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THE 8 PRINCIPLES OF SIDEWALKS

Building more active cities

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This guide provides municipal technicians and city planners with a practical approach and guidelines on how to design good quality sidewalks. It was written for a Brazilian context, but we believe it is worth to provide a translation, so other cities around the world can adapt and apply the guidelines considering their needs and local context. We hope that this guide will help improve infrastructure and mobility for pedestrians by turning sidewalks into more attractive spaces.



Santarém/Brazil

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FOREWORD

Sidewalks are like open veins, through which the life of a city flows. They are for everyone, democratic, making no distinction about who uses them. They serve as a foundation to the majority of the population's daily travels and have a direct impact on the whole population, with an influence on quality of life, culture, business and the identity of places.

Even so, the quality of sidewalks is a secondary issue in Brazilian city planning, and an indication of the sparse value afforded to public spaces in the country. In most cases, because responsibility for sidewalks falls to property owners, decisions pertaining to their construction do not always address the needs of the wider population. Within public spheres, there are so many players

involved (departments of urban planning, public works, traffic, accessibility, the environment, water companies, sewage, electricity, among others) that no one ends up fully committing to ensuring their quality.

Imagine cities with spaces better suited to people walking, with active frontages, quality lighting, guaranteed accessibility, abundant urban forestry and practical urban furniture. What would happen? More people would walk more and depend less on automobiles, cutting local pollutant emissions and greenhouse gases. Streets with increased pedestrian occupation and public transport stations would be safer. Commercial establishments would gain new clientele, and hospitals would receive fewer cases involving pedestrian

accidents. Trees would contribute to improving the microclimate, citizens would be healthier due to increased exercise, and quality of life would surely improve.

This publication provides an in-depth look at the world of sidewalks, integrating regulations, planning and execution. More than a mere technical guide serving as inspiration to designers, it offers insights into actions able to transform reality through shared responsibilities. There is currently a discrepancy between investments in infrastructure for vehicles and that aimed at people. A collective vision is needed for our cities, and The 8 Principles of Sidewalks are a means to inspire Brazilian cities to strive for this objective.

There is a growing need for a new approach to urban management. Sidewalks do not necessarily need an owner. They are used by all and, thus, responsibility for caring for them should be shared by all. This publication sheds light on the transformative capacity of cities when implementing solutions involving all interested parties.

Essentially, it is about making urban spaces democratic, so that everyone can commute safely and so that pedestrians are guaranteed the right of way – as set out in the Brazilian National Policy for Urban Mobility, which celebrated its fifth anniversary in 2017. There is still much to be done to make this law a reality in Brazilian cities and WRI Brasil will continue to provide support on the road towards sustainability.



Luis Antonio Lindau
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Olinda/Brazil

EXECUTIVE SUMMARY

HIGHLIGHTS

- Urban space and infrastructure dedicated to pedestrians should be prioritized on public agendas, considering that the majority of Brazilians are walking commuters.
- Sidewalks are spaces for pedestrian circulation and occupation and are comprised of elements that go beyond merely paving walkways that run alongside roadways.
- This guide proposes eight principles for the construction of spaces appropriate for pedestrians, based on extensive reviews of national and international literature.
- The elements are described objectively, including the design, benefits and real examples of application.

- To ensure coordination among the players responsible for the construction, maintenance and qualification of this infrastructure, it is fundamental that each of the different elements that comprise a sidewalk is clearly understood and taken into account.

CONTEXT

Walking is the most democratic way to commute. It is the oldest and most common mode of transport in the world, not to mention being a far healthier option – for both people and cities. However, the expansion of cities, facilitated by decades of prioritizing private, motorized mobility, along with the substandard quality of sidewalks, has dissuaded people from walking. Poor quality paving, insufficient widths for pedestrian circulation, crudely designed urban furniture

and vegetation, illegal vehicle parking and sidewalks occupied by informal commerce are a few of the challenges faced in Brazilian cities.

Integrated and articulated action involving several players is a challenge faced in the planning and management of sidewalks.

Responsibility for infrastructure and for policies that regulate this space involves public and private actors with different competences and attributions. The lack of clear definitions regarding the roles of these actors and inadequate attempts to coordinate these actions result in the neglect of a public space so essential to urban vitality.

There is no single and established guidance encompassing national and international references on sidewalks.

The available literature includes guidelines for the construction of sidewalks based on several sources. Books and reports on urban planning concepts, guides featuring municipal codes, construction process manuals, legislation and technical regulations provide specific details on the construction of sidewalks. However, this scattered information requires a long process of systemization to become an useful tool to urban planners. As such, this guide aims to fill a gap by reviewing modern approaches and practices, and systematically condensing them into practical recommendations.

ABOUT THE GUIDE

The 8 Principles of Sidewalks systematizes the most relevant Brazilian and

international references into a single publication about the planning, design and construction of sidewalks that meet

the needs of people walking. Information is provided in an objective and well-illustrated manner, divided into eight key principles for sidewalks. The principles touch on the varied elements of a sidewalk, benefits of including each element and recommendations to help achieve a high standard for pedestrian infrastructure projects. Furthermore, it presents real examples or evidence of the advantages of correctly implementing these elements.

The goal of this guide is to provide deeper insight into the role of sidewalks in spaces that provide opportunity for social

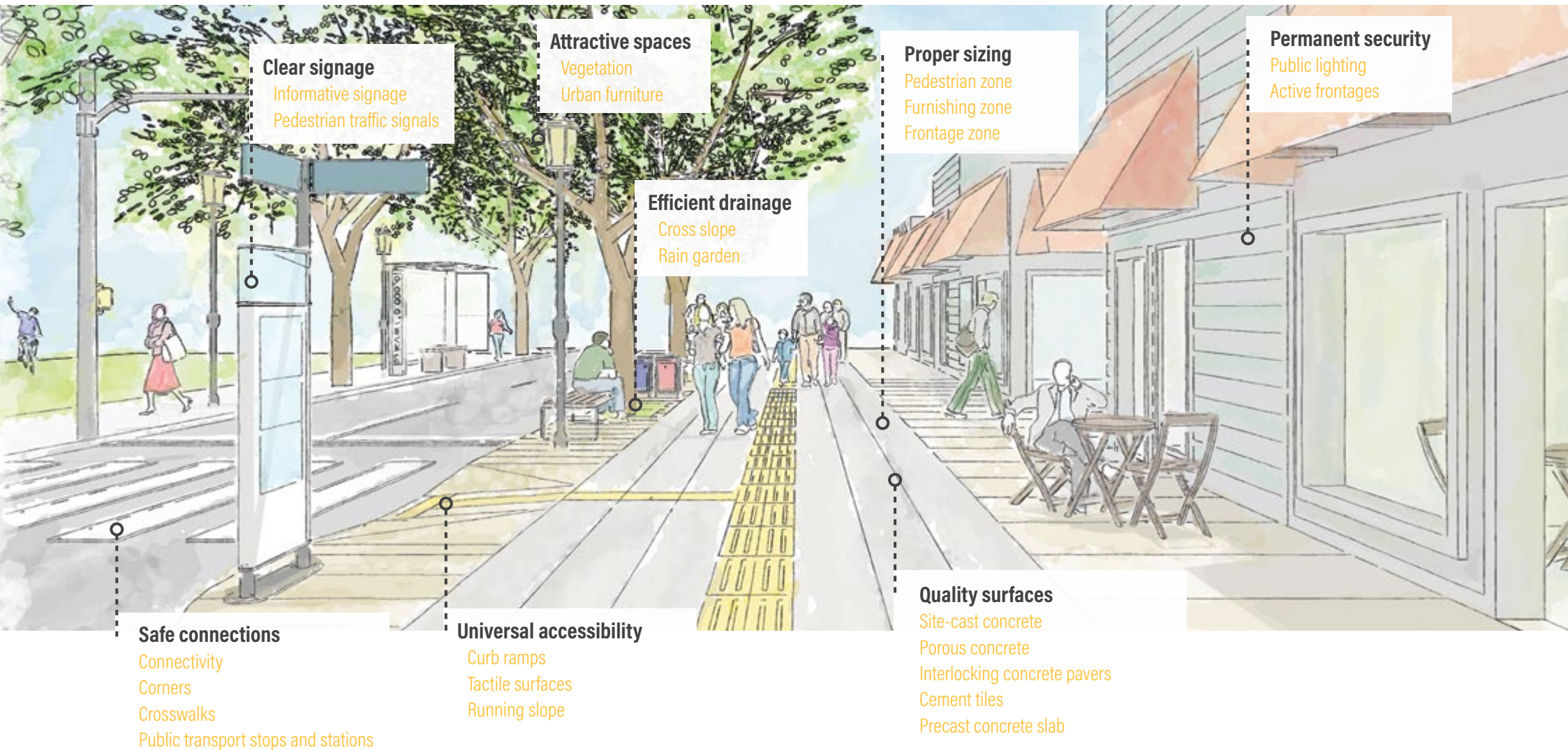
interaction among people. The principles reiterate the characteristics of an urban setting suited to pedestrian mobility, which simultaneously encourage people to interact more with the city. The guide is aimed at managers and technicians from the public sector, as well as consultants, students, political leaders and social movement representatives interested in planning and building quality sidewalks.

This guide contains original material on infrastructure for pedestrians that can greatly benefit many cities, since the quality of sidewalks is a theme of global relevance.

Cities in developing countries are experiencing an opportune moment in terms of democratizing public spaces. In many nations, social movements, civil society and activist organizations, and the general population are discussing the value of walking and ways to encourage more of it.

WRI Brasil supports local leaders in preserving the environment through solutions that contribute to sustainable

development. WRI Brasil is focused on research and the application of methods in the areas of climate, forests and cities. Through publications and guides like this one, it strives to disseminate relevant information so that decision makers can effectively implement public projects and policies that improve quality of life.



Source: prepared by the authors.

Table ES-1 | Contribution of the eight principles to improving the quality of sidewalks

CONTRIBUTION OF THE EIGHT PRINCIPLES TO IMPROVING THE QUALITY OF SIDEWALKS		
PRINCIPLES OF THE SIDEWALK	WHAT DOES IT MEAN?	HOW DOES IT CONTRIBUTE TO THE QUALITY OF SIDEWALKS
Proper sizing	Sidewalk width compatible with the use of the area	Provides pedestrians with comfort and safety
Universal accessibility	Use of elements to facilitate access for everyone	Contributes by making urban space more inclusive
Safe connections	Elements that interlink sidewalks and help to build a network	Facilitate and prioritize walking
Clear signage	Series of signs that guide pedestrians within urban spaces	Provides information about the city at the scale of pedestrians
Attractive spaces	Elements that contribute to making spaces more pleasant	Motivate people to walk and occupy urban public spaces
Permanent security	Aspects that provide improved public security in urban spaces	Increases the sensation of security while walking
Quality surfaces	Techniques to ensure a firm and regular sidewalk surface	Provide pedestrians with comfort and safety
Efficient drainage	Techniques to ensure the flow of rain water	Contributes to maintaining sidewalk functionality

Source: prepared by the authors.

CONCLUSIONS

Seeing sidewalks as an urban space dedicated to facilitating coexistence among people is fundamental to understanding the importance of the principles presented here. Appropriate sidewalk sizing, in proportion to the flow of pedestrians, is essential to developing a network of paths that encourage walking. Sidewalks must provide a comfortable setting for coexistence among people, with well-planned furniture and vegetation. The paved surface should be firm and continuous, to provide pedestrians with a sense of comfort and safety, and for easy access by people with reduced mobility. Building frontages also influence pedestrian experience, along with lighting and efficient rainwater drainage. Additionally, places where people walk should be equipped with clear signage at a pedestrian scale.

Building sidewalks that comply with the eight principles is an important step towards encouraging people to walk more in their daily routines. This guide offers recommendations that reinforce the functions of sidewalks. To effectively enhance the conditions for safe walking throughout the city, it is vital that sidewalk improvement projects are integrated



into the Master Plan and the Urban Mobility Plan. The mixed use of land and the availability of quality public transport are also fundamental components in a pedestrian-friendly city.

RECOMMENDATIONS

Improving the quality of sidewalks through the application of the eight principles can be the first step in an urban renewal process. As such, municipal administrators need to identify who is responsible for applying each in their cities and to ensure coordination if there are multiple players. The municipal government must take an integrated

approach to managing all sidewalk elements, to guarantee quality infrastructure and accessibility for pedestrians. Even sidewalk elements that are not public responsibility can be monitored with the help of the information in this guide.

This guide can be used as support material for the professional development of specialists in pedestrian mobility.

Urban planners should develop expertise regarding the eight principles of sidewalks during their academic education. This guide can be used to instruct students of engineering, architecture, geography, design and other related areas. The future professionals will then be

able to create more sustainable urban projects and build cities geared towards people.

We recommend reading this guide in conjunction with the guide *Cities Safer by Design: Guidance and Examples to Promote Traffic Safety through Urban and Street Design*, authored by WRI Ross Center for Sustainable Cities. Walkable cities also require a safe and accessible design for all users. This report presents good practices to implement road safety measures in streets.



INTRODUCTION

Walking is the oldest and most common means of transport in the world. In Brazil, 36% of the population's daily commute is on foot (ANTP, 2015). However, people are beginning to walk less, whether due to urban sprawl and the consequent increase in motorized modes and distances to be traveled, or due to personal safety risks or poor walking conditions.

Whatever the case, walking continues to be a basic necessity, exercised on a daily basis, even though people may use other means of transport, too. As such, walking may be considered an activity that traverses all other social practices. Accessible pedestrian mobility, besides guaranteeing the right to come and go, also contributes to ensuring access to other social rights, such as education, health and culture.

