestrians

Subsequently, the index to classify the compliance of the urban space was obtained by the aggregation of all criteria after the normalization process. Normalizing implies that all criteria must be assessed and all evaluated values must be "converted" in a new single scale. In this case, the normalization process establishes two possible values, 0 or 1; the criterion score is 0 when it does not comply with the law standards and is 1 when it is according to the law parameters. The standard parameters defined by the law for each criterion, used as control points to the normalization process, were gathered. Table 2 shows those values for the criteria of the subgroup "sidewalks and other pedestrian walkways".

The selected criteria are in some cases specific and cannot be globally applied to the network segments: for instance, levelled crosswalk criteria are not applicable to underground pedestrian passages. Furthermore, the number of criteria to be considered for a subgroup can also vary according to the existence or not of some elements.

Table 2: Classification of sidewalks and other pedestrian walkways

Classification = 1	**Classification = 0**
Free sidewalk width, along primary and distributor roads	
≥1.50m	<1.50m
Width of pedestrian walkways in planted areas with a length not greater than 7 m	
≥0.90m	<0.90m
Ramp slopes	
not greater than 6%; length not lower than 0.75m or full multiples of this value	greater than 6%; length lower than 0.75m or not full multiples of this value

For these reasons, when defining the criteria aggregation function to calculate a subgroup compliance index, all those nuances have to be taken into account and reflected in the calculation process. Equation (1) shows how a subgroup compliance index is obtained.

$$CIS_s = \sum_i w_{is} \times c_{is} \quad (1)$$

where:

CIS_s: compliance index of subgroup s
w_{is}: weight of the criterion i in the subgroup s
c_{is}: normalized value of criterion i in subgroup s
i: index of criteria applicable to the analysed spaces

In equation (1), it can be seen that a weight is applied to each criterion defining their relevance to the whole subgroup index. Specifically for this study, an equal contribution of the criteria to the subgroup compliance index was adopted. As such, Equation (1) can be classified as a Weighted Linear Combination (to an extensive description, see Weighted Linear Combination in [12]).

In order to assign equal weights to each criterion of a subgroup, the following formula was used:

$$w = 1/n_s \quad (2)$$

where:

w_{is}: weight of the criterion i in subgroup s
n_s: number of criterion evaluated in the group s

This approach results in equal weights to all criteria and also guarantees that the condition is fulfilled in specific cases. When one or more criteria are not applicable in an area, the evaluation is still possible because the index only counts the number of estimated criteria (n_s).

Then Equation (3) is applied to obtain each group index.

$$CIG_g = \sum_j ws_j \times CIS_j \quad (3)$$

where:

CIG_g: compliance index of group *g*
ws_j: weight of subgroup *j*
CIS_j: compliance index of subgroup *j*

Finally, Equation (4) is used to combine all group indexes to obtain the global compliance index for each segment~~s~~ of the network:

$$GCI = \sum_j w_j \times IC_j \quad (4)$$

where:

GCI: Final Compliance Index
w_j: weight of group *j*
g_j: compliance index of group *j*

3 Model application

The methodology presented in the previous section was implemented and tested on a case study in some streets of the city of Braga, Portugal. Braga is located in the Minho region at the Northwest of the country. It is surrounded by the municipalities of Amares at North, Póvoa de Lanhoso at East, Guimarães at Southeast, at South by Vila Nova de Famalicão, at West by Barcelos and at Northwest by Vila Verde. Braga has an area of 183.40 km²[13] and is composed by 62 *freguesias* (smallest Portuguese administrative division): 23 are urban, 22 are mainly urban and 17 median urban. Braga is the capital of the district and of the Metropolitan area of Minho. It is one of the largest cities of the country with 176154 habitants and a population density of 960.50 hab/km²[13]. According to the National census of 2001 (Census 2001), 35% of the city population are between 0 to 25 years old, 54% are in the group age of 24 to 64 years and the elderly represent 11% of the population.

The study area is inserted in the urban perimeter of Braga, in the boroughs of S. Vicente, S.Victor, S. João do Souto and S. Lázaro. It was chosen for the fulfilment of some requirements considered important to validate the study: the continuity between areas allows defining networks which interconnect locations; and the date of construction/rehabilitation of the streets makes it possible to analyse the practices before and after the DL163/2006.

Taking in consideration these standards, the chosen network interconnects the area of the Municipal Cemetery (post DL163/2006), *Santa Margarida Street* (pre DL163/2006), *Avenida Central* (pre DL163/2006) and *Avenida da Liberdade* (pre DL163/2006 and partially rehabilitated in 2009).

After defining the study area, the field work was initiated in order to collect data regarding the physical characteristics of the streets. It consisted of collecting the characteristics required for the study, such as sidewalk width and height, ramp slopes, position of the urban furniture, like dustbins, benches, poles, bushes, etc. Tables 3a, 3b and 4 show the criteria effectively considered in this case study. Not all criteria from the full list derived from DL163/2006 were evaluated. It should be noted that this list must be adapted in accordance with the characteristics that are intrinsic to each case study, reflecting that some criteria are not applicable in the chosen area.

