XIII CTV Congreso Internacional Ciudad y Territorio Virtual
International Conference Virtual City and Territory
BARCELONA 2019

GROUND LEVEL PERMEABILITY AS INDICATOR OF WALKABILITY IN CITIES

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Initial submission: 2019-06-16; **Definitive submission:** 2019-11-15; **Publication:** 2019-12-21

Citation: Lopez-Besora, J. *et al.* (2019). Ground level permeability as indicator of walkability in cities. In *XIII CTV 2019 Proceedings: XIII International Conference on Virtual City and Territory: "Challenges and paradigms of the contemporary city":* UPC, Barcelona, October 2-4, 2019. Barcelona: CPSV, 2019, p. 8658. E-ISSN 2604-6512. DOI http://dx.doi.org/10.5821/ctv.8658

Abstract

For centuries, urban developments were dimensioned on a human scale. Cities had a limited number of inhabitants and a size which was not convenient to overtake so as not to exceed a balance point. Over time, after important discoveries in the field of transportation, these limits blurred. Mechanical transport systems made possible the expansion of cities because private cars allowed people to move easily and at a reduced cost. Then, the prioritization of vehicle traffic in streets grew at the expense of pedestrians. Street quality decreased gradually with this change, as authors like Jane Jacobs warned in the middle of the last century.

After decades of urban sprawl, academic and political institutions call today for a totally opposite model. A shift towards compact cities, with mixed use neighborhoods and walkable streets is aimed nowadays. The study presented in this paper is focused on the last point, the promotion of streets designed for people to walk, enjoy and feel secure.

Walkability is a concept that integrates several aspects related to street design with the aim of inviting people to move on foot. One of the aspects that affect walkability is the direct relationship between pedestrians and ground floors, both regarding the appearance and permeability of façades. Permeable ground level façades provide a connection between pedestrians and the surrounding buildings, making them feel secure and comfortable in the street.

Some institutions have developed urban sustainability assessment tools which evaluate walkability of urban developments, among other parameters. Usually, a score system quantifies the degree of compliance of some metrics related to walkability. In this study, two metrics from the TOD Standard 3.0 assessment tool were applied to a case of study, both referred to ground level permeability. The objective is double: testing the system itself by getting some reference values and finding out the relation between the values in detail and their position along the street.

The assessment was carried out in two streets in Gràcia neighborhood, Barcelona: Verdi and Bruniquer-Terol-Ros de Olano. The streets are perpendicular, 5-10 meters wide and 780 and 882 meters long. Gràcia is considered a vibrant, active, compact and mixed-use neighborhood, so that it would be expected to achieve a high score in ground level permeability.

The chosen parameters are metric 1.B.1, "Visually active Frontage" and 1.B.2, "Physically Permeable Frontage". The metrics were applied to the mentioned streets in a field study following the procedure defined in the standard. A series of pictures and a floor plan of the zone were used to this end. The result of 1.B.1 metric was a 100% of visually active frontage in both streets, which means that all segments or blocks have more than 20% of transparent length. This value corresponds to the maximum value in the score. In the case of 1.B.2 metric, the number of entrances per 100 meters of block frontage is 17 in Bruniquer-Terol-Ros de Olano and 20 in Verdi. The required value to obtain the maximum score in the TOD Standard is 5 entrances per 100 meters, so both streets are much over the score. According to both metrics, walkability would be widely reached.

The analysis of each segment showed a relationship between ground level permeability and two features: plot distribution and the age of the building. Apart from this, an important question arose when applying the procedure, the influence of time; whether it be the time of day, the time of the year, or the situation of the premises on the ground floor according to market fluctuations. Depending on them, the data acquisition on field might change the result.

The application of walkability TOD Standard metrics in the field has resulted to be an easy and useful tool to analyze ground level permeability, though subject in some way to the criteria applied in the data acquisition. The values obtained

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have been much higher than the maximum required in the score, so compact cities may need another range of values to provide a subtler definition of walkability because the score seems to be out of scale. The application in this field study has shown that the score is bound to the context and that a tool may consider that the nature of cities is variable.

Key words: walkability; ground level; compact city; TOD Standard

1. Introduction

The way people move in cities has experimented several changes in the last centuries. After a long time in which cities were designed to be used at foot or horse speed, the irruption of cars gave rise to a new model based on non-human distances. This change entailed the expansion of the urban sprawl model, which monopolized most urban developments in the last century (Arellano & Roca, 2010).