The quality of sidewalks should be a priority within public policies, to encourage more people to walk and create an attractive and inviting public space, as well as one that is safer for walking. Streets with more life provide a greater sense of security, benefit local commerce and increase quality of life and the sense of citizen benefit, which, in turn, leverages a sense of ownership and care for public spaces by the population. There are myriad benefits for cities that value

and enhance the quality of their sidewalks. They have the potential to be socially inclusive, as, once accessible, they increase the general autonomy and safety of the population. Sidewalks also stimulate active commutes, which encourage a healthier lifestyle, while also being environmentally beneficial. By promoting alternatives to motorized transport, they contribute to a reduction in the emission of pollutant gases.

However, Brazilian cities have low quality sidewalks and, oftentimes, no sidewalk infrastructure at all. In the 2010 Census, the Brazilian Institute of Geography and Statistics (IBGE) looked at the condition of sidewalks around Brazilian residential buildings and houses. Results show that, even around housing considered suitable (served by general utility services like water, sewage and garbage collection), only 80% of the streets featured sidewalks and, in residential

areas considered unsuitable (those not served by any of the aforementioned services), the number falls to just 9%. In terms of universal accessibility, data is even more disheartening: only 5.8% of housing considered suitable features sidewalk ramps for wheelchair users, dropping to 0.2% in areas around unsuitable housing (Brasil, 2012b).

Data on the reality of sidewalks is still scarce, which complicates the development of well-grounded studies and public policies. This scenario is expected to improve, thanks to the growing number of organizations now working with pedestrian mobility incentives in Brazil. Data from *Como Anda* (Cidade Ativa and Corrida Amiga, 2017), a study mapping these organizations, has revealed that 48% of them were established in the five years following the release of the National Urban Mobility Policy in 2012 (Brasil, 2012a). In 1997, the year the Brazilian Traffic Code was established, only 10% of these organizations existed.

The lack of quality paving, insufficient widths and various obstacles on sidewalks, ranging from inappropriately located urban furniture, to irregular garbage disposal points, invasion by illegal parking and the irregular encroachment of private property, and even occupation by street

vendors, attests to a lack of specific public policies that prioritize pedestrian mobility. The layout, material, geometry and standards vary according to the social and economic reality of the region and the period when the sidewalk or neighborhood were developed. The presence of sidewalks may be a good social and quality-of-life indicator, as the quality of sidewalks can often be related to the income and economic profile of the region.

Sidewalk planning and management is further hampered by the number of players, both public and private, that influence infrastructure. In Brazil, property owners are responsible for building and maintaining sidewalks, with the exception of those set out in the accessible routes plan, a document that lists sidewalks to be executed and maintained by the public authority to guarantee accessibility for people with disabilities or reduced mobility, including routes with a high flow of pedestrian traffic. Whenever possible, these routes should be integrated with public transport systems, as stated in the Brazilian Law for the Inclusion of People with Disabilities (Statute of Disabled People) (Brasil, 2015). There is also a portion of most Brazilian cities in which sidewalks are developed through unauthorized construction or informal labor, generally without compliance with the standards required under accessibility regulations.

In Brazilian cities, departments for public works and urban planning influence and approve projects by public and private entities, which, in turn, are responsible for executing and maintaining sidewalks. Traffic agents monitor usage and handle any obstacles or accidents on sidewalks (falls, fractures, etc.) and inspect infrastructure for junctions, crosswalks and traffic lights. Water, sewage, lighting and other urban utility and services constantly interrupt pedestrian routes to access their infrastructure, which is generally located on sidewalks. Departments for accessibility are responsible for overseeing sidewalk accessibility. Environmental departments are responsible for urban forestry and pruning urban vegetation. The presence of so many players, all with different skills and attributes and lacking clearly defined responsibilities and coordination in terms of actions, jeopardizes the regularity and continuity of sidewalks. Sidewalk management is therefore considered a highly complex issue in Brazilian cities.

It is thus up to public authority to ensure the population's right to quality sidewalks, whether by means of incentives and efficient oversight of private construction, or by assuming responsibility for construction and permanent maintenance. There are many examples of

sidewalk administration, both in Brazil and the rest of the world, with several players involved and divided opinions about the best way to manage the process. Regardless of the standard adopted by a city, it is important that responsibilities are established in municipal legislation or policy.

The goal of this publication is to provide techniques to guide the development and implementation of better sidewalk projects in Brazil, taking into account the importance, complexity and difficulties associated with the subject. However, even though there are plenty of good examples, additional effort is required to formulate regulations, to ensure integrated planning, to devise ways to distribute attributes and responsibilities, to find sources of financing and to create educational programs and campaigns, etc. Clear procedures must be crafted, while existing municipal legislation will need to be revisited. The proportion of public investment geared towards pedestrian infrastructure, in terms of financing and planning, is minimal when compared to resources aimed at space for motor vehicles. This discrepancy reflects the bias enjoyed by motorized traffic, which results in responsibilities for sidewalk construction and maintenance being left to private property owners in Brazil. As such, it is vital that we create clear

procedures and criteria based on specific municipal legislation to guarantee the quality of pedestrian spaces, listing the materials approved for use and the most suitable means of maintenance.

This publication presents a list of recommendations, references and national and international standards to guide the planning, execution and maintenance of sidewalks. It is based on carefully developed guidelines aimed at developing healthier and more active cities. The eight principles approach should not only form the basis of how to design and construct a high quality sidewalk, but also provide the foundations for a more sustainable urban space. None of the principles is sufficient to create an adequate sidewalk on their own. The principles are codependent to ensure their intended function can be achieved as part of the whole.

The publications and projects developed by WRI Brasil aim at transforming the reality by offering cities the tools to effectively implement measures that make them safer and more humane. *The 8 Principles of Sidewalks* guide has arrived at an opportune and necessary moment in Brazil. There are many entities, including pedestrian activist groups, emerging to highlight the need for better access and the democratization of



public spaces. The target audience for this publication includes managers and technical experts from the public sector, consultancies, students, political leaders, social movements and other parties interested in the subject.



THE 8 PRINCIPLES OF SIDEWALKS

This publication is structured into chapters that represent each of the eight principles of the sidewalks. Each principle is divided into subcategories and includes multiple elements that are explained in terms of project principles, benefits, application and evidence, along with illustrative images of real examples.

The problems related to sidewalks in Brazilian cities begin with a lack of sufficient reference material providing guidance on how to conceptualize, design and execute a quality sidewalk. What exactly constitutes a good sidewalk is still not completely clear in the minds of the population, designers or builders. The eight principles presented in this publication serve as a key to understanding what is essential for creating good quality sidewalks. The detailed information provided for each of these principles, including benefits and applications, provides the necessary guidance to ensure many more pedestrian infrastructure projects of excellence in the country. This publication provides a path to the conceptualization and development of better sidewalk projects, immediately providing an answer to a major obstacle to quality sidewalks in Brazil: a lack of concise

and certified references, encompassing topics that go beyond width and paving, and which help influence people to choose to walk.

These eight principles were defined through a meta-analysis of over 30 national and international publications on urban public space. They include legislation, technical regulations, guides with municipal codes, constructive process manuals, books and reports on urban planning concepts, all cited in-text and listed in the references. By analyzing the elements mentioned frequently in multiple of these publications, the attributes of well-designed sidewalks were identified. The attributes were then grouped according to potential outcomes for the urban space and quality of life of the local population. Keywords associated with these attributes were used to find further studies and discover other specific

Table I-1 | The eight principles of sidewalks, their elements and expected outcome of their application

PRINCIPLE	ELEMENT	RESULTS
Proper sizing	<ul style="list-style-type: none"> • Pedestrian zone • Furnishing zone • Frontage zone 	Guarantees enough space for people to walk and occupy the sidewalks.
Universal accessibility	<ul style="list-style-type: none"> • Curb ramps • Tactile surfaces • Running slope 	Provides an urban space that everyone can use.
Safe connections	<ul style="list-style-type: none"> • Connectivity • Corners • Crosswalks • Public transport stops and stations 	Ensures continuous walking routes connected to other means of transport.
Clear signage	<ul style="list-style-type: none"> • Informative signage • Pedestrian traffic lights 	Promotes communication between people and the urban space.
Attractive spaces	<ul style="list-style-type: none"> • Vegetation • Urban furniture 	Provide an environment where people feel comfortable.
Permanent security	<ul style="list-style-type: none"> • Public lighting • Active frontages 	Invites people to occupy urban spaces with more regularity.
Quality surfaces	<ul style="list-style-type: none"> • Site-cast concrete • Porous concrete • Interlocking concrete pavers • Cement tiles • Precast concrete slabs 	Confer a sense of comfort and safety while walking.
Efficient drainage	<ul style="list-style-type: none"> • Cross slope • Rain garden 	Fosters sidewalk resilience.

references for each of the principles. The eight principles and their subcategories were discussed and defined by specialists in urban development and mobility from WRI Brasil, aiming to provide an integrated overview of the concepts related to spaces for pedestrians. The eight principles represent the key topics in the development of sidewalks and environments that are more inviting and accessible. They are not intended to form standardized regulations, but rather guidance that should be interpreted using local expertise and adapted to the specific urban context.

Source: prepared by the authors.





Porto Alegre/Brazil

CHAPTER 1.

PROPER SIZING

Proper sizing for sidewalks allows for varied and conflict-free forms of use, ensuring that the urban elements included on the sidewalk do not create obstacles for pedestrians. A sidewalk should be comprised of an area free of any interference – the pedestrian zone – which is where people walk.

Urban furniture, like flowerbeds, trees, street lights and sign posts, should be located within the furnishing zone. To ensure comfortable access to buildings and to accommodate the furniture of commercial establishments, a sidewalk should also include a frontage zone.

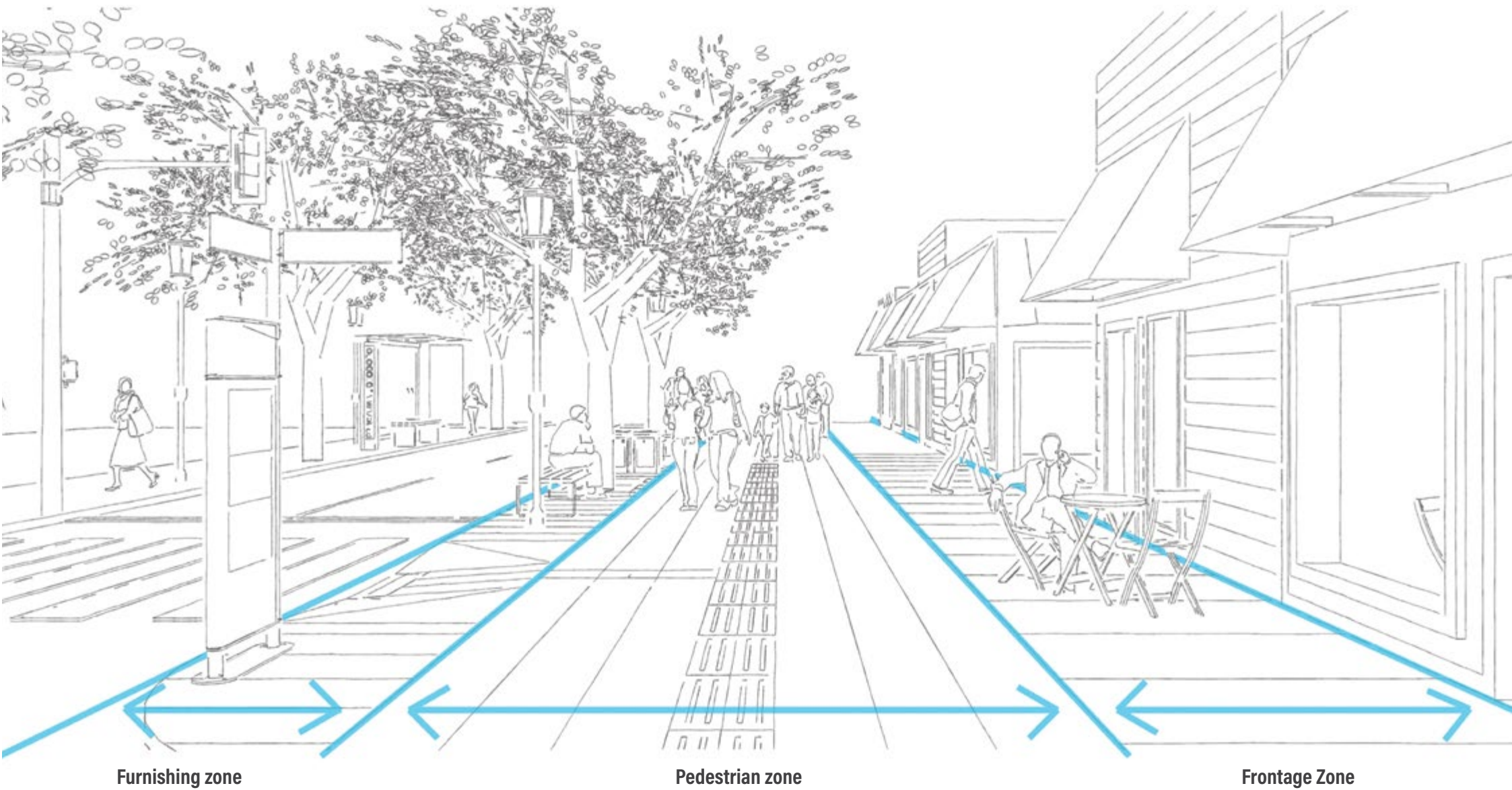
Figure 1 | Pedestrian priority lane

Signage for the pedestrian priority lane in Erfurt, Germany, showing free access for bicycles and restricted days and times for delivery vehicle access.