To implement the spatial analysis, three steps were performed:

- ✓ collection of the cartography for extraction of the study area;
- ✓ edition of the studied streets in a GIS platform;
- ✓ addition of fields to the attribute tables for storing data collection and calculation results;

The storage of data collected is a very important step in the process. It implies the design of an efficient and robust database structure. This is a transitional step towards a successful implementation [14]. With data collection concluded and stored, the calculation process was initiated. The first operation consisted on the application of the normalization. As the criteria values are expressed in different ranges of values and different units, this is a crucial stage for achieving a compliance index. Normalizing the values to a common scale enables their combination to obtain an index. As previously referred, the collected values were "transformed" to values of 0 or 1, where 0 represents the non-compliance of the criterion and 1 is assigned when in accordance with the law. To illustrate this process, a segment of the network corresponding to a crosswalk is used as an explanatory example

Table 3a Criteria of group "Sidewalks and walkways"

Subgroup 1- Accessible route
Permanency zone:
Free area
Frontal corner
Lateral corner
Range:
Frontal range
Frontal range over obstacles
Frontal range over obstacles (when 0.30m<C≤0.50m)
Lateral range
Lateral range over obstacles (when 0.30m<C≤0.50m)
Lateral range over obstacles (when 0.50m<C≤0.60m)
Free width:
Continuous and unobstructed circulation path
Free width (when B≤0.60m)
Free width (when 0.60<B≤1.50m)
Manoeuvring areas:
90º Rotation
180º Rotation
360º Rotation
Change of direction:
90º direction change
180º direction change
180º direction change in "T"
Free height in all width of the path
Protruding objects:
The objects should not protrude more than 0.1m from the wall if the inferior limit of the object is at a ground level height between 0.7m and 2m.
The objects can protrude from the wall at any dimension if the inferior limit of the object is at a height inferior to 0.7m.
Protruding objects in pillars or columns:
The objects should not protrude more than 0.30m from the supports if the inferior limit of the object is at a ground level height between 0.7m and 2m.
The objects can protrude at any dimension if the inferior limit of the object is at a height inferior to 0.7m.
Subgroup 2 - Sidewalks and other pedestrian walkways
Free sidewalk width, along primary and distributor roads
Width of pedestrian walkways in planted areas with a length not greater than 7 m

Table 3b Criteria of group "Sidewalks and walkways"

Subgroup 3 - Public Stairways
Width of stairways and landings
Depth of superior and inferior landings
Intermediate landings
Steps depth
Steps height
Stair nosing
Non-slip surfaces with visual signalling
Handrails presence when total height > 0.4m
Staircase width
Subgroup 4 - Ramps in public spaces
Inclination
Curvature radius
Horizontal rest platforms
Handrails
Lateral borders
Guards
Pavement lateral extension

Table 4 Criteria for the group "Crosswalks and pedestrian passages"

Subgroup 1- Crosswalks (pedestrian crossings)
Curb height
Pavement
Width of the intersection zone of the crosswalks and the median strips
Pavement slope
With lighting system:
Height of the activation device
Crossing pace
Subgroup 2 - Pedestrian overpasses or underpasses
Ramps:
Inclination
Curvature radius
Horizontal rest platforms
Handrails
Lateral borders
Guards
Pavement lateral extension
Width
Double handrails
Stairs:
Width of the stairways and landings
Depth of the superior and inferior landings
Intermediate landings
Steps depth
Steps height
Stair nose
Non-slip surfaces with visual signalling
Handrails

Figure 1 shows the network used as case study. In the same figure, the location of the crosswalk is enhanced by means of a red circle. The crosswalk is located in the convergence of *Avenida Central* and *25 de Abril* Street, near a high school (*Escola Secundária Dona Maria*). It is crossed by a high flow of pedestrians during the day. Table 5 presents all the steps of the evaluation process, showing the considered criteria, the collected values from field work, the normalization, the weights and the index calculation (by application of Equation 1). Table 5 also includes a picture of the crosswalk and a map showing how the index is represented through the simbology of the segment.

The map in Table 5 shows that the index value obtained for this crosswalk appears symbolized with a light green colour. As specified by the map legend, the chosen colour indicates that the index value is between 0.75 and 1. This means that the crosswalk is not fully in conformity with the standards. Observing the calculation process, it can be seen that a criterion (Green light time) is not respected, thus failing the assignment of the maximum index value (the value of 1, if all criteria standards had been met).

Five applicable criteria were evaluated in the example segment shown in Table 5. The curb height has to be less than 0.02m in all width of the crosswalk; the pavement has to be ramped with an inclination inferior to 8% in the direction of the pedestrian passage and inferior than 10% in the direction of the curb or the pedestrian walkways. The width of the intersection zone of the crosswalks with the median strips has to be greater or equal to 1.2m.