Over time, this model has been questioned. Authors such as Jane Jacobs or Jan Gehl warned about the dehumanization of cities and the loss of human-based quality in streets and public spaces, monopolized by cars. In her book "*The death and life of great American cities*" (Jacobs, 1992), Jane Jacobs discusses the success and failure of urban planning decisions, obtained from her observation of human behavior. She observed that urban density, small blocks, mixed-use developments and physical connection between public space and buildings were characteristics of vibrant and secure neighborhoods. In the same line, the production of the Danish architect Jan Gehl is oriented to guide planners towards urban models based on the fulfillment of pedestrians and cyclists needs. His books "*Cities for people*" (Gehl, 2010) and "*Life between buildings: using public space*" (Gehl, 2011) explain some reflections about quality public spaces and, in the center of the discussion, the paper of people in urban design. This idea is highlighted by the analysis of cities at eye level, focused on the perception of people. In Spain, an exhaustive study of walkable cities (Pozueta Echavarri, Lamíquiz Daudén, & Porto Schettino, 2009), established that pedestrians speed up in streets with opaque ground level façades. The study confirms that people need some visual connection with the interior of buildings to feel comfortable when walking on the street. Also, visual monotony is a feature to avoid in walkable cities.

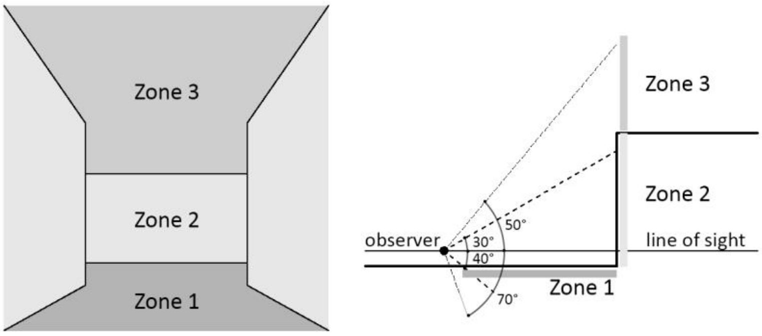
The concept of city is linked to the presence of people in the street (Borja & Muxí, 2001). In this line, the concept of walkability was defined with the aim of promoting the presence of other human beings in streets to improve people's social life, comfort, health and sense of security. This concept joins different aspects related to the quality of streets, considered from pedestrians' point of view (Southworth, 2005). A walkable city offers a friendly built environment in which people are predisposed to spend time on streets and move on foot. The definition of how friendly a built environment is includes the coincidence of some aspects such as: the presence of other human beings and vegetation, a minimum presence of cars, a lack of monotony in buildings, an appropriate density, mixed uses, ground floor retail, and physical and visual connection with the interior of buildings, to say some.

Physical and visual connection take place at ground level because of the characteristics of our sense of vision. The human visual field is limited by vertical and horizontal angles that frame the environment (Panero, Zelnik, & Castán, 1983). However, the vertical limits of a person who walks are constantly changing, while de horizonal ones practically not. As a consequence, the pedestrians' visual field defines a urban scene which is mostly occupied by ground level at the center and pavements on bottom, while the most part of buildings and the sky usually remains

ISSN e: 2604-6512

out of vision (Lopez-Besora, Serra-Coch, Coch, & Isalgue, 2016), as shown in Figure 1. For that reason, the characteristics of ground level façades play an important role in the perception that pedestrians have of the urban environment, since they are at the center of our visual field and their permeability represents the point of contact between outdoors and the interior of the building.

Figure 1. **Pedestrians' visual scene in urban environments**



Source: Lopez-Besora et al. Daylight management in Mediterranean Cities: When shortage is not the issue. Energies 2016, 9, 753

The decision of taking a way on foot or by other means of transport is influenced by people's taste and the characteristics of the environment, like ground level permeability. In recent years, some methods of measuring walkability integrated in sustainability assessment tools have appeared. LEED ND (USGBC, 2014), BREEAM Communities (BREEAM, 2012) and TOD (ITDP, 2017) are some of the most widespread. Such standards use a wide range of metrics to assess new developments and existing communities, but the methodology and the weight given to each parameter is changes depending on the procedure. All of them have in common that the sections related to walkability include requirements about ground floor characteristics.

The first one, LEED ND (Leadership in Energy & Environmental Design, New Developments) evaluates the occurrence of functional entries at ground floor level and the importance of the proportion between clear glass and blank surfaces, which is stipulated in a minimum of 60-40%. The second one, BREEAM Communities (Building Research Establishment Environmental Assessment Method, Communities), establishes a specific point about the appearance of the public realm. A special mention is focused on ground floors, which give a sense of vibrancy promoting activity overspill to the street and allowing views both out and in. This is a specific mention on visual permeability. The third one is the TOD Standard. This tool was created by the *Institute for Transportation & Development Policy*, a body specialized on aspects related to transport. The purpose of the tool is the validation of new or existing communities in terms of urban quality. Here, a specific point is exclusively focused on walkability.

The TOD scoring system is simple and requires limited and easy to find information. Eight principles configure this tool (walk, cycle, connect, transit, mix, densify, compact and shift), defined by some objectives that in turn are scored through one, two or three metrics. The maximum points that can be obtained by meeting the requirements are 100 (ITDP, 2017).
The Walk principle is structured in three objectives:

- A. The pedestrian realm is safe, complete, and accessible to all.
- B. The pedestrian realm is active and vibrant.
- C. The pedestrian realm is temperate and comfortable.