Correctly designing a sidewalk to accommodate the myriad users and flows is crucial to guaranteeing the fulfillment of its functions in terms of mobility. Pedestrian flows are extremely flexible regarding direction, speed and the occupation of urban spaces. These flows vary according to the average walking speed of pedestrians, which, in turn, is related to the physical condition of the people and local declivity and infrastructure of the sidewalk. Technical regulations and municipal guidelines establish minimum measures for sidewalks; however, to offer comfort and encourage people to walk, it is necessary to establish widths compatible with the demand at the busiest times of day. Sizing space dedicated to pedestrians along a street should be based on the premise of giving pedestrians priority, as well as democratizing the urban space.

Figure 2 | Proper sizing



Source: prepared by the authors.



Mexico City/Mexico

1.1. PEDESTRIAN ZONE

The pedestrian zone is the area of a sidewalk intended exclusively for uninterrupted pedestrian traffic. Defined by the Brazilian Traffic Code as a “footway”, it may not be obstructed by any item, including urban furniture, infrastructure, dropped curbs for vehicle access or any other such interference, whether permanent or temporary.

PROJECT PRINCIPLES

- Sizing the pedestrian zone should be calculated to comfortably accommodate a maximum flow of 25 pedestrians per minute, in both directions, for each meter of width, while 1.20 m is the minimum permitted width. Thus, to determine the width of the pedestrian zone, considering the flow of pedestrians, the equations is as follows:

$$L = F / K + \sum i \geq 1,20 \text{ m}$$

Where:

L is the width of the pedestrian zone;
F is the estimated or measured flow of

pedestrians during peak hours, considering a comfort level of 25 pedestrians per minute for each meter of width;

K equals 25, which represents the pedestrian flow per minute, defining the comfort level for the sidewalk according to Brazilian Technical Standards (NBR) 9050/2015;

$\sum i$ is the sum of values relative to the impedance factors, that is, elements on the sidewalk that are avoided by pedestrians: 0.45 m adjacent to the store facades; 0.25 m adjacent to the urban furniture; 0.25 m adjacent to the entrances of the adjacent buildings.

- The clearance height for overhead obstacles should be at least 2.10 m.

BENEFITS

- Correctly sizing the pedestrian zone makes the sidewalk more comfortable and inviting.
- Sidewalks with clearly defined pedestrian zones help prevent conflicts among walking

pedestrians, pedestrians standing in front of stores or street vendors and urban furniture.

- The width of the pedestrian zone is one of the main features of an accessible sidewalk, which should allow a wheelchair to be able to turn and change direction or pass another wheelchair.
- Correctly sized pedestrian zones increase the value of tourism and leisure areas when they allow couples, friends and families to walk together.

APPLICATION

- Correctly sizing of the pedestrian zone depends on pedestrian demand and is subject to a local diagnosis, especially during peak pedestrian flow periods.
- Public transport stops and stations should never be placed within the pedestrian zone, as they induce pedestrians to use traffic lanes to pass people blocking the pedestrian zone while waiting for the bus.

Figure 3 | Pedestrian detour due to public works

Works to improve the quality of sidewalks in Lisbon, Portugal, with pedestrian detours along the traffic lanes duly barricaded.



Figure 4 | Shared lane in the historic city center

Pedestrian priority along a street declared historical heritage in Salvador, Brazil.



- Temporary maintenance and other construction works that interrupt the pedestrian zone should feature signage and be isolated, assuring the minimum passage width of 1.20m for pedestrians, or providing a safe pathway alongside the roadway. This pathway should be connected to the sidewalk through ramps with minimum width of 1.0 m, 10% slope and necessary signage.
- In locations where adequate sizing is not possible, such as in historic centers and heritage sites, other options can be explored, such as pedestrianized or shared streets.

CASES AND EVIDENCE

The city of London, England, created a guide for the appropriate sizing of sidewalks, intended to improve the compatibility of walkway and crosswalk projects with the volume and type of users in each context. The document was created following a study of pedestrian behavior. Besides gauging the daily flow of pedestrians and their walking speed, the study also looked at the number of pedestrians forced to alter their routes or speed in order to avoid obstacles. Also measured were the distances that people left between each other and street furniture, an important piece of information in determining a comfortable width for pedestrian routes. The study also featured interviews to assess people's perceptions of comfort and how this could affect their behavior (Transport for London, 2010).

ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- Manual de Projeto Geométrico de Travessias Urbanas. DNIT, Brasil, 2010. p. 100-101.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 74-77.
- Pedestrian Comfort Guidance for London. Transport for London, 2010. p. 25.

Figure 5 | Sizing according to pedestrian flow

The city of London, England, sizes its sidewalks according to the flow of pedestrians in each location. In some cases, as in the image below, the whole street can be used only for pedestrians.



1.2.

FURNISHING ZONE

Located between the curb and the pedestrian zone, the furnishing zone is intended to accommodate street furniture (benches, garbage bins, public telephones, bicycle racks etc.) and services (sewage, water and electricity grids, vertical signage, fire hydrants etc.). The furnishing zone should be developed adjacent to the pedestrian zone, to guarantee the uninterrupted pedestrian circulation.

PROJECT PRINCIPLES

- The furnishing zone should have a minimum width of 0.70 m.
- It may be paved or covered by vegetation, in a way that increases ground permeability, especially in residential areas.
- The furnishing zone should not be located close to corners, as the installation of urban furniture and services may interfere with pedestrian circulation.

- In commercial areas, temporary furniture like advertising “sandwich” boards or tables and chairs, may only be used if their dimensions do not affect circulation in the pedestrian zone.

BENEFITS

- The installation of furniture and services in the furnishing zone keeps the pedestrian zone clear of any interference or obstruction.
- The furnishing zone also separates the pedestrian walking zone from the vehicle traffic or bicycle lane, ensuring greater safety and comfort for pedestrians.
- Placing utility boxes or manholes within the furnishing zone ensures that possible situations such as the absence or misalignment of manhole covers remains outside of the usual pedestrian traffic zone.

- Locating underground services below the furnishing zone safeguards the surface of the pedestrian zone from regular demolition and reconstruction.

- The installation and organization of furniture and urban services in a dedicated space on sidewalks enhances the appeal of the environment and makes walking more pleasurable.

- Planting trees in the furnishing zone brings environmental benefits, as well as safety and comfort for pedestrians.

APPLICATION

- All and any equipment that may form an obstacle to the free passage of pedestrians must be placed within the furnishing zone, such as: street lights, sign posts, fire hydrants, post boxes, garbage bins, bus stops, benches, flowerbeds, vegetation and bollards.



- Curb ramps for vehicle access must be placed within the furnishing zone and not interfere with the pedestrian zone surface level.
- Manhole covers for underground services and sidewalk grates should also be placed within the furnishing zone. In cases where this is not possible, grate grids should not exceed 15 mm and must be installed transversally to the flow of pedestrians, so that the grid openings do not represent a trip hazard to passing pedestrians.
- Manhole covers must be completely level with the surface.

CASES AND EVIDENCE

The Green and Accessible Sidewalk project rebuilt sidewalks in the neighborhood of Vila Pompeia, in the city of São Paulo, to remove irregular steps formed by unevenly installed vehicle access ramps and to improve pedestrian accessibility. The pedestrian zone was leveled and access ramps for vehicles were relocated within the furnishing zone and the property entrances only.

Landscaping elements were also added to the sidewalks, making the environment greener and more pleasant. The project improved pedestrian safety as people who previously walked on the roadway were able to use the redesigned sidewalk (Figure 6). Those responsible for the project estimate that the construction of the sidewalks directly benefited some five thousand people living in the neighborhood (Altamirano et al., 2008).

ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- Calçadas verdes e acessíveis melhoram a mobilidade, a permeabilidade e embelezam a paisagem urbana. Altamirano, G. et al., 2008.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015. p. 74-77.

Figure 6 | Vehicle access ramp

One of the sidewalks before and after the Green and Accessible Sidewalks project in São Paulo, Brazil.



1.3.

FRONTAGE ZONE

The frontage zone is located between the pedestrian zone and the buildings or lots. This is the space that typically forms the boundary between public and private property, used by people that are entering or exiting buildings. This sidewalk zone is characterized by an “edge effect”, providing a good space for pedestrians to pause or stop out of the flow of movement. This concept refers to people’s preference to remain at the edges of a space, where their presence is more discreet, their backs are protected while sitting, and they can enjoy the atmosphere and a good view of their surroundings. Frontage zones between buildings and the street are spaces with potential to host myriad activities that link indoor functions with life out in the street. They can also feature vegetation, access ramps, awnings, sandwich boards, and other elements, as long as none of these impede access to the properties and they still allow for the safe transit of pedestrians.

PROJECT PRINCIPLES

- The recommended width of a frontage zone is 0.45 m.
- In commercial areas, temporary furniture like advertising boards, tables and chairs, may only be used if their dimensions do not affect the pedestrian zone for pedestrian circulation.
- The boundaries should be clear, with different surfaces for the pedestrian zone and the frontage zone, in order to emphasize locations where private furniture may be placed without interfering in the pedestrian zone.

BENEFITS

- Provides a space between the pedestrian zone and building fronts, essential for buildings that open directly onto the sidewalk.

- Located adjacent to store fronts and services, it provides sufficient space for people to stop in front of stores without obstructing the flow of pedestrians.
- It may form a space for meetings on the edge between public and private space, by means of a change in paving at the entry to the building or by installing a small bench below a window.

APPLICATION

- Buildings and lots access ramps must be located in the frontage zone and are subject to municipal approval, guaranteeing a maximum ramp slope for people with reduced mobility, even if this means having to extend the ramp into the building.
- Drainage areas and vegetation can be installed in this zone.

CASES AND EVIDENCE

In Amsterdam, Netherlands, access zones were designed to encourage residents to occupy the street. Sidewalks along a block were designed by an architecture firm and feature tailored access zones to increase interaction between the housing and public area. The sidewalk becomes an extension of people's living rooms, providing a wide leisure area. This atmosphere generates a sense of safety in the country and has direct benefits, especially for children (Karssenberget al., 2015).

ADDITIONAL REFERENCES AND GUIDELINES

- A cidade ao nível dos olhos: lições para os plinths. Karssenberget al., 2015.
- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, BRASIL, 2017a.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 74-77.

Other principles of the sidewalk related to proper sizing:

2. UNIVERSAL ACCESSIBILITY

2.1 Curb ramps

3. SAFE CONNECTIONS

3.4 Public transport stops and stations

5. ATTRACTIVE SPACES

5.1 Vegetation

5.2 Urban furniture

Figure 7 | Interactive frontage zone

A frontage zone measuring around 1 m wide is transformed into an area for interaction among people. Amsterdam, Netherlands.





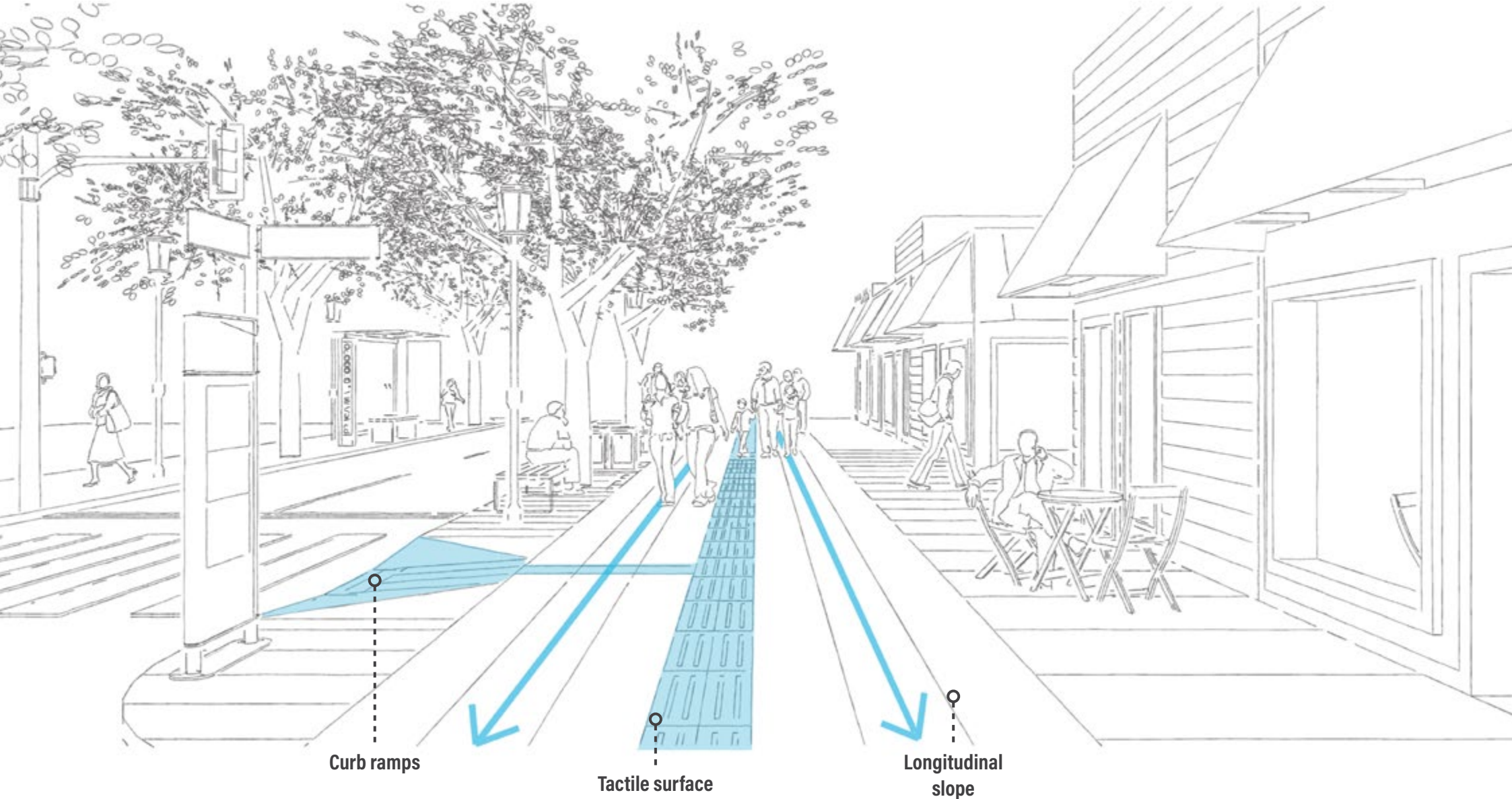
Lisbon/Portugal

CHAPTER 2.