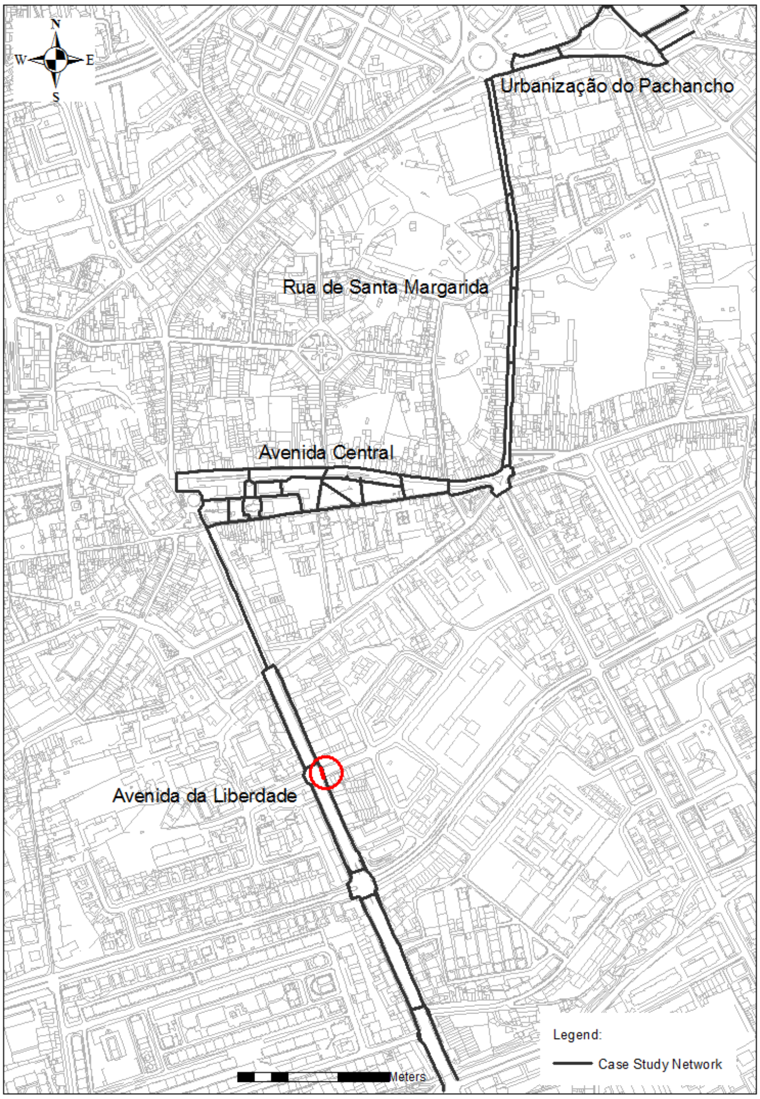
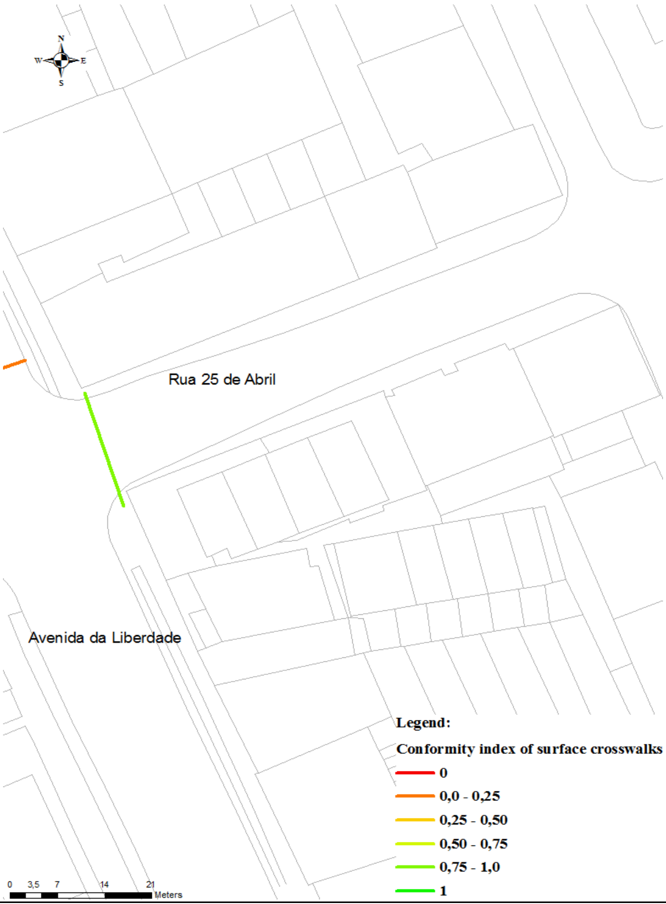


Figure 1 Case study network and crosswalk highlighted - *Avenida Central* and *25 de Abril* Street