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The study presented here is focused on the assessment of ground level permeability and the TOD standard has two specific metrics to measure this characteristic. The metrics are included in objective B, defined in the *walk* principle, and they are specifically referred to visual and physical permeability:

- Metric 1.B.1. Visually Active Frontage.
- Metric 1.B.2. Physically Permeable Frontage.

The methods explained above have highlight the importance of walkability in future cities. In fact, the benefits of walkable cities are numerous. The type and amount of energy used for transportation is one of them. Cities with pleasant pedestrian routes and an appropriate design of collective transport network contribute to the reduction of private car use and, therefore, the amount of energy used for moving. In addition, the reduction of private cars in favor of other means of transport affects public health by reducing particles emission to the atmosphere and pollution. Recently, more than 230 European cities have established Low Emission Zones (ZBE) in order to limit the access of vehicles in city centers. Policies like this have contributed to improve the quality of air in cities like Stockholm or Madrid (Elcacho, 2007).

For all these reasons, among others, the mobility model based on private cars is under consideration today in many cities around the world. This situation is manifest in big metropolis that grew in the last century with huge expansions based on urban sprawl models. In these cases, the concept walkability along with an important public transport investment is under consideration by local governments. For all of them, walkability is a key factor which illustrate this change of paradigm aimed by cities with a high car dependence.

Compact cities are the opposite of sprawl developments. In Europe, it has been the main urban model for centuries (Morganti, 2013) (EEA-FOEN, 2016), for historical and geographical reasons. However, long periods of economic growth led to the creation of suburbs with great occupation of land but less urban quality for pedestrians (Frumkin, 2002). Even some town centers have lost some of their commercial and leisure activities that have moved to the outskirts. The benefits and charm the city had before, have been lost along the way. Going back to the principles of walkability is a way to return to a model that was thoroughly fulfilled in compact cities.

2. Objective

The objective of this study is to find out the strengths and weaknesses of walkability standard metrics referred to ground level façade permeability by putting them into practice in a case of study in Barcelona. The amount of information is not enough to provide with the necessary data to draw conclusions about the area and its urban tissue. However, an approximation of the values obtained in a compact urban tissue represented by two characteristic streets in the same neighborhood will be obtained.

3. Methodology

The methodology is based on the TOD Standard tool, created by the *ITDP - Institute For Transportation & Development Policy*. The tool can be used in two modalities: scoring new development projects or evaluating station catchment areas. The first modality measures a defined area to find out investment, land use and planning opportunities. The catchment area of

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existing transit stations is a complementary method to understand the land around transit stations and their area of influence, while exploring new chances for the future. In this work, the tool is implemented in two streets of Barcelona with the aim of having the metric values of the whole street and detailed in segments.

The analyzed metrics are 1.B.1 and 1.B.2, referred to ground level façades. Visually Active Frontage metric (1.B.1) defines the “Percentage of walkway segments with visual connection to interior building activity” (ITDP, 2017). To this end, the number of public walkway segments were quantified. In streets less than 20 meters wide, both sidewalks must be counted as one segment. Then, the number of public walkway segments that qualify as visually active were also quantified. To be considered as visually active, the length of a walkway segment must be more than 20% visually penetrable or transparent, as defined in the TOD Standard. The second measure divided by the first calculates the percentage. The results show the percentage of visually active segments of the street. Also, the percentage of transparent length of each segment is calculated. The scoring system establishes that the maximum points (6 points) are reached if 90% of the segments or more are visually active. The minimum (2 points) corresponds to 50-60%.

The second metric, Physically Permeable Frontage metric (1.B.2) is defined by the “Average number of shops, building entrances, and other pedestrian access per 100 meters of block frontage” (ITDP, 2017). In this case, the length of each block frontage that abuts public walkways has been divided by 100 m. Then, the number of entrances in each block has been quantified. Finally, the second measure divided by the first calculates the average number of entrances per 100 m of block frontage. Only qualifying entrances can be measured: it means that emergence exits, storage doors, garages and driveway entrances have not been counted. The width of the street is not considered in this metric, so each segment corresponds to one block frontage. The information about the total length and each segment of the street is also provided in the results. According to the scoring system, the maximum points (2 points) are reached if there are 5 or more entrances per 100 m. If there are 3 or more entrances per 100 m, the score gives 1 point.

The materials used for the implementation of the methodology were pictures from ground level façades taken all along both streets. The pictures, taken during the field study, were scaled and inserted in a digitalized floor plan. The superposition of vector data and raster images made possible to measure the number of entrance points and the length of blocks and transparent elements. The measures were then introduced in tables for their analysis.