UNIVERSAL ACCESSIBILITY

As a public space, sidewalks must be accessible to all citizens under article 5 of the Brazilian Federal Constitution, which establishes the right to come and go for all Brazilians. Universal accessibility includes people with the most diverse physical and sensory attributes: from people with reduced mobility, like the elderly and wheelchair users, to people with temporary limitations, such as those walking on crutches, pregnant women or parents with baby strollers. Listing these characteristics is a good way to reflect on how to meet the needs of all sidewalk users.

Figure 8 | Universal accessibility



Source: prepared by the authors.

Box 1 | UNIVERSAL DESIGN

The term universal design¹ was initially created with a focus on eliminating architectural barriers in the design of buildings and urban spaces. The goal of the concept evolved and became a feature of spaces, objects and systems that consider the scope of human diversity, as a means to guarantee equal and autonomous use of all the components of an environment. Sidewalks with universal design feature the following characteristics: adaptability to all people, simple and intuitive to use, mitigate mistakes that pedestrians may make while walking and require low physical effort. These aspects contribute not only to improving mobility, but also to an increase in road safety, as they facilitate the transition from street to sidewalk for pedestrians.

The universal design concept is defined under Brazilian Federal Law 13,146/15 (Statute of Disabled People) and Federal Law 10,098/00, which establishes general regulations and basic criteria for the promotion of accessibility. All elements that compose sidewalks must be planned and executed from the perspective of universal design. As such, the design of sidewalk elements such as furniture, signage, crosswalks

and building entries must be simple, so they are easy to use regardless of the experience, knowledge, language proficiency or capacity of the user to decode the urban environment. The distances to be traveled and the sizing of public spaces should not submit people to additional effort or physical exhaustion that could be avoided or minimized. City spaces should be comprehensive, foreseeing the needs of people with impaired sight or hearing, who are illiterate or don't understand the local language, creating unique solutions with visual, colored, tactile and audible elements.

Making urban streets more accessible is a challenge. The hesitation to initiate planning for the systemic improvement of urban environments begins with the lack of data that would provide an understanding of the real dimension of work needed. To overcome this information gap, Lisbon City Council conducted a study to diagnose the accessibility of city sidewalks. Known for its steep streets and large stairways, it seemed that biggest challenge would be coming up with strategies to overcome street slopes. However, the diagnosis revealed that a lack of accessibility

was attributed to slope for only 8% sidewalks in the city. The remaining sidewalks considered inaccessible presented other types of barriers, such as insufficient widths for pedestrian circulation and vehicles parked on walkways.

Based on this diagnosis, Lisbon City Council created the Pedestrian Accessibility Plan (Gouveia, 2013), with the goal of preventing the creation of new barriers, adapting existing buildings and mobilizing the community around the creation of a city for all. These objectives are applied to public streets, municipal facilities, in the public transport network and in the inspection of private works. Additionally, the plan also outlines actions to solve transversal challenges, such as the training of new urban planners and the creation of accessible voting stations.

¹ Conception of products, environments, programs and services to be used by all people, without the need for adaptation or a specific design, including assistive technology resources.

Figure 9 | **Guaranteeing universal design**

The guidelines defined by the Lisbon Pedestrian Accessibility Plan include a guarantee of accessibility for pedestrians, while maintaining the historical character of the sidewalks adjacent to the pedestrian zone.



Sidewalks with universal design adapt to all types of people, have a simple and intuitive use, mitigate mistakes committed by pedestrians while walking and require low physical effort.

2.1. CURB RAMPS

Lowering a sidewalk at the point where it meets a pedestrian crosswalk is an important element that improves accessibility. Despite being associated with wheelchair users, this element provides benefits for pedestrians in general, especially the elderly and people pushing strollers or carrying large loads. The functionality of curb ramps depends not only on good design, but also on the way they are executed.

PROJECT PRINCIPLES

- The minimum width for a curb ramp is 1.50 m, though, ideally, the ramp would be the same width as the crosswalk.
- The slope must remain constant throughout its extension and may not exceed 8.33% (1:12) in the longitudinal direction of the ramp.
- Besides the area occupied by the curb ramp perpendicular to the actual curb, a pedestrian zone of at least 1.20 m must also be maintained.
- On narrow sidewalks, where the walkway width is not enough to accommodate a curb ramp and a pedestrian zone with a minimum width of 1.20 m, introduce either a curb extension or an elevated crosswalk, or lower the entire sidewalk width (parallel with the curb), with a minimum width of 1.50 m and equipped with lateral ramps with a maximum slope of 8.33% (1:12).
- Sidewalks should preferably be lowered using leveled concrete, with a regular, firm, stable and non-slip surface, present a pressure resistance of 20 MPa (megapascals) and feature a tactile surface. The surface must be completely even at the meeting point between the edge of the curb ramp and the gutter or the road.

Figure 10 | Curb extension

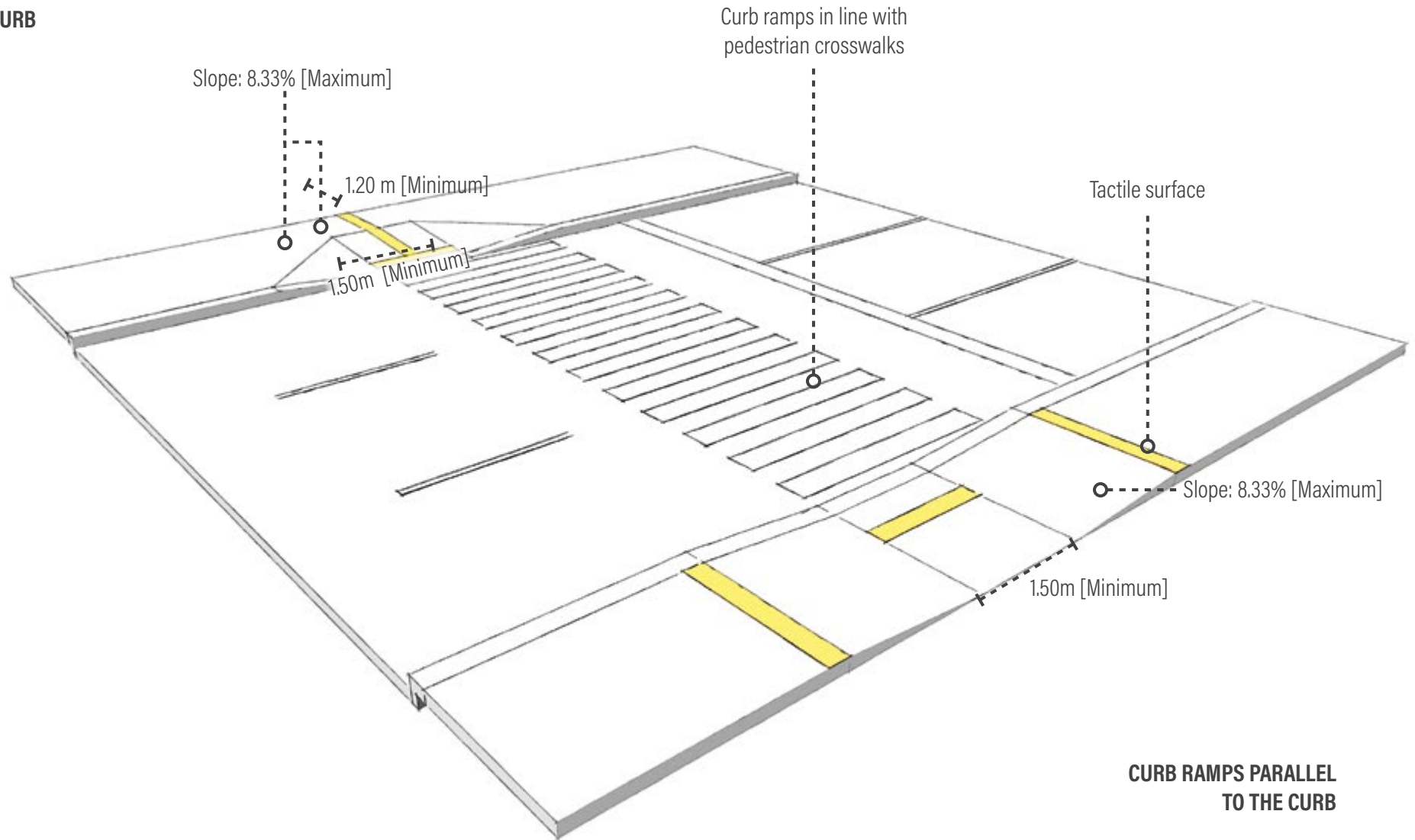
Curb ramp installed on a corner with an extended curb in Fortaleza, Brazil.



Figure 11 | Types of curb ramps

Complying with the measurements and slope of curb ramps are determining factors in terms of accessibility.

CURB RAMPS PERPENDICULAR TO THE CURB



Source: prepared by the authors.

- Ramp design must offer good drainage and flow conditions to prevent the formation of pools of water.
- The curb ramp must not create an obstacle to the longitudinal flow of pedestrians on the sidewalk.
- The curb ramps on both ends of the crosswalk should, preferably, be aligned.

BENEFITS

- Provides a smooth connection between the sidewalk and the road surface.

- Improves accessibility conditions, aiding the crossing of pedestrians in general, though especially so for people with reduced mobility and those handling wheeled devices, such as baby strollers and handcarts.

APPLICATION

- Curb ramps can be installed on corners or midway along blocks.
- The curb ramps must be constructed in the direction of flow for pedestrian crosswalks. Desire lines for pedestrian traffic must be

taken into consideration, as, in general, they represent the shortest and most direct routes.

- Raised crosswalks can be installed over roadways with a speed limit below 40 km/h. As such, in certain cases, speed bumps are built just before crosswalks, to further reduce vehicle speeds.
- Curb ramps are mandatory at pedestrian crosswalks.



Figure 12 | Curb ramps parallel to the curb

Sidewalk in Porto Alegre, Brazil, with total curb ramp.



CASES AND EVIDENCE

Tohme is a remote system that collects data on the location of curb ramps using geolocation. It was developed by researchers from the University of Maryland, USA, using a combination of crowdsourcing, computational viewing, machine learning technology and online map data. The goal is to create a system able to collect information on accessibility from any city in the world by analyzing photos of its streets, widely available thanks to online map systems. Tohme reduces the amount of time people spend on identifying and mapping accessibility problems, while still maintaining the quality of the findings.



Figure 13 | **Curb ramps perpendicular to the curb**

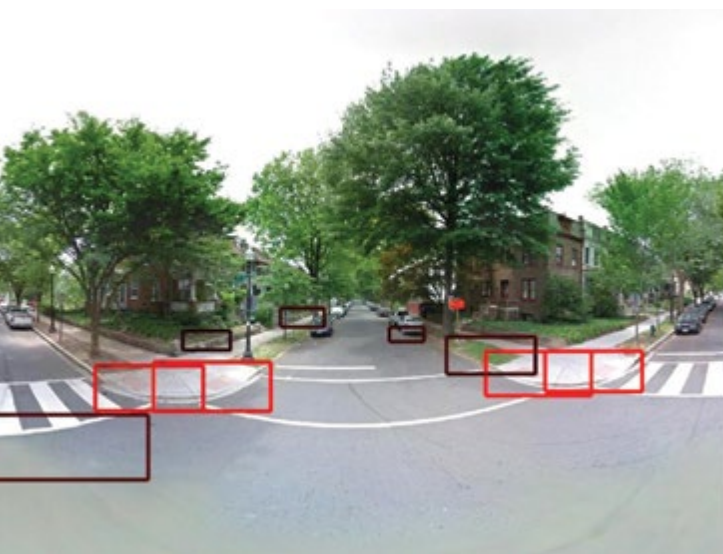
Sidewalks with enough space for curb ramps perpendicular to the curb, aligned on both ends of the pedestrian crosswalk.



Additionally, it provides cities with coherent information on the degree of sidewalk accessibility, integrated with modern geotechnology tools. In a study of over a thousand intersections in four North American cities, Tohme registered a similar number to the manual registration of sidewalk curb ramps, with a 13% reduction in time spent to gather the information. In the future, it is hoped that Tohme can be integrated into a heat map viewing tool for city accessibility or a navigation system that recommends accessible routes (Hara et al., 2014).

Figure 14 | **Remote curb ramp sidewalk identification system**

Real outcome of the assessment conducted by Tohme: (a) an image from Google Street View, (b) results for detecting sidewalk curb ramps using a computer system (with the higher confidence level in light red) and (c) results following the crowdsourced verification.



ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 79-82.
- Resolução nº 495, de 5 de junho de 2014. CONTRAN, Brasil, 2014b.
- Tohme: Detecting Curb Ramps in Google Street View Using Crowdsourcing, Computer Vision and Machine Learning. Hara, K. et al., University of Maryland, 2014.