Table 5 Detailed calculation of a crosswalk index

Criteria evaluated				
Criteria	**Values**	**Normalization**	**Weight**	**Segment index** $CIS_s = \sum_i w_{is} \times c_{is}$
Curb height	0 m.	1	1/5	1× 1/5+
Pavement	0 m.	1	1/5	+1× 1/5+
Width of the intersection zone of the crosswalks and the median strips	Not applicable			
Pavement slope	0.3%	1	1/5	+1×1/5+
With lighting system:				
Height of the activation device	1.1 m.	1	1/5	+1× 1/5+
Green light time	0.32 m./s.	1	1/5	+1× 1/5
	Result of the segment index			1

Picture	**Map**
	

In the specific case of the represented segment, this criterion is not applicable due to the inexistence of an intersection zone. The pavement slope should be less than 2% in the direction of the pedestrian crosswalk. Figure 2 illustrates the configuration of a crosswalk without lighting system according to the DL163/2006.

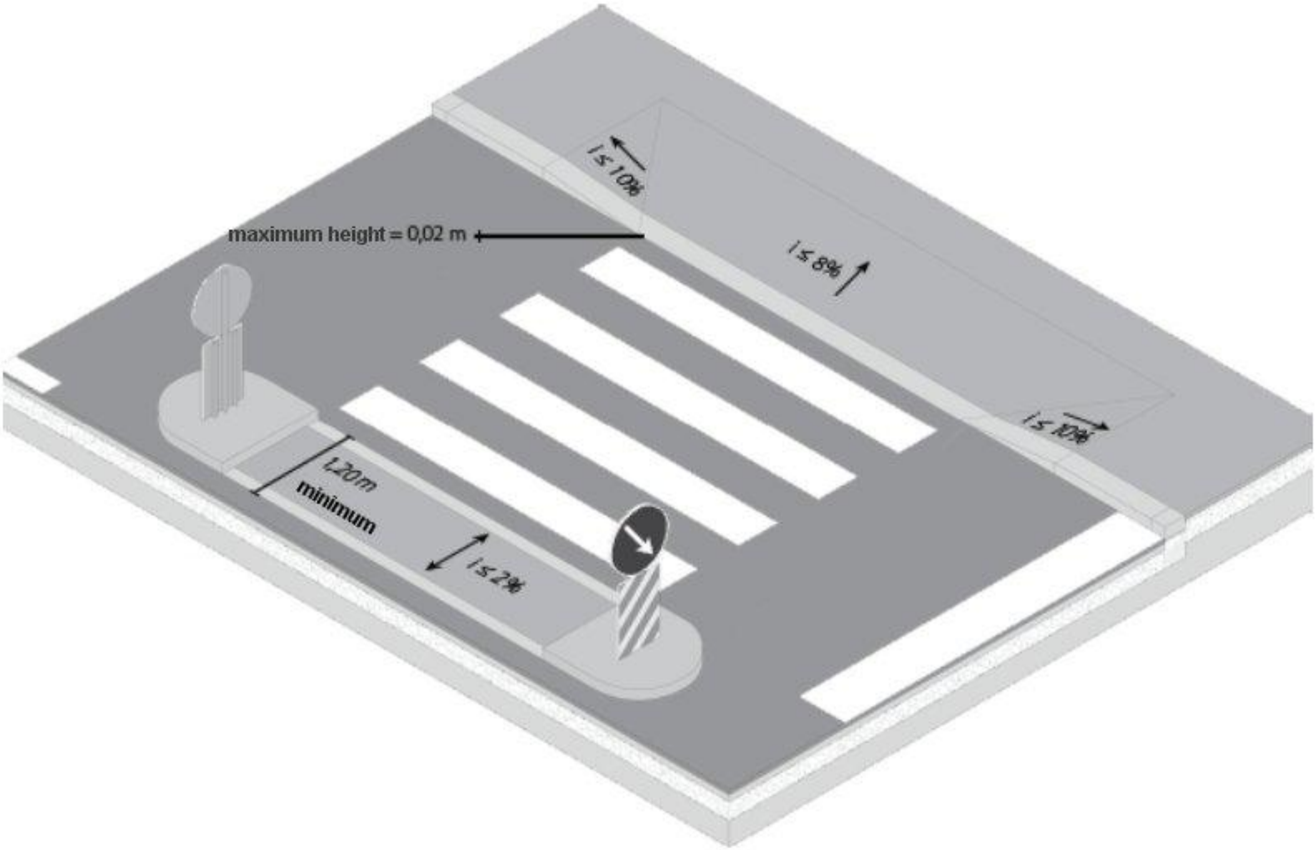


Figure 2 Configuration of a crosswalk without lighting system (source: [10])

When a crosswalk has a lighting system, two more criteria have to be evaluated. The first one is the height of the activation device of the lighting system that must be between 0.8m and 1.2m, as Figure 3 illustrates. The second one is the crossing pace which cannot exceed 0.4m per second, allowing pedestrians to travel to the other side of the street while the crossing green light glows.