Also, the results are shown graphically over a street plan which shows the particularities of each block/segment along the street. The graphical approach has been introduced in this work through pictures and drawings. It is a useful information for studying public life (Gehl & Svarre, 2013) and understanding the particularities of urban tissues (Serra-Coch, Chastel, Campos, & Coch, 2018).

4. Case of study

The methodology has been implemented in two streets of Barcelona, in the district of Gràcia. Gràcia is a core district of Barcelona, with an area of 418,6 ha and 120.000 inhabitants

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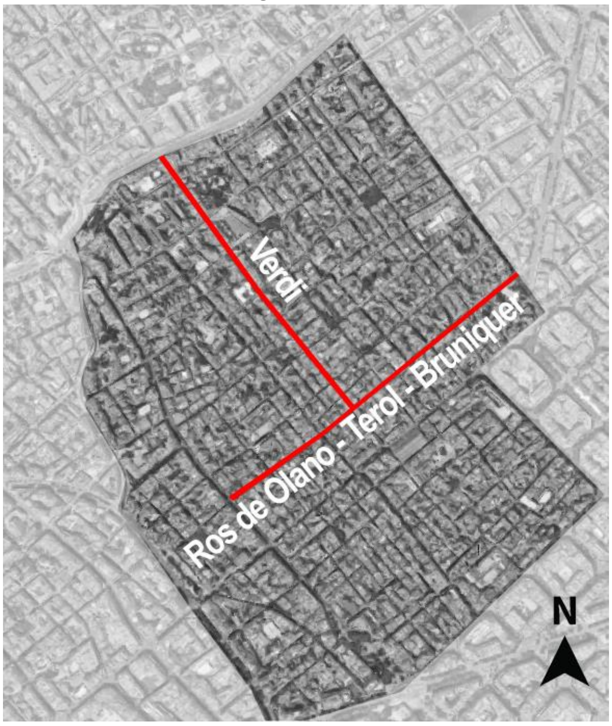
approximately [2]. It is considered a compact neighborhood with a density of 382 inhabitants per hectare [3]. It was an independent village in its origins, but it was annexed to Barcelona in 1897. It has an excellent communication with the rest of the city, due to its proximity to the center and the main transit network. The neighborhood is fundamentally residential, mixed with consolidated retail stores and cultural and leisure premises in ground floors. The social tissue in Gràcia is active, since it houses many social and cultural entities combined with bars, restaurants, and a cinema.

Today, the district has five neighborhoods: El Coll, Vallcarca/Penitents, La Salut, Camp d'en Grassot/Gràcia Nova and Vila de Gràcia. The streets chosen for the study are Verdi and Bruniquer-Terol-Ros de Olano. Despite having three names, the second street is continuous in its layout. Both streets are part of Vila de Gràcia, the historical center of the district (Figure 2). The streets have restricted areas for pedestrians and the access to vehicles is limited, with slow traffic zones.

Figure 2. **Vila de Gràcia neighborhood with the studied streets**



Source: elaborated by authors with a Google Maps image basis

The main direction of Bruniquer-Terol-Ros de Olano is NE to SW. It starts at Escorial at NE, and at SW it ends at Gran de Gràcia, the main artery of the neighborhood. It is perpendicular to Verdi, which crosses in Plaça de la Revolució. The width of the street ranges from 5,5 to 8 m. The studied section of the street is 882 m long and it is divided in 12 segments or block frontages named S.1-S.12, as represented in Figure 3. When the metric requires a difference between both sides of the street, the suffix NW or SE is added to the name of the segment.

[2] https://ajuntament.barcelona.cat/Gràcia/es/el-distrito-y-sus-barrios/el-distrito-y-sus-barrios
[3] https://www.bcn.cat/estadistica/castella/dades/anuari/cap01/C0101050.htm

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Figure 3. **Bruniquer-Terol-Ros de Olano: segments' name**

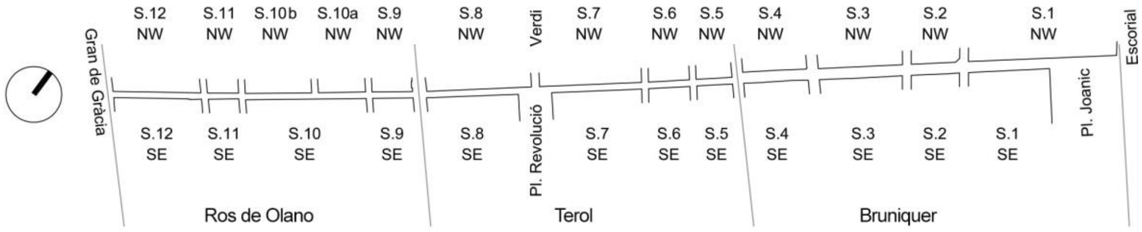
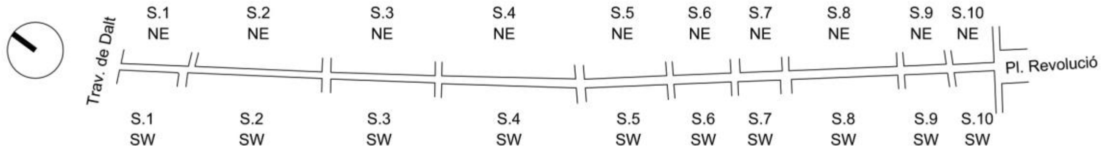


Figure 4. **Verdi: segments' name**



Source: own elaboration.