Figure 15 | Challenges for the elderly

Inaccessible sidewalks force the elderly to walk in the roadway in Olinda, Brazil.





Box 2 | ARE CITIES PREPARED FOR ELDERLY POPULATION?

Estimates are that by 2060, the elderly will represent one third of Brazil's population, which is sure to have major impacts across multiple spheres. One of them is mobility in cities, as, with increased age comes the increased risk of falls or being run over. More so than ever, this trend calls for urban planning to include pedestrian safety measures. Impaired sight, ability to evaluate traffic risks, reduced mobility, health conditions, fragility and reduced walking speed when crossing roads are all factors that expose elderly pedestrians to risk while circulating in urban environments.

According to the World Health Organization (2013), certain measures can be implemented to increase the safety of elderly pedestrians:

- increase the time allocated for pedestrians to cross at crosswalks with traffic lights;
- installation of crosswalks with high visibility for both drivers and pedestrians;

Source: World Health Organization, 2013.

- repairs to curbs and damaged access ramps;
- installation of pedestrian refuge medians or central flowerbeds;
- narrowing roadways with traffic calming techniques;
- raising public awareness about elderly pedestrian safety needs;
- reduction of legal speed limits;
- increased measures by traffic authorities to enforce against exceeding speed limits and driving under the influence.

2.2. TACTILE SURFACES

Tactile surfaces were developed as a sensory guide for those with impaired vision to use while walking, allowing them to perceive routes and obstacles with their feet or canes. Tactile surfaces have colors and textures that differ and stand out in relation to their surroundings, and must be easily detectable through vision and touch. There are two types of tactile surfaces. One is a tactical directional surface, with continuous linear relief and installed in the direction of travel. The other is a tactile warning surface, comprised of truncated domes.

PROJECT PRINCIPLES

- The tactile surface must be made of a rigid material that is non-slip under any conditions, and in a color that contrasts with the surrounding surface.
- When the tactile surface is made from concrete and integrated into the sidewalk surface, there should be no height variations.
- When the tactile surface is applied to the surface of the sidewalk rather than at level with it, the resulting height difference from the regular sidewalk paving should not exceed 3 mm.
- Tactile directional or warning surface must be detectable in both wet and dry conditions, maintaining a clear contrast in relation to the sidewalk surface, and it must be noticeable by the majority of the population, regardless of the colors used.

BENEFITS

- Allows people with impaired vision to detect changes in surface height or situations of risk, such as suspended objects not detected by canes.
- Guides people with impaired vision when they are walking in large open areas without continuous physical points of reference (e.g. fences or street frontages).

Figure 16 | **Integrated tactile surface**

Sidewalk featuring concrete tactile surface integrated into the sidewalk surface.



APPLICATION

- Tactile directional surface must be installed:
 - on the outside limit of open lots without adjacent building facades, such as gas stations, garage and parking entrances and exits, or when buildings are set further back from the street;
 - within the pedestrian zone and aligned with its direction, or in the case of sidewalks or walkways located in parks or undeveloped areas positioned according to pedestrian flow;
 - transversally to the sidewalk, demarcating the crosswalk area, and in line with pedestrian traffic lights, if present;
 - transversally to the sidewalk, identifying access to elevated footbridges or underground crosswalks;

- Tactile warning surface must be installed:
 - on curb ramps and raised crosswalks, positioned in parallel to the crosswalk or perpendicular to the walking line;
 - in locations where the tactile directional surface changes direction, indicating the existence of route alternatives;
 - at the start and end of ramps and stairs;
 - below obstacles suspended between 0.60 m and 2.10 m above the ground, with a larger upper volume than base volume (trees, signs, public telephones, etc.), placed 0.60 m from its broadest point.

CASES AND EVIDENCE

As the need for guidance and the number of potential hazards vary from place to place, it is difficult to define standard recommendations for the installation of tactile surface that suitably cater to the array of situations that play out in urban settings. Once installed, a tactile surface becomes a part of an environment that is already complex by nature. This environment features a variety of tactile and sensory information, that can influence the ease with which the tactile surface can be detected. For this reason, any potential location for a tactile surface should be

carefully studied and reviewed before installation. Perception of the tactile surface is influenced not only by its physical characteristics, but also by the ease with which they can be understood by users, their past experiences with tactile surfaces, the type of cane and the touch technique applied.

Sidewalk networks are complex environments that concentrate paths with myriad origins, destinations and courses. The path defined by the tactile directional surface must indicate these variations, coupled with the provision of additional clarification about the location and points of interest. Information on accessible

Figure 17 | **Tactile overlaid surface**

Sidewalk featuring tactile surface laid on top of the sidewalk.



routes in a city can be made available on internet pages or through tactile maps along the routes, but can also be provided to the population through training sessions organized by transport companies and administered by mobility experts.

Tactile warning surface can become problematic if installed on a large scale. In addition to not being self-explanatory, tactile warning surfaces merely alert users that there are variations in the elements around them, though without actually knowing how the guidance system works, it is not clear what sort of precaution should be taken – whether it's a change in direction, the end of the walkway, a building entrance or exit or an overhead obstacle.

Technology like Responsive Street Furniture and the BlindSquare App can work in complement to tactile surfaces and are being developed to aid people that face any type of difficulty while walking along city streets. The application is activated by a user's mobile phone. When passing by points of reference, the app provides information about the street, along with surrounding services, while also activating urban services, such as increasing the intensity

of public lighting and crossing times at traffic lights. Increasing and ensuring the quality of such services and devices represents a new opportunity for cities, and can contribute to improving the functionality of tactile surfaces (Grunwald, 2008; Pirttimaa, 2016; Ross Atkin Associates, 2015).

ADDITIONAL REFERENCES AND GUIDELINES

- Blindsquare App, Software de computador. Pirttimaa, I., 2016.
- Human Haptic Perception: Basics and Applications. Grunwald, M., 2008.
- NBR 16537: Acessibilidade – Sinalização tátil no piso – Diretrizes para elaboração de projetos e instalação. ABNT, 2016.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 47-50.
- Responsive Street Furniture. Ross Atkin Associates, 2015.
- Segurança de Pedestres: Manual de Segurança Viária para Gestores e Profissionais da Área. OMS, 2013.



Brasília/Brazil

2.3. RUNNING SLOPE

The running slope of sidewalks is an element that is often hard to control, as the sidewalk profile line should continuously follow that of the adjacent street. However, very steep sidewalks may become obstacles to people with reduced mobility, especially when the surface is wet or covered with dust or leaves, which increase the risk of slipping. As such, making steep sidewalks part of an accessible route is a challenge faced by most cities. In contrast to ramps built inside buildings, walkways may continue with unbroken slopes for several blocks, making it difficult for more vulnerable pedestrians to walk uphill.

PROJECT PRINCIPLES

- The running slope of the pedestrian zone of sidewalks must continuously follow the slope of the adjacent roadway.
- Ideally, the running slope of sidewalks should be less than 5%, characteristic of an accessible route.

- Slopes equal to or greater than 5% must comply with design criteria established for ramps, such as sizing and the provision of handrails.
- When the slope of the sidewalk is close to or exceeds the maximum permitted for an accessible route, it is advisable to create level rest areas every 50 m for slopes of up to 3%, or every 30 m for slopes between 3% and 5%. These areas should preferably be located outside of circulation zones and must be sized to allow for wheelchairs to be maneuvered. They may also feature conveniences such as benches and drinking fountains.

BENEFITS

- Sidewalks with moderate running slopes may form part of a network of accessible routes.

APPLICATION

- In areas with steep slopes, wide sidewalks should be installed to allow wheelchair users to circulate in zig-zag movements.
- For new land developments, roads should be planned and designed with topography taken into account and aim to reduce slopes.
- The installation of handrails is a viable solution in certain situations. For example, where steep stairs are installed within very short spaces, on downward slopes or close to built installations such as bus stops.
- It is best to avoid other factors that, when combined, compound the challenge of raised running slopes, such as narrow pathways, irregular surfaces and cross slopes greater than 2%.



Belo Horizonte/Brazil

- Besides implementing architectural changes to sidewalks with expressive slopes, signage indicating the running slope of the sidewalk should be used to inform users about alternative routes with lesser slopes.

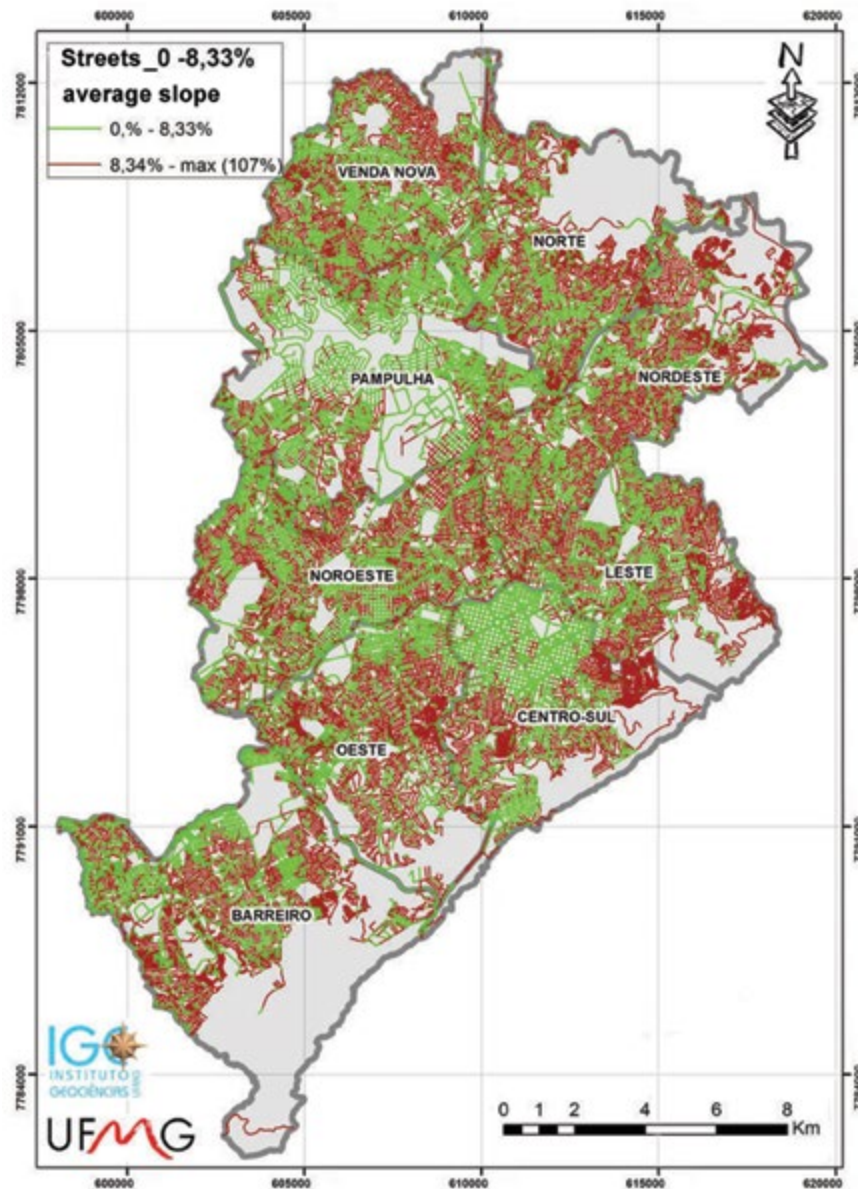
CASES AND EVIDENCE

In Belo Horizonte, as is common in many Brazilian cities, local topography is a huge challenge to fostering urban accessibility. To understand the complexity of this problem and identify possible solutions, the city developed a Terrain Slope Map. The project was undertaken by the Institute of Geosciences of the Federal University of Minas Gerais, in partnership with the Institute for Transport and Development Policy (ITDP Brasil) and the municipal Transport Department, BHTRANS. It analyzed 4,700 km of streets and avenues in the state capital, resulting in a database of minimum, maximum and average slopes for 51,713 sections of city streets. This knowledge allows for better planning for urban mobility. The hope is that this database can stimulate the creation of smartphone applications that calculate accessible routes and help people to choose the best form of transport (BHTRANS, 2016).

ADDITIONAL REFERENCES AND GUIDELINES

- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 47-50.
- Pesquisa apresenta Mapa de declividades de Belo Horizonte. BHTrans, 2016. Available at: <http://www.bhtrans.pbh.gov.br/portal/page/portal/portalpublico/Temas/Noticias/Pesquisa%20apresenta%20Mapa%20de%20declividades%20de%20Belo%20Horizonte>.

Figure 18 | Terrain Slope Map for Belo Horizonte, Brazil



Source: prepared by the authors.

In contrast to ramps built inside buildings, walkways may continue with unbroken slopes for several blocks, making it difficult for more vulnerable pedestrians to walk uphill.