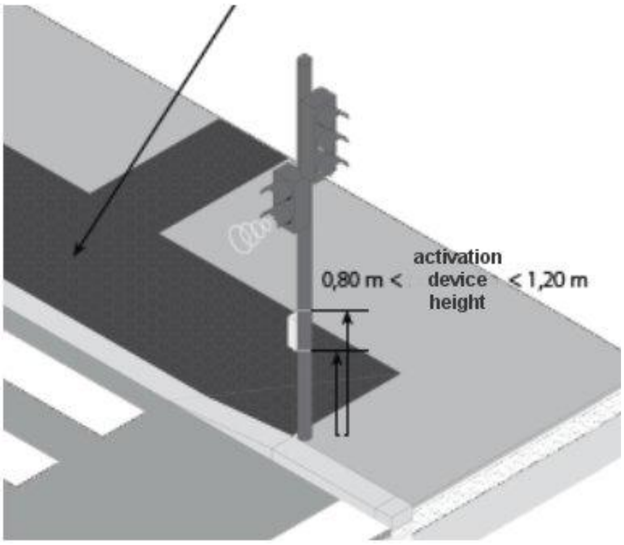


Figure 3 Configuration of a crosswalk with lighting system (source: [10])

4 Results

Figure 4 shows the compliance map for the criterion *ramp slope of sidewalks and pedestrian walkways*. The ramp slope of the sidewalks and pedestrian walkways cannot exceed 6% in order to be in compliance with DL163/2006. Three colours were used for better understanding the map: green to show when the criterion is respected (normalized value is 1), red when the standards are not complied with (normalized value is 0), and yellow to indicate when the criterion is not applicable (no value).

An equal contribution of each criterion was adopted for the subgroup compliance index. Equation (1), referred in section 2, was used to aggregate the criteria and to obtain an index. Then, the compliance indexes for crosswalks and sidewalks were obtained combining all the subgroup indexes of each group, using Equation (3) and considering only the applicable criteria.

Figure 5 shows the map illustrating the obtained index for the sidewalks and walkways group. This index was achieved by the aggregation of the subgroups in Table 3 and by the application of Equation (3). Six classes of values, symbolized by six different colours, were considered as shown in the legend of Figure 5, however only three are actually represented in the map. In fact, all the obtained index values are above 0 and below 0.75, fitting only in those three classes. For that reason, it can be observed that no segment has got an index value of 0, which would indicate a full incompliance with the standards. In contrast, there is also no segment in total compliance, as there are no features in the value 1 class. These results can be explained by the non-compliance of some criteria. In the subgroup *Accessible route*, the criterion *protruding objects in pillars or columns* failed mainly due to the inappropriate position of the waste bins and the *change of direction* criterion as the *90º direction change.* The subgroup *public stairways* failed most of the time due to non-compliant *steps height*, *non-slip surfaces with visual signalling*, *handrails*, and *staircase width*. In the *ramps in public spaces* subgroup, the criteria that often gets non-compliance values are the *handrails* and the *horizontal rest platforms*.