Verdi Street crosses Vila de Gràcia from NW to SE, linking Vallcarca and Eixample neighborhoods. The street has a pronounced slope in the northern section that decreases in the southern part, before Plaça de la Revolució. The width of the street ranges from 5 to 10 m. The section between Travessera de Dalt and Terol has been analyzed, with a total length of 780 m divided in 10 segments or blocks. The segments are named S.1-S.10. When the metric requires a difference between both sides of the street, the suffix NE or SW is added to the name of the segment. The identification of segments is represented in Figure 4.

5. Results and discussion

The information taken during the field study permitted measuring the length of transparent and blank surfaces, and the number of qualifying entrances in each block. These values were put in tables and a floor plan, and the results were analyzed.

Starting with 1.B.1 parameter, 100% of the segments of Bruniquer-Terol-Ros de Olano and Verdi are considered as visually active (Table 1). It means that all the measured segments were more than 20% visually active or transparent. The 100% of visually active shown in Table 1 is associated to the street considered as a whole. However, the values of the field study are also specified in segments which permit a detailed analysis. Tables 2 and 3 show the active frontage percentage of the segments that configure Bruniquer-Terol-Ros de Olano and Verdi.

Table 1. **Bruniquer-Terol-Ros de Olano and Verdi: visually active frontage percentage**

	Bruniquer-Terol-Ros de Olano	Verdi
Number of public walkway segments	12	10
Number of visually active segments	12	10
Visually active frontage percentage	**100%**	**100%**

Source: own elaboration.

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Table 2. **Bruniquer-Terol-Ros de Olano: visually active frontage percentage per segments**

		Frontage (m)			Visually active frontage (m)			Active frontage percentage (%)	Visually active (Y/N)
		NW	SE	TOTAL	NW	SE	TOTAL		
C.BRUNIQUER	S.1	124	71	195	69	25	94	48%	Y
	S.2	42	42	85	25	18	43	50%	Y
	S.3	73	72	146	48	30	78	53%	Y
	S.4	56	56	112	31	20	51	46%	Y
C.TEROL	S.5	31	31	62	9	12	20	32%	Y
	S.6	36	36	72	11	18	28	39%	Y
	S.7	89	79	168	42	45	86	51%	Y
	S.8	91	80	172	46	42	88	51%	Y
C.ROS DE OLANO	S.9	35	36	71	7	13	20	29%	Y
	S.10a	41	105	205	19	45	86	42%	Y
	S.10b	58			22				
	S.11	27	27	54	12	11	23	43%	Y
	S.12	77	77	153	52	33	85	55%	Y
AVERAGE								45%	Y

Source: own elaboration.

Table 3. **Verdi: visually active frontage percentage per segments**

	Frontage (m)			Visually active frontage (m)			Active frontage percentage (%)	Visually active (Y/N)
	NE	SW	TOTAL	NE	SW	TOTAL		
S.1	59	52	111	34	29	63	57%	Y
S.2	111	117	228	49	44	93	41%	Y
S.3	91	91	182	30	48	78	43%	Y
S.4	117	118	235	55	65	120	51%	Y
S.5	72	72	144	44	43	86	60%	Y
S.6	51	50	101	26	30	56	55%	Y
S.7	37	37	74	24	13	37	50%	Y
S.8	95	93	188	57	56	112	60%	Y
S.9	28	38	65	20	24	44	68%	Y
S.10	27	35	62	21	18	39	62%	Y
AVERAGE							55%	Y

Source: own elaboration.

According to those tables, the average visually active frontage in Verdi is 55%, and 45% in Bruniquer-Terol-Ros de Olano. Apart from this, the percentage of transparent frontage ranges from 29% to 68%, much higher than 20% needed to be considered as visually active. The lowest value corresponds to segment S.9 in Ros de Olano, with a 29% of visually active frontage, and the highest one corresponds to segment S.9 in Verdi Street, with a 68% of transparent length. From the results, it seems that Verdi Street is more active in terms of ground level transparency. Despite that, a segment with 29%, would be widely considered as visually active according to TOD standard.