Other principles of the sidewalk related to universal accessibility:

3. SAFE CONNECTIONS

3.2 Corners

3.3 Pedestrian crosswalks

7. QUALITY SURFACES

7.1 Site-cast concrete

7.2 Porous concrete

7.3 Interlocking concrete pavers

7.4 Cement tiles

7.5 Precast concrete slabs

8. EFFICIENT DRAINAGE

8.1 Cross slope



Belo Horizonte/Brazil

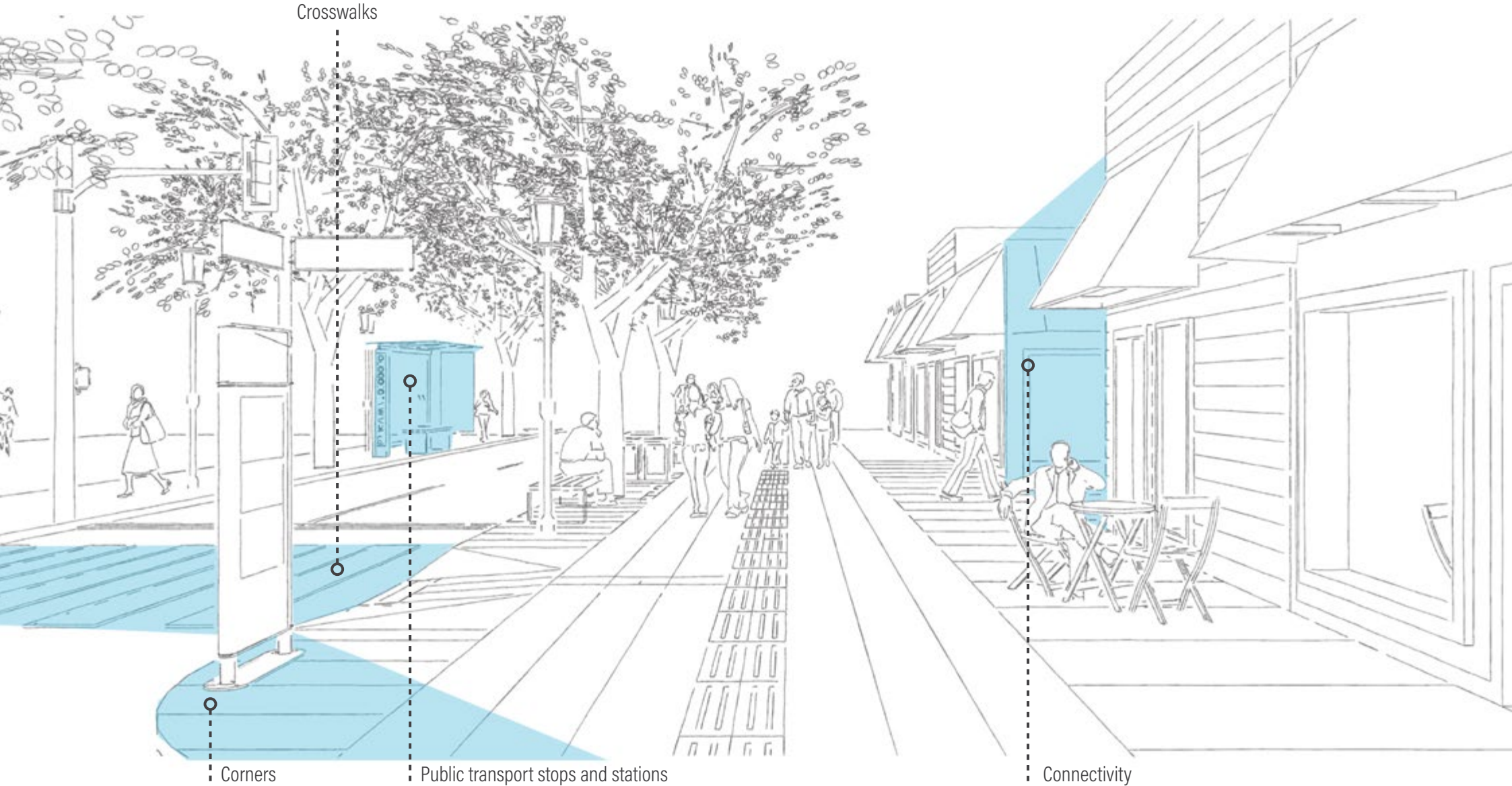
CHAPTER 3.

SAFE CONNECTIONS

Besides sidewalks, the path taken by pedestrians also traverses other urban spaces, such as intersections, crosswalks, alleys, stairs and public transport stops. To create a walking network, it is important that connections among these elements are accessible and safe.

Planning connections includes not only urban infrastructure, but also the actual operation of streets. Traffic light timing, for example, must be compatible with pedestrian flow, crosswalk distances and the walking speed of pedestrians. Similarly, safe and comfortable access to public transport is essential to build an efficient urban mobility network that smoothly integrates pedestrians.

Figure 19 | Safe connections



Source: prepared by the authors.

3.1.

CONNECTIVITY

Connections through alleys and stairs, as well as private lots, such as galleries and passages, allow for pedestrian circulation even where motorized vehicles are not permitted. Additionally, they can stimulate the development of social, cultural and economic activities. Many cities, however, don't take advantage of these types of spaces, which end up being used to dump garbage or park vehicles. However, in line with the examples of older cities that were planned prior to the automobile era and are interlaced with historical pathways, it is possible to make cities more connected for pedestrians, encouraging the use of these paths through housing complexes, stores, restaurants, bars and parks.

PROJECT PRINCIPLES

- Blocks should have a maximum length of 250 m to shorten distances, increase route options and encourage walking.

- When blocks exceed a length of 250 m, alleys, galleries and passages can be designed as a means to form connections.
- Passages with changes in level, like tunnels and footbridges, are not usually appropriate. They are very often avoided by pedestrians as they require additional physical effort and are associated with a lack of security.

BENEFITS

- Providing more direct routes for pedestrians encourages walking.
- Quality pedestrian passages can become spaces for hosting temporary events, as well as for the development of long-term recreational activities.

APPLICATION

- To ensure a high degree of connectivity, a connectivity index calculation can be applied. The index is calculated by dividing the total number of segments along the route between intersections by the total number of intersections. An index number equal to or greater than 1.4 represents good connectivity.

CASES AND EVIDENCE

Restoration works on the stairs of Rua Cotoxó, in the neighborhood of Pompéia in São Paulo, are result of a study that engaged users and local residents, with the aim of maintaining the identity of the neighborhood. The situational diagnosis was overseen by an organization called Cidade Ativa, as part of the initiative Olhe o Degrau (Mind the Step), aimed at encouraging the inclusion of the stairs into the pedestrian mobility network. Problems identified by the population, such as a lack of visibility and lighting, irregular surfaces and a lack of handrails, were all addressed.

Issues linked to local cultures and use of space were also diagnosed through the study, which identified the hopes and dreams of the population that use the stairs. This identity was incorporated into the design and expressed through graffiti paintings by artists that began their careers in that neighborhood. The stairway restoration works were overseen by Brookfield Incorporações (Cidade Ativa, 2017).

ADDITIONAL REFERENCES AND GUIDELINES

- Active Design Guideline. Promoting Physical Activity and Health Design. City of New York, 2010.
- Olhe o Degrau Cotoxó: arte e cores para quem caminha. Cidade Ativa, 2017. Available at: <<https://www.cidadeativa.org.br/single-post/2017/02/06/Olhe-o-Degrau-Cotox%C3%B3-arte-e-cores-para-quem-caminha>>.

Alleys, stairs, galleries and passages can become spaces for developing social, cultural and economic activities.

Figure 20 | Olhe o Degrau Project

User engagement to restore the stairs on Rua Cotoxó, São Paulo, SP.



3.2. CORNERS

Corners are the points where two streets (and pedestrian zones) meet. It's also where pedestrians usually choose to cross. The confluence of different users at intersections means this location is prone to traffic crashes involving pedestrians. The presence of excessive obstacles on the sidewalk, such as signs and furniture or parked cars, jeopardizes pedestrians and drivers visibility, putting both at greater risk. Corner design must ensure that routes are accessible and safe, providing connections between adjacent sidewalks. Extending the line of the curb into the vehicle traffic lane on corners can reduce the speed of turning vehicles and offer greater protection to pedestrians. Curb extensions can also be appropriate on certain streets at mid-block.

PROJECT PRINCIPLES

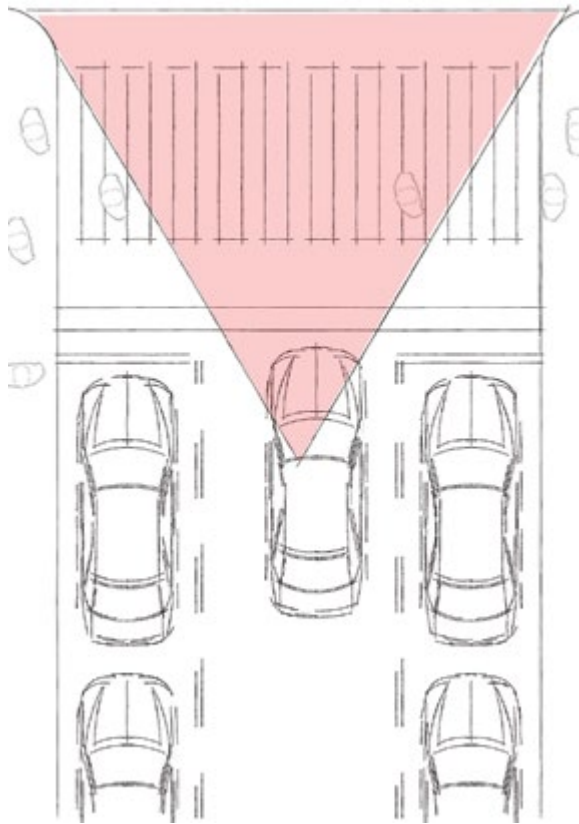
- Corner areas must be obstacle-free between the guide and the extension of the building line. They also need to ensure space enough to accommodate pedestrians prior to crossing.
- Street lights or utility poles, public telephones, trees, grates, hydrants, traffic signs and other vertical elements must be avoided in this area. If installation is necessary, this equipment must be located to minimize the impact of obstruction to pedestrians and drivers visibility.
- It is vital to minimize the radius of curvature of the corner, which should not exceed 4.5 m, to ensure slower turning speeds and to reduce the distance for pedestrian crossings.
- Corners must feature curb ramps in accordance with existing regulations. In Brazil these are the Brazilian Traffic Code and the NBR 9050/2015 from the Brazilian Association of Technical Standards (ABNT).
- On corners with reduced visibility between pedestrians and drivers, a curb extension is recommended. It should be 10 m long and the same width as the parking lane. When extending the curb conflicts with the vehicle radius of curvature, it is better to reduce the curb extension in size rather than eliminate the measure altogether.
- Drainage must be carefully designed on curb extensions to prevent interruptions caused by flowing water. This may include the suitable placement of drains or the use of elements that carry water through or around curb extensions.

BENEFITS

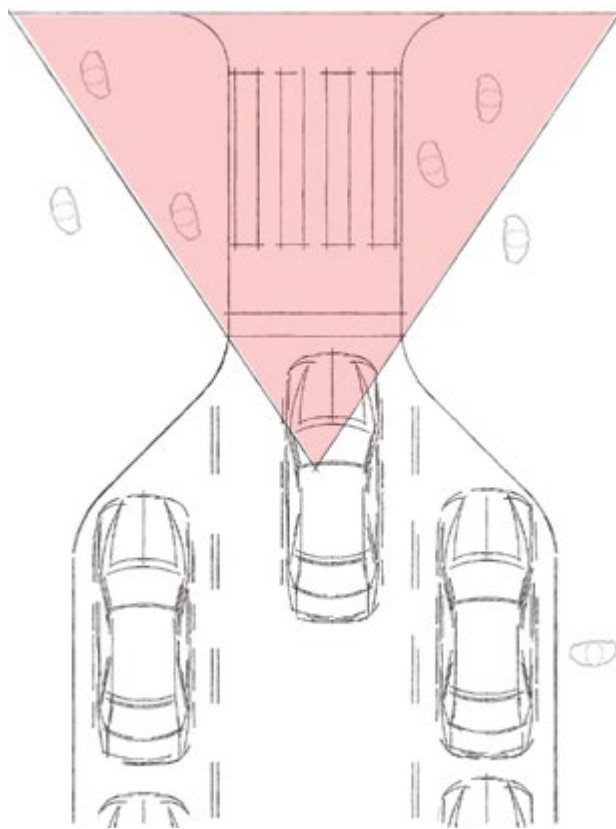
- Corners with curb extensions and/or smaller radius of curvature result in a larger area to accommodate pedestrians, with greater flexibility for siting curb ramps, reducing the distance and time for crossing and the speed of turning vehicles. Corners with curb extensions physically prevent illegal parking close to intersections and crosswalks.
- Corners with curb extensions create an additional space on the sidewalks that

Figure 21 | Angle of visibility on corners

Drivers visibility on corners without curb extensions.



Drivers visibility on corners with curb extensions.



Source: prepared by the authors.

can be used to hold vegetation and urban furniture, as long as they do not form an obstacle in the pedestrian zone or to the visibility of pedestrians and drivers.

APPLICATION

- To avoid restricted visibility between pedestrians and drivers, the ideal distance from the start of the permitted parking zone to the curb is positioned in relation to the corner and according to the road's speed limit.
- On roads where buses stop in the traffic lane, curb extensions can be used midway along the block to define the bus stop point and create an additional waiting area with a shelter, benches and other facilities for passengers.

CASES AND EVIDENCE

Evidence from Latin American cities shows that

the likelihood of running over pedestrians or of vehicles colliding increases by 6% for every additional meter of road width that a pedestrian has to cross. A study by Adriazola-Steil et al. (2015) showed that 90% of crashes in bus corridors do not involve buses and actually occur outside the bus lanes. To determine factors that influence the number of crashes, data was collected and analyzed on the priority public transport systems in Mexico City, Guadalajara, Bogotá and Porto Alegre for a period ranging from three to seven years, depending on the city. In each city, crash data was looked at from different perspectives, such as the length of pedestrian crosswalks or the presence of central refuges. The conclusion was concluding that in locations where the crosswalk distance is reduced, like on corners with curb extensions, the chances of people being run over dropped (Adriazola-Steil et al., 2015).