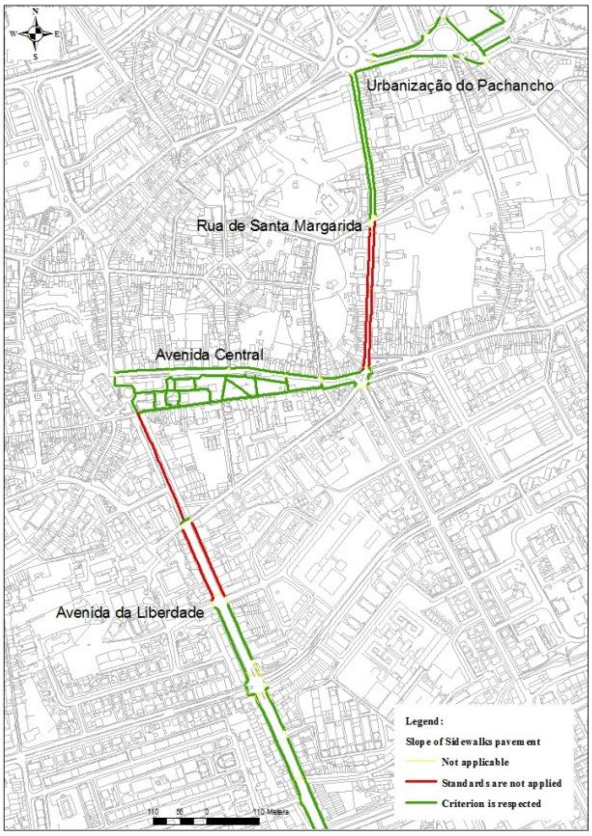


Figure 4 Compliance map for ramp slope of sidewalks and pedestrian walkways

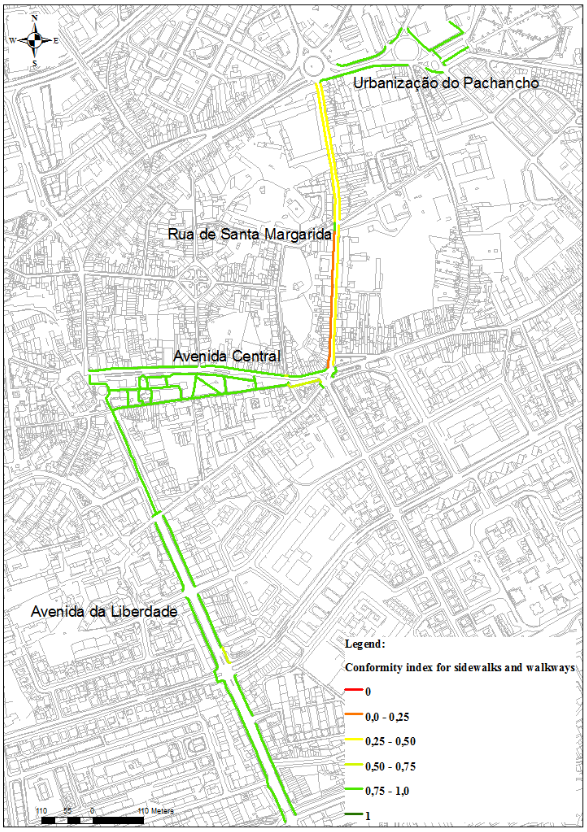


Figure 5 Compliance map for sidewalks and walkways

Figure 6 represents the height of the activation device in crosswalks with lighting system. As previously referred, the activation device has to be at a height between 0.8 m~~.~~ and 1.2 m. As in Figure 4, the green colour means that the referred values are respected. Conversely, crosswalks are symbolized in red when the criterion value is not in compliance. Once again, yellow colour is used to show where the criterion is not applicable. Figure 7 illustrate the index for the crosswalks and pedestrian passages group. Six colours are now present, as shown in the legend: red when none of the criteria is fulfilled, orange when the index have a classification between 0 and 0.25, light orange when classification ranges from 0.25 to 0.50, yellow corresponds to values from 0.50 to 0.75, light green for values between 0.75 and 1, and dark green when all criteria are respected, resulting in the value of 1.

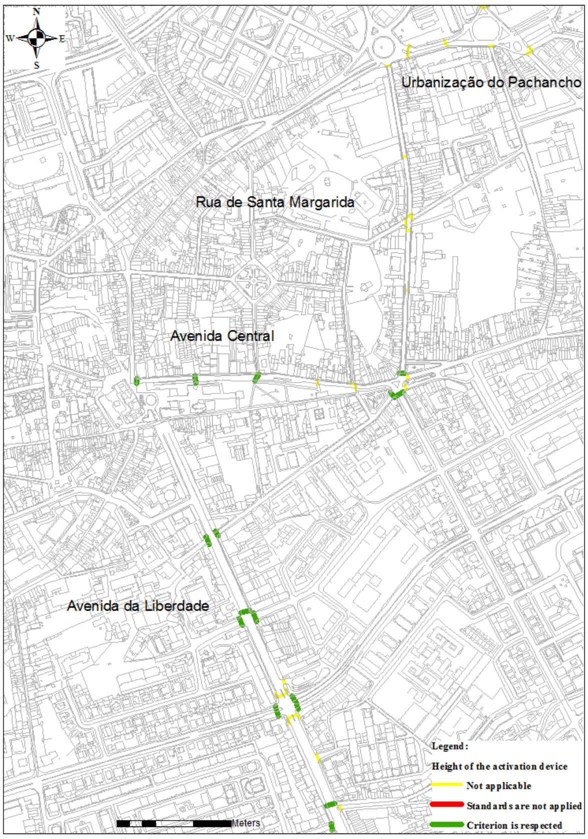


Figure 6 Compliance map for the height of the activation device in crosswalks with lightning system

In this group, the crosswalks with better classification are the ones located in *Urbanização do Pachancho* which can be explained by the recent requalification of the area. Among the criteria evaluated for the group, the curb height and the pavement slope were the ones with more values in non-compliance with DL163/2006, regarding the surface crosswalks. In the subgroup pedestrian overpasses or underpasses, the criteria that obtained worst results were the height of the steps and the intermediate landings.