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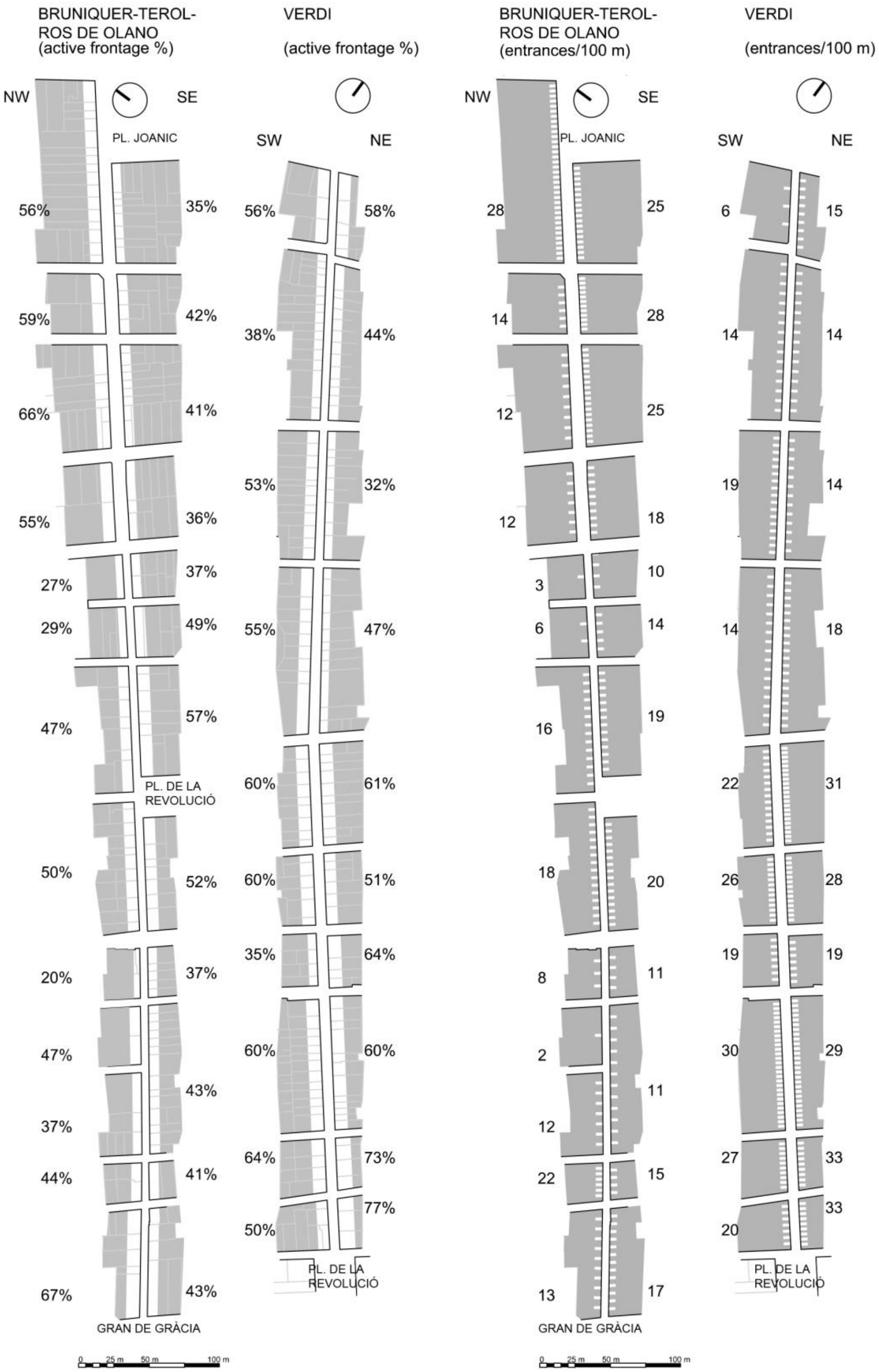
Figure 5. **Bruniquer-Terol-Ros de Olano and Verdi: maps with 1.B.1 and 1.B.2 metrics specified for each block**



Source: own elaboration.

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The implementation of TOD standard fixes that the streets less than 20 m wide must be considered as a unique segment, and this premise has been considered on measuring 1.B.1 parameter. However, the percentage was also calculated for the block frontage at each side of the street. Figure 5 shows the values graphically over a map with different widths which represent the transparent percentage of blocks. The minimum is 20%, obtained in Ros de Olano, block S.9-NW (Figure 6). The maximum is 77% and it corresponds to Verdi, block S.10-NE (Figure 7). The façade of the mentioned blocks reflects this fact, showing a completely different appearance in Verdi and Ros de Olano ground levels.

The nature of Verdi and Bruniquer-Terol-Ros de Olano explains this difference in average and single values. The main direction of historical streets in Gràcia is NW-SE, following the slope of the topography. Some of those streets are named after torrents, reminding original streams of water: Torrent de l'Olla, Torrent de les Flors or Torrent d'en Vidalet. Transversal streets such as the studied one serve as a functional connection, and sometimes they do not cross the whole neighborhood as the others do. Even Bruniquer-Terol-Ros de Olano change name three times in the studied section. It is not an isolated case, since it happens in other parallel streets.

Figure 6. **Ros de Olano: block S.9-NW**

Source: authors.