Table 1 | Distance between the start of the parking lane and the corner related to the road speed limit

ROAD SPEED LIMIT (KM/H)	START OF THE PARKING LANE IN RELATION TO THE CORNER (M)
Between 30 and 50	6
Between 50 and 70	15
Over 70	Parking should not be permitted within this area.

Source: Brasil, 2010.

Figure 22 | Curb extension with bus stop

Curb extensions can be used midway along a block to create an additional waiting area.



ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- Manual de Projeto Geométrico de Travessias Urbanas. DNIT, Brasil, 2010. p. 106.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 78.
- Segurança viária em sistemas prioritários para ônibus: recomendações para integrar a segurança no planejamento, projeto e operação das principais rotas de ônibus. Lindau, L. A. et al., EMBARQ/World Bank Group, 2015.
- Urban Street Design Guide. NACTO, 2013.

Figure 23 | Curb extensions on corners

Curb extensions reduce the crossing distance and prevent vehicles from parking too close to intersections. Joinville, Brazil.



3.3. PEDESTRIAN CROSSWALKS

Crossing roads is part of the daily walking routine for pedestrians, whether at intersections or otherwise. Pedestrian crosswalks signaled by paintings on the pavement along the street indicate safe connections between sidewalks. They may be built at road level, connected to sidewalk curb ramps, or raised to sidewalk level. They may also be accompanied by curb extensions to reduce the crossing distance or be located at intersections or midway along blocks, and may be accompanied by traffic lights. Regardless of their configuration, the goal is to alert road users that this is a point of attention prone to conflicts between vehicles and pedestrians and that, in any situation, priority should always be given to pedestrians.

PROJECT PRINCIPLES

- The width of a crosswalk must be enough to allow the free flow of pedestrians in both directions. The minimum width is 3 m, through 4 m is recommended.
- At intersections, a crosswalk must be marked at least 1 m from the transversal lane line.
- A vehicle stop line must be installed 1.60 m before the crosswalk at signalized intersections. In the absence of traffic lights, other traffic moderation measures must be applied to increase pedestrian safety while crossing.
- Conflicts among transport modes at intersections can be minimized with the installation of segregated cycling lanes and pedestrian refuge islands in addition to marked crossings.
- Good visibility must always be maintained. One way to do so is by installing curb extensions. Unsignalized crosswalks on roads with more than two traffic lanes may increase the risk of pedestrians being run over.
- The distance between crosswalks should be short, to minimize the walking distance and offer choices for direct routes, thus increasing the chances of being used.
- A fully accessible crosswalk should allow pedestrians to cross the street without obstacles, while providing visual and audible information about traffic light phases and tactile warning surfaces identifying the start of the vehicle traffic area.
- In Brazil, raised pedestrian crosswalks must comply with the guidelines of the Brazilian National Traffic Council (CONTRAN) Resolution 495, of 2014: a length equal to the width of the lane, platform width between 4 m and 7 m and a height equal to the height of the sidewalk, which shall not exceed 15 cm.

Figure 24 | Raised crosswalk

Raised crosswalks act as physical elements to help reduce vehicle speed, Londrina, Brazil.



BENEFITS

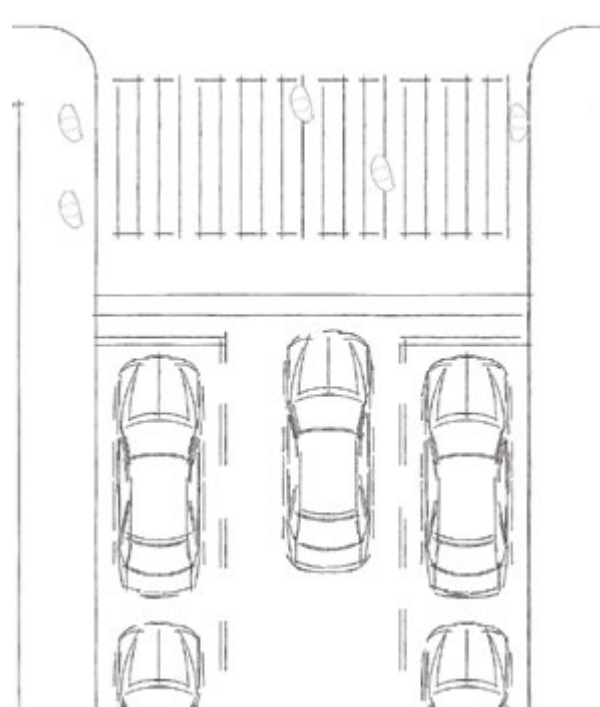
- Crosswalks are a point where pedestrians can safely cross the street. They also highlight areas prone to conflict between pedestrians and motorized vehicles.
- Pedestrian crosswalks are essential to a safe walking network, complementing sidewalks, stairs and public elevators, among other elements.
- Raised crosswalks are physical elements that help to reduce vehicle speed. They increase the visibility for pedestrians and the drivers' perception of the presence of these crosswalks. They should be installed on roads with speed limits below 40 km/h.

APPLICATION

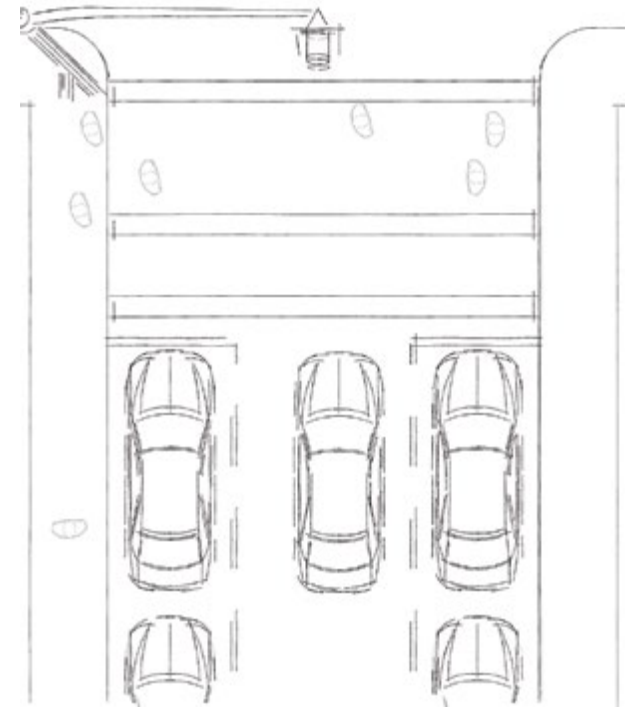
- All pedestrian crosswalks must be carefully designed or audited to guarantee the safety of users.
- Pedestrian crosswalks must feature special lighting in areas lacking public lighting, due to the risk of crashes involving pedestrians at night and in locations close

Figure 25 | Types of pedestrian crosswalks

Zebra crossing.



Crosswalk with two parallel lines.



Source: prepared by the authors.

Pedestrian crosswalks signaled by pavement markings such as white lines or “zebra” stripes indicate safe connection path between sidewalks.

to pedestrian traffic hubs, such as schools, public transport terminals and hospitals.

- Crosswalks must be used in locations where there is a need to organize, regulate or give preference to pedestrians while crossing the road.
- Striped “zebra” crosswalks should be used in locations with a significant volume of pedestrian traffic, regardless of the presence of traffic lights. The same type of crosswalk should be used in cases in which the volume of pedestrians calls for a crosswalk with a width over 4 m.
- Pedestrian crosswalks comprised only of two parallel lines should only be used at signalized intersections.
- Crosswalk lines must be straight, located close to the intersection and follow the pedestrian desire path.
- Raised crosswalks should only be installed on road sections with speed limits of up to 40 km/h.
- Diagonal crosswalks can be used in the case of high pedestrian traffic flows and multiple traffic light phases. The measure allows pedestrians to cross intersections from every direction, including diagonally, at the same time.

CASES AND EVIDENCE

Simply painting crosswalks on the road, without other associated mechanisms to increase pedestrian safety may, in fact, represent a danger to people by creating a false sense of safe. A study comparing one thousand intersections with painted crosswalks and another thousand without, all unsignalized, showed that painted pedestrian crosswalks on their own do not make a significant difference to road safety. The study goes on to show that the application of painted crosswalks on roads with multiple lanes and traffic flows over 12,000 vehicles per day increases the risk of crashes when compared to unpainted crossings, except when combined with additional safety mechanisms, such as centralized pedestrian islands or refuges. On roads with multiple lanes and more than 15,000 vehicles per day, pedestrian crosswalks increase the risk of traffic crashes even in the presence of centralized pedestrian islands or refuges (Global NCAP, 2016).

ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- Manual Brasileiro de Sinalização de Trânsito – Volume IV, Sinalização Horizontal. CONTRAN, Brasil, 2007. p. 46-48.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 78-79.
- Cities Safer by Design: Guidance and Examples to Promote Traffic Safety through Urban and Street Design. WRI Ross Center for Sustainable Cities, 2016.
- Promoting safer cars worldwide. GLOBAL NCAP, 2016.
- Resolução nº495, de 5 de junho de 2014. CONTRAN, Brasil, 2014b.

Figure 26 | Diagonal crosswalk

"X" crosswalks, or pedestrian scrambles, allow pedestrians to cross an intersection from every direction, including diagonally, at the same time, São Paulo, Brazil.



3.4. PUBLIC TRANSPORT STOPS AND STATIONS

Many people face serious problems in accessing public transport due to poor connections between the sidewalk and vehicle boarding points. Public transport stops, and stations located on sidewalks are important points for pedestrian and service integration, but they can also pose major obstacles for those walking along sidewalks. Encouraging more people to walk begins with sizing sidewalks appropriately, considering all the elements that should be allocated to the area, including public transport stops with enough waiting space. For passengers wanting to board or disembark vehicles safely and comfortably, vehicles must stop at a sufficient distance from the sidewalk.

PROJECT PRINCIPLES

- Bus stops and light rails must provide space enough for passengers to board and disembark. A continuous section of sidewalk is recommended, measuring 2.40 m wide at the stop point, roughly equal to the area from the rear to the front of the bus.

- Overcrowding at public transport stops, pedestrian crosswalks, centralized islands or refuges may induce pedestrians to walk in traffic lanes or to cross at unsafe locations. Sidewalk sizing must take into consideration the expected volume of passengers at peak travel times so as to reduce the probability of overcrowding.
- The size of the sidewalk around the stop area must consider the needs of wheelchair users and the space necessary to board or disembark using bus access ramps, when available.
- A curb extension can be used to expand the sidewalk space and accommodate public transport passengers. When possible, this space should be at least 10 m long, 2.20 to 2.70 m wide and be free of steps. In the event of height variations between the curb extension and the sidewalk, the width should be increased to 3 m to accommodate a ramp.

BENEFITS

- Appropriate design of sidewalks around public transport stops helps prevent conflict between pedestrians and passengers waiting for public transport or accessing stations.
- It also improves the image of the public transport system and the experience of passengers as it provides more comfort to people waiting for the bus or accessing stations.

APPLICATION

- Sidewalks that feature bus stops must be sized adequately so that the infrastructure and waiting bus passengers do not interfere with the pedestrian zone aimed at pedestrian circulation.
- In cases where the width of the sidewalk is not sufficient to host a stop, waiting area and pedestrian zone, a curb extension should be installed to increase the area available, or the location should be changed to somewhere more appropriate.

CASES AND EVIDENCE

Line 4 of the Metrobus, the BRT system of Mexico City, is different from the other lines. To preserve the urban image of the Historic Center while also maintaining level boarding, low-floor buses were used as standard, instead of high-floor buses which would require the construction of large boarding platforms. In some cases, the sidewalk was raised completely, with access via lateral ramps.

Other principles of the sidewalk related to safe connections:

1. PROPER SIZING

1.3 The frontage zone

4. CLEAR SIGNAGE

4.1 Informative signage

6. PERMANENT SECURITY

6.2 Active frontages

ADDITIONAL REFERENCES AND GUIDELINES

- Bus Stop Design Guide. Roads Service and Translink, 2005.
- Caderno técnico para projetos de mobilidade urbana: Sistemas de prioridade ao ônibus. Ministério das Cidades, Brasil, 2017b.
- Manual de Projeto Geométrico de Travessias Urbanas. DNIT, Brasil, 2010. p. 102-103.
- Traffic Safety on Bus Priority Systems: Recommendations for integrating safety into the planning, design, and operation of major bus routes. Adriazola-Steil, D. Hidalgo et al., EMBARQ/World Bank Group, 2015.

Figure 27 | Accessible integration with public transport

Metrobus Line 4 station with a raised sidewalks that allows for level boarding, in Mexico City, Mexico.



Rota de Pedestre

Pedestrian Route | Ruta Peatonal

→ Prefeitura Municipal
Palácio dos Governadores
City Hall | Governor's Palace
Alcaldía | Palacio de los Gobernadores

← Basílica e Most. de São Bento
São Bento's Basilica and Monastery
Basílica y Monasterio de São Bento



CHAPTER 4.

CLEAR SIGNAGE

It is common for people to avoid walking when they don't know the distances and times necessary to reach their destinations. The signage used in cities usually guides motorized vehicles. However, just like drivers, pedestrians also need clear and coherent information on how to behave and orient themselves within urban environments.

As such, the city signage system must be conceived to meet the needs of all people, regardless of their means of transport, level of knowledge or specific skills. Together with other elements, clear signage encourages walking by providing information and increasing pedestrians' confidence.

Figure 28 | Clear signage



Source: prepared by the authors.