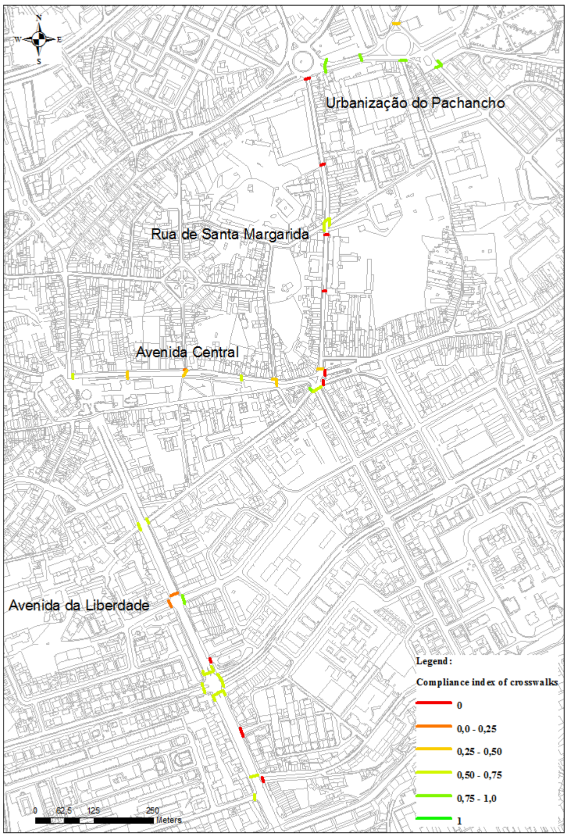


Figure 7 Compliance map for crosswalks and pedestrian passages

To conclude, a final map showing the global index of compliance with DL163/2006 was generated joining the maps of both groups. Figure 8 shows a global map of the index for the chosen study area. The compliance index illustrated in Figure 8 allows a global and integrated view of the conditions offered to people with mobility constraints in this area. As previously mentioned, the best performance is represented by the value of 1, representing a full compliance with the standards. Conversely, an index equal to 0 means that none of the criteria were positively evaluated. As shown in the figure, none of the network segments reached the maximum index (full compliance). *Avenida Central*, *Avenida da Liberdade* and *Urbanização do Pachancho* are the streets with higher indexes, depicted as greener. On the opposite side, the evaluated segments of *Rua Santa Margarida* obtained indexes with values below 0.5 (illustrated in orange and red colours in Figure 8).

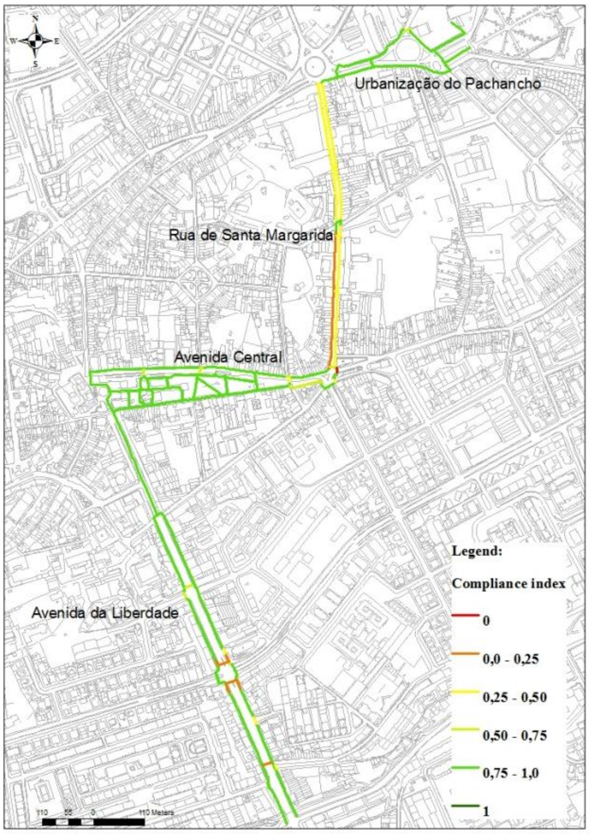


Figure 8 - Compliance index map

5 Discussion

As demonstrated in Figures 4, 5, 6, 7 and 8, the proposed model allows evaluating the compliance of urban spaces at several levels. Figures 4 and 6 showed that an analysis can be done at the lower level, which is at the level of a single criterion. It is possible to understand how a specific parameter did perform by comparison with the standards. As the criteria are grouped under a well-defined structure, output maps can also be produced using the same structure. At the higher level of criteria aggregation, Figures 5, 7 and 8 were presented to show a global and integrated evaluation of the chosen network conformity with the standards defined by law DL163/2006.

Observing the map for the ramp slope of sidewalks and pedestrian walkways (Figure 4), it can be seen that the majority of the segments are in compliance with the Portuguese law. However, some are not: those segments are located in a very uneven surface, a fact that can explain this result. The poor performance of the *Rua Santa Margarida* can be partially explained by its strong slope and by the lack of interventions to enhance street conditions, as highlighted in Figure 9.

(a)

(b)

Figure 9 – Pictures of *Rua Santa Margarida*

In what concerns the crosswalks (Figure 7), none received the classification of 0 (red colour in the map) nor 1 (darker green in the map). It can be concluded that none of the crosswalks failed in the entire set of evaluation criteria, but also none was totally in accordance with the standards.

Since the global index of compliance is a weighted linear combination of groups of criteria, the map of this index did not reveal any segment of the network with maximum score (equal to 1). For this reason, it can be concluded that there are no segments of the network in full compliance with the standards defined in DL163/2006.