Figure 7. **Verdi: block S.10-NE**

Source: authors.

The second parameter studied is 1.B.2, physically permeable frontage. The unit of measure is the segment defined by the block frontage, whose length is not obtained by the addition of both sides of the street but individually. The total length of segments of each street was measured and divided into 100 m. Then, the total number of entrances was counted. The second measure divided by the first gives the value of the metric. The results corresponding to the street and each side are shown in Table 4. It shows that the number of shops, building entrances and other pedestrian access per 100 meters of block frontage is 17 in Bruniquer-Terol-Ros de Olano, and 20 in Verdi. The separated values at both sides of the street show that the average number of entrances in Bruniquer-Terol-Ros de Olano at NW is 15 and 18 at SE. In Verdi, 21 entrances were counted at NE and 19 at SW. These numbers are not much different, though the higher values were obtained in Verdi.

The distribution of entrances along the street development, and the values reached in each segment is shown in Figure 5. In this figure, the measured number of entrances is drawn in each block frontage, while the number specifies the quantity of entrances per 100 meters. According to Figure 5, Table 5 and Table 6, the lowest values in Bruniquer-Terol-Ros de Olano

ISSN e: 2604-6512

are 3 and 2 entrances per 100 meters, corresponding to segments S.5-NW and S.10a-NW, respectively. In Verdi the lowest value is 6 entrances per 100 meters in segment S.1-SW.

Figure 5 shows that the distribution of entrances is not even along both streets. The drawing also depicts the density of entrances in each block. In the case of Bruniquer-Terol-Ros de Olano, this density increases and decreases along the street. In general terms, there is a coincidence between the highest number of entrances per 100 m and the longest blocks. The plot distribution of streets and their dimension defines the number of housing entrances and the number of shops in each block. In the case of Verdi, the tendency is different. In Figure 5 the image shows an increase in density of entrances from Travessera de Dalt to Plaça de la Revolució, with the maximum value at S.9-NW and S.10-NW. The section of the street next to Travessera de Dalt allocates principally housing at ground floor level (Figure 9). This type of housing has one entrance and one or two transparent windows which are not considered as physically permeable. As the street goes down, the number of shops and other qualifying entrances increase (Figure 10) as well as life and vibrancy of the street. In fact, the lower part of Verdi is full of shops, bars, restaurants, and a cinema.

Table 4. **Bruniquer-Terol-Ros de Olano and Verdi: number of entrances per block frontage (100 m)**

	Bruniquer-Terol-Ros de Olano			**Verdi**		
	TOTAL	NW	SE	TOTAL	NW	SE
Length of block frontage /100 meters	14,94	7,82	7,12	13,90	6,87	7,03
Number of entrances along public walkways	247	117	130	280	146	134
Physically Permeable Frontage	**17**	**15**	**18**	**20**	**21**	**19**

Source: own elaboration.

Table 5. **Bruniquer-Terol-Ros de Olano: number of entrances per block frontage (100 m) per segments**

		Block Frontage / 100 (m)		Number of entrances		**Number of entrances / block frontage per 100 m**	
		NW	SE	NW	SE	**NORTH-WEST**	**SOUTH-EAST**
C.BRUNIQUER	S.1	1,24	0,71	35	18	**28**	**25**
	S.2	0,42	0,42	6	12	**14**	**28**
	S.3	0,73	0,72	9	18	**12**	**25**
	S.4	0,56	0,56	7	10	**12**	**18**
C.TEROL	S.5	0,31	0,31	1	3	**3**	**10**
	S.6	0,36	0,36	2	5	**6**	**14**
	S.7	0,89	0,79	14	15	**16**	**19**
	S.8	0,91	0,80	16	16	**18**	**20**
C.ROS DE OLANO	S.9	0,35	0,36	3	4	**8**	**11**
	S.10a	0,41	1,05	1	12	**2**	**11**
	S.10b	0,58		7		**12**	
	S.11	0,27	0,27	6	4	**22**	**15**
	S.12	0,77	0,77	10	13	**13**	**17**

Source: own elaboration.

ISSN e: 2604-6512

Table 6. **Verdi: number of entrances per block frontage (100 m) per segments**

	Block Frontage / 100 (m)		Number of entrances		Number of entrances / block frontage per 100 m	
	NE	SW	NE	SW	NORTH-EAST	SOUTH-WEST
S.1	0,59	0,52	9	3	**15**	**6**
S.2	1,11	1,17	15	16	**14**	**14**
S.3	0,91	0,91	13	17	**14**	**19**
S.4	1,17	1,18	21	17	**18**	**14**
S.5	0,72	0,72	22	16	**31**	**22**
S.6	0,51	0,50	14	13	**28**	**26**
S.7	0,37	0,37	7	7	**19**	**19**
S.8	0,95	0,93	27	28	**29**	**30**
S.9	0,28	0,38	9	10	**33**	**27**
S.10	0,27	0,35	9	7	**33**	**20**

Source: own elaboration.