An integrated analysis of the whole network can be made by observing Figure 8. In accordance with the previous conclusions, it can be seen that no segment of the network appeared with full incompliance (score equal to 0). On the other hand, no segment has reached a score of 1, which would indicate a full compliance with the standards. Somehow, these results may not be regarded as a surprise in what concerns the network sections prior to the decree-law. However, when observing those segments constructed or improved after the release of the DL163/2006, a lack of integration of the new standards is revealed, namely in the municipal rules for edification, and/or a lack in the adjustment of the monitoring process when verifying whether the new requisites were effectively being respected.

6 Conclusions

For pedestrians with mobility constraints, the presence of physical barriers in an urban environment can severely condition their possibilities of having an active and participative role in society. In this context, a spatial evaluation model was proposed to classify physical urban environments for pedestrians. The analysed urban spaces are classified to translate the level of compliance with the requirements defined by law for the urban circulation of pedestrians with mobility constraints. Using the Portuguese law DL163/2006 as framework, a set of criteria was collected and used as the basis for the proposed model. For testing the model, a case study was applied, consisting of a pedestrian circulation network selected in the city of Braga, Portugal. This selection was made in order to encompass streets built or reconstructed before and after the implementation of this law. The model implementation and the case study analyses were conducted in a GIS platform. This integration was performed with the aim of taking advantage of the GIS edition and analysis toolset, as well as its graphical display capabilities.

Maps for several groups of criteria were generated, showing the level of compliance of the network segments. From the analysis of the results, segments can be pointed out as performing positively or negatively. The same work was developed also for the global index of compliance (combination of the whole set of criteria). This model can be useful for city managers to identify which parts of the city do not yet meet the legal requirements. It is also advantageous to verify whether new projects will implement solutions in compliance with the standards defined in the Portuguese law. The use of maps, i.e. of graphical representations, simplifies the analysis of the global index to find where compliance is not achieved. In those cases, it is also easier to identify which group or groups of criteria need to be improved. This analysis is possible since a map for each group, subgroup or even for each criterion can be generated.

References:

[1] Zegeer, C.V.; Seiderman, C.; Lagerway, P.; Cynecki, M.; Ronkin, M.; Schneider, R. (2002) **Pedestrian Facilities User Guides – Providing Safety and Mobility**, U.S. Department of transportation- Federal Highway Administration

[2] Tight, M. R; Kelly, C.; Hodgson, F. C.; Page, M (2004) Improving Pedestrian Accessibility and Quality of Life, **10th World Conference on Transport Research**, Istanbul, 4th-8th July 2004.

[3] Batty, M, Agent-based pedestrian modeling. ***Environment and Planning B***, 28(3), 321-326, 2001.

[4] Clarke, P.; Ailshire J. A.; Lantz, P, Urban built environments and trajectories of mobility disablility: Findings from a national sample of community-dwelling American adults (1986-2001), ***Social Science and Medicine***, 69, 964-970, 2009.

[5] Sedlak, P.; Komarkova, J.; Piverkova, A. (2010) Spatial analyses help to find movement barriers for physically impaired people in the city environment- Case study of Pardubice, Czech Republic, **WSEAS Transactions on Information Science and Applications, Issue 1, Volume 7.**

[6] Vozikis, K.T (2009) Are there accessible environments in Athens, Greece today?, **WSEAS Transactions on Environment and Development, Issue 7, Volume 5.**

[7] Frye, A. (2011), **Mobility: Rights Obligations and Equity in and Ageing Society**, 2011 International Transport Forum on Transport for Society, Leipzig, Germany, 25-27 May

[8] Ministry of Work and Social Solidarity, (2006), "Decree-law nº163/2006", **Diário da República**, 1º série-Nº152, Portugal (in Portuguese).

[9] Sedlak P.; Komarkova J.; Jedlicka M.; Hlasny R.; Cernovska I. (2011) The use of modelling tools for modelling of spatial analysis to identify high-risk places in barrier-free environment. **International Journal of Systems Applications Engineering & Development, Issue 1, Volume 5.**

[10] Teles, M. F., Ferreira, L., Oliveira, M., Pais, A., Martins, B. (2006-2009) **Accessibility and Mobility for all**, National Secretary for the Rehabilitation and Integration of Disabled People, Inova, Porto (in Portuguese).

[11] Rodrigues D.S., Neiva, C.L., Ramos R.A.R. (2011), **Pedestrian mobility-mapping circulation conditions for persons with restrains of movement in a central area**. 12th International Conference on Computers in Urban Planning and Urban Management, Lake Louise, Canada

[12] Malczewski, J. (1999), **GIS and Multicriteria Decision Analysis**, New York: John Wiley & Sons, Inc.

[13] INE (2011), **http://www.ine.pt**, Statistics Portugal.

[14] Tsouchlaraki A., Achilleos, G., Nasioula, Z., Nikolidakis A. (2010) A System for Monitoring Environmental Quality of Urban Road Network and for Supporting Decision Makers, **WSEAS Transactions on Environment and Development, Issue 3, Volume 6.**