Figure 9. **Verdi, S.2-NE (fragment)**

Source: authors.

Figure 10. **Verdi, S.6-NE**

Source: authors.

From the results, a series of considerations can be made. First, the relation between the obtained values and the score established in the TOD Standard. In metric 1.B.1, the maximum score is obtained when 90-100% of segments are visually active. According to that, 6 points of 6 would be reached in both streets, since 100% of segments accomplish this requirement. In addition, the vast majority are much over the 20% required. In metric 1.B.2, the minimum entrances per 100 meters of block frontage needed to reach the maximum score is 5. In this case, the obtained values are also much over the minimum, though 2 block frontages would not accomplish this requirement. But if we consider the street as a unit, the 15 and 21 entrances per 100 meters obtained in Bruniquer-Terol-Ros de Olano and Verdi respectively, exceed more than enough the score.

Secondly, the implementation of metrics 1.B.1 and 1.B.2 has led to consider some questions about the urban fabric. The results have shown that the plots size and distribution in a block determines the number of entrances and visually active points. The main direction of streets

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and blocks in Gràcia is NW-SE, so plots mainly face NW-SE directions, as it happens in Verdi. However, transversal streets are configured in most sections by end walls. The section Bruniquer-Terol-Ros de Olano is a transversal street and therefore, it is composed by many end walls with less entrances and transparent surfaces. Other considerations related to the position of transparent walls or entrances next to the corner or in the middle of the segment were deduced from this study.

The period in which the building was finished also determines the permeability of ground level façades. Structural systems changed at the beginning of the twentieth century from load-bearing walls to waffle slabs supported by pillars. This system became usual from the middle of this century, allowing wider openings at any level of the building. It changed the appearance of ground level façades, which became less massive. Most segments shown in this study belong to the first period, when narrow openings but a high number of entrances for shops and housing configured ground floors.

Finally, the importance of time has posed some questions during the field study. When considering transparent surfaces, the standard permits the existence of operable interior or exterior curtains or shutters. Mobile devices change the appearance of streets, especially in the case of retail. Shopping hours or the timetable of housing inhabitants determine the degree of visual permeability beyond the maximum potential. Apart from this, the fluctuations of market also influence the situation of commercial premises in ground floors.

6. Conclusions

The main objective of the study was testing the TOD Standard metrics related to ground level permeability (Visually Active Frontage and Physically Permeable Frontage) in a case of study. These metrics are included in the requirements for walkable cities by favoring the conditions to get an active and vibrant public space. The parameters have been easy to apply in a case of study with few data. However, the application of the method has raised an important issue: the moment or time in which the parameter is measured. The different opening hours and the specific situation of commercial premises make the visually active parameter variable. Measuring the potential of a street without considering this fact seems incomplete.

Besides the method, the results inevitably arose some singularities about the urban tissue. The location of the metrics in a map showed their distribution in the space. Figure 5 shows the values along Bruniquer-Terol-Ros de Olano and Verdi. It seems not to have a logic distribution at first sight. However, a relationship between the results and some facts like the plot distribution or the age of the building have been observed.

Apart from block singularities, Verdi has resulted more permeable than Bruniquer-Terol-Ros de Olano, according to both metrics. Nevertheless, the differences between the streets are small. The answer to the question of whether Verdi is more active and vibrant than Bruniquer-Terol-Ros de Olano, the answer is that the observation and knowledge of the neighborhood reinforce this argument, provided that more cultural and social activity is concentrated in Verdi.

Finally, is has been noted that the values obtained in the metrics are much higher than the minimum required by the TOD Standard score. The results of the Visually Active Frontage metric obtained in the streets double and triple the maximum (29-68% vs. 20%). With respect to

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Physically Permeable Frontage metric, the situation is similar. A minimum of 5 entrances per 100 meters of block frontage are required to get the maximum points. There are only 2 segments of 44 under this value in the analyzed streets. The results obtained in Bruniquer-Terol-Ros de Olano lead to the conclusion that the TOD Standard permeability metrics are out of scale for a compact city with the characteristics of the studied neighborhood. However, more samples would be needed to calibrate the score to the scale of other urban models and measure an intangible concept such as walkability.

Acknowledgements: This work has been supported by the Spanish Ministry of Economy under project code: BIA2016-77675-R. Other acknowledgements to Victor Sánchez, architect and Master student, and Yasmina Sansaloni Architecture Degree student.

Author's contributions: First author has developed the Introduction, Objective, Walkability, Methodology, Case of study, Results and discussion and Conclusions sections; second author has developed the Introduction, Objective, Walkability, Methodology, Case of study, Results and discussion and Conclusions sections; third author has developed the Introduction, Objective, Walkability, Methodology, Case of study, Results and discussion and Conclusions sections.

Conflict of Interest: The authors declare no conflict of interests.

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ISSN e: 2604-6512