Box 3 | INFORMATION ACCESSIBILITY

All city signage in a city must be designed so that it can be easily used by everyone. Accessible signage orients, warns, instructs, informs and provides direction regarding specific elements or places through a range of human scale communication techniques. Dimensions, colors and textures can be explored to ensure that pedestrians understand the signage. Essential information must be presented visually, audibly and in tactile forms, according to the principles of the senses, and as per the table:

Table 2 | Installation and category of signage according to the application.

APPLICATION	INSTALLATION	CATEGORY	TYPES		
			VISUAL	TACTILE	AUDIBLE
Spaces, equipment and buildings	Permanent	Directional or informative	yes	yes	no
				no	yes
		Emergency lighting	yes	yes	yes
	Temporary	Directional or informative	yes	yes	no
					Emergency lighting
		Emergency lighting	yes	no	yes
Furniture	Permanent	Informative	yes	yes	no
				no	yes
	Temporary	Informative	yes	yes	no

It is important that texts containing guidelines and instructions on how to use areas, objects, equipment, regulations, and standards of conduct are clear and objective. They need to present the essential information in Braille and embossed, using active and affirmative sentences, with an emphasis on the sequence of actions. Furthermore, signage should be located so that users can clearly identify the utilities available in the urban environment. Signs should be fixed in locations where decisions are made, in a logical and guiding sequence, from the starting point to the arrival point, and should be repeated whenever an alternative route is available.

Source: adapted from the ABNT, 2015.

Source: ABNT, 2015.

4.1.

INFORMATIVE SIGNAGE

Most of the signage in the cities is made for drivers, with often very little information for pedestrians. Difficulty in understanding the arrangement of avenues, streets, parks and promenades, often connecting at confusing angles and forming indirect paths, can create a veritable obstacle to anyone hoping to walk in the city. A system of informative signage for pedestrians encourages walking among visitors and even local residents.

PROJECT PRINCIPLES

- The signage system must be easy to understand by users, employ common characteristics and always offer instructions on how to read maps.
- It should also provide information such as distances to places of interest, walking times, directions to reach these places and maps of the region.
- These structures should be designed according to human scale, with positions and heights in

the environment suited to pedestrian access, and must be located at points of public transport, road intersections and points of interest.

- Maps should present two scales: one larger, with a general overview for pedestrians to outline routes within 15-minute walk by foot or using public transport, and another smaller map, for distances of up to 5 minutes walking.
- Systems should provide sufficient information, without excess.
- Signage may be interactive, for example presenting the health benefits of walking, such as the number of calories burned or the impact on reducing air pollution by choosing to walk instead of using a car.
- Signage can also be used to tell stories about the community, for example by featuring curious facts about important places in the region, adding interest to the walk.

BENEFITS

- Encourages pedestrian mobility.
- Helps pedestrians to plan their routes with ease, reliance and autonomy.

APPLICATION

- Maps and other components of the signage system must be installed at least 45 cm from the curb, ideally on sidewalks measuring more than 2.40 m in width and should not pose an additional obstacle to pedestrian circulation.
- Maps must be oriented in the direction they are being viewed.
- Signage can be incorporated into public transport systems and public bicycle services.

CASES AND EVIDENCE

Rio de Janeiro is implementing an orientation and signage system to facilitate walkings, called Rio a pé (Walk Rio), which will feature 600 informative pieces. The project, with support of the Ministry of Tourism, has installed bilingual totems and signs in some parts of the city, featuring routes, tourist attractions and points of interest, such as stores and services, all within a radius of 5, 10 and 15 minutes walking. Each of the routes have specific colors according to the type and scale and are separated into City Routes, Leisure Routes, Neighborhood Routes and Local Routes (Rio a pé System, 2016).

A 2002 study by International Business Research showed that 66% of public transport users in New York, USA, would consider changing their means of transport to walking after having seen a map indicating distances. Among tourists, this index rises to over 80% (Central London Partnership, 2006).

A 2005 study by Ipsos MORI for the borough of Islington, in London, UK, revealed that 49% of interviewees had seen and used informative signage installed by the borough; and of these, 83% were satisfied, 47% of respondents said

that the maps encouraged them to walk, and only 5% did not consider the maps useful (Central London Partnership, 2006).

ADDITIONAL REFERENCES AND GUIDELINES

- A Prototype wayfinding system for London. Legible London. Transport for London. Yellow Book, 2007.
- Caderno técnico para projetos de

mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.

- Legible London. A wayfinding study. Central London Partnership, 2006.
- Sistema Rio a Pé. Rio de Janeiro, 2016. Available at: <<http://sistemarioape.com.br/>>.
- Street Design Manual. Department of Transportation NYC, 2015. p. 182.

Figure 29 | Rio a pé System

Informative signage for pedestrian includes maps featuring the location, routes and distances to points of interest. Rio de Janeiro, Brazil.



Box 4 | LEGIBLE LONDON: PEDESTRIAN SIGNAGE

Legible London is an intuitive, consistent and official public information system aimed at pedestrians in London, UK. It provides information in several forms, including maps and directions, helping people to find the best route to their intended destination.

In a 2008 study to identify challenges faced by pedestrians when walking through the city, 57% of Londoners cited a lack of information, affirming that they would walk more often if there was better orientation. Added to this, a diagnosis identified that pedestrians planned trips based on perceived distances from the underground metro maps, which, however, do not represent real distances. Around 5% of passengers that exited the station at Leicester Square, for example, initiated their journeys no more than 800 m away, a distance that could easily be covered on foot if this information were available. The study found that encouraging these people to walk instead of taking the underground could significantly reduce overcrowding on trains, bolster the local economy and increase public safety, not to mention the many health benefits gained by walking.

Source: Central London Partnership, 2006.

The first step to designing an effective signage system is being aware of the real priorities of the different pedestrians in the city, whether visitors or residents. Prior to developing this kind of system, it's important to know local policies, regulations and responsibilities, while also studying the physical structures at locations where signage will be installed, and the cultural habits of the local population. For this purpose, studies were conducted in London to identify how pedestrians get around and what the most effective types of signage and information would encourage them to walk more.

The information system was developed based on a "mental map" concept, which transformed geographic elements in the city, such as junctions, routes and areas, into locations recognizable to the majority of the population. The more consistent the mental map, the more confidence people have in walking the city. The information system was coupled with a consistent naming policy for places and a strategy for positioning signage.

The Legible London team found that it was essential for any signage system to be simple and well implemented. A comprehensive approach, with long-term policies and adequate funding is vital to ensuring a system that works properly.

After a successful pilot program in central London, the Legible London team created a common approach to public wayfinding signage for all 33 city boroughs, expanding the wayfinding concept to encompass the entire city.

4.2. PEDESTRIAN TRAFFIC SIGNALS

Pedestrian traffic signals are used to indicate when pedestrians may cross a road or intersection. They may be accompanied by audible or vibrating

signals and countdown timers. Additionally, many cities employ tailored images on traffic lights as a means to leverage their local identity.

Figure 30 | Pedestrian traffic signals with local identity

Pedestrian traffic signals with images of the São Paulo Municipal Theater and Belo Horizonte City Hall in Brazil.



PROJECT PRINCIPLES

- There are basically two types of traffic lights: fixed-time, in the case of the continuous presence of pedestrians, or activated, when a button is pressed.
- Signal times should be set according to a walking speed of 0.4 m/s, using the slower speeds of older walkers as a baseline.
- When manually activated, the button should be between 0.80 m and 1.20 m from the ground.
- The signal should indicate the action to be taken by the pedestrian: stop or cross, according to the traffic light phase.
- All pedestrian traffic signals located in areas where the crossing time is greater than 7 seconds must also include a countdown timer showing the remaining interval for crossing.
- Short cycle times encourage people to wait for the next green light to cross safely.
- The pedestrian signal and the entire crosswalk must be completely visible to users.

- The area for pedestrians waiting to cross must be large enough to accommodate and protect all users and, in specific cases, include protection from vehicle traffic, such as barriers.
- Besides the visual signal, pedestrian traffic signals should also issue a synchronized audible or vibrating signal, at 10 decibels above the local noise level.
- Traffic lights programming must prioritize pedestrians crossing perpendicular to traffic by providing them with a cross light in advance of the traffic light turning green, in order to improve their visibility to turning traffic. This is known as a “lead pedestrian interval”.

BENEFITS

- Announces pedestrian priority while crossing, reducing conflicts with vehicles and increasing safety.
- Ensures more accurate decisions for when to start to cross.
- Reduces the number of crossings during the red-light phase of pedestrian traffic signals.

- Increases the number of crossings completed fully before the signal changes color.
- Fixed-time signals involve lower initial and maintenance costs than activated signals.

APPLICATION

- Pedestrian traffic signals must be installed together with vehicle traffic control signals.
- Pedestrian traffic signals must be set up so as to allow for the exclusive crossing of pedestrians while all conflicting vehicle movements are stopped.
- Installation is especially recommended in locations with specific safety demands, where children, the elderly and people with impaired visual or reduced mobility circulate.
- The response time for an activated signal should be approximately 5 seconds, based on the time necessary for an approaching driver to stop safely. Longer waiting times are only acceptable on high capacity roadway crossings.

CASES AND EVIDENCE

An interview with users aimed at gaining a pedestrian perspective on elements that could facilitate crossing at a location close to the University of Michigan, USA, showed that 74% of people believed that traffic control measures could encourage pedestrians to cross at specific locations, because the availability of pedestrian traffic signals would influence user's behavior (Sisiopiku and Akin, 2003).

The application of pedestrian traffic signals with audible signals in 12 North American cities resulted in different conclusions regarding user satisfaction and the effects on the environment. In nine of them, residents and local businesses complained about the sound of the traffic light. Three cities had problems with the location of the device, receiving suggestions on possible improvements from users with impaired vision. One city tested audible signals with a verbal announcement and an audible electronic signal and concluded that the second option was more widely accepted by the population. Another found that communication among all the agencies involved was crucial to the success of the traffic light implementation project (U.S. Department of Transportation, 2009).

A comparative analysis of 1,297 signalized intersections in 15 cities revealed that the risk of crashes involving pedestrians at intersections with exclusively pedestrian crossing times fell by almost half when compared to intersections with standard traffic control signals (Zegger et al., 1982).

ADDITIONAL REFERENCES AND GUIDELINES

- Effect of pedestrian signals and signal timing on pedestrian accidents. Zegeer, C.V. et al., Transportation Research Record 847, 1982. p. 62-72.
- Manual Brasileiro de Sinalização de Trânsito – Volume V, Sinalização Semafórica. CONTRAN, Brasil, 2014a. p. 218-227.
- Manual of Uniform Traffic Control Devices. U.S. Department of Transportation, 2009.
- Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data. Sisiopiku, V. P., Akin, D., Elsevier, 2003.

Other principles of the sidewalk related to clear signage:

2. UNIVERSAL ACCESSIBILITY

2.2 Tactile surface

3. SAFE CONNECTIONS

3.3 Crosswalks



Rio de Janeiro/Brazil

CHAPTER 5.

ATTRACTIVE SPACES

When walking along streets, people interact constantly with the urban environment. Sidewalks play an important role in encouraging this experience and making it more pleasant. Convincing people to walk is a way of increasing physical exercise and quality of life and reducing congestion in cities.

An attractive space is not measured by the number of people that use the sidewalk, but rather by the ambiance that the space transmits, the ease of walking, the opportunity for occupying that space and by the sense of place created by the surroundings. The setting and positioning of urban furniture are critical when it comes to comfort and well-being in urban spaces. The variation presented by building facades, multiple entrances and storefront windows make walking more enjoyable. The vegetation and type of paving in seating areas, if well selected, can turn sidewalks into spaces for social interaction, adding more life – and, consequently, safety – to the city.

Figure 31 | Attractive spaces



Source: prepared by the authors.

5.1. VEGETATION

An urban forestry plan must be established to avoid conflict between trees and urban equipment.

The inclusion of vegetation confers texture and color to streets, which are usually dominated by concrete and asphalt. Vegetation can also help characterize different regions of the city. Trees and vegetation in general offer environmental benefits, while also increasing pedestrian comfort, providing shade and protecting them from vehicle traffic. Populating the furnishing zone of a sidewalk with vegetation contributes to preserving the natural landscape, increasing ground permeability and air quality, while also encouraging more walking. However, it is important to avoid conflicts between trees and urban equipment such as street lights or utility poles, piping and walls. To avoid these conflicts, it is necessary to develop an urban forestry plan – a technical instrument with guidelines relevant to the specific characteristics of each city.

PROJECT PRINCIPLES

- Flower beds located close to the curb or building entrances must be sized according to the plant species and take up a maximum

of 1/3 of the sidewalk width in total, and never interfere with the pedestrian zone.

- In order to be suitable to accommodate trees, sidewalks must meet minimum measurement requirements. In areas without building setbacks, sidewalks with trees must be a minimum of 2.40 m wide, and in locations where building setback is mandatory, they must be a minimum of 1.50 m.
- The following distances from urban elements must be considered when planting trees:
 - a minimum of 5 meters from the corner so as not to interfere with intersection visibility;
 - a minimum of 2.40 m from building frontages;
 - a minimum of 0.30 m from curbs;
 - a minimum of 5 m between small trees, 8 m between medium-sized trees and 12 m between large trees.

- Venomous or thorny plants, tree with roots that may damage sidewalk paving and trees with branches lower than 2.10 m should not be used in areas adjacent to circulation zones.
- Species selection must consider root characteristics, to avoid them cracking and forcibly raising the sidewalks. The most recommended species are those with taproots, formed by a primary root that penetrates the ground vertically.
- Tree species that produce large fruits should be avoided to prevent falling fruits causing damage or injuring pedestrians.
- Any grates used to cover tree roots must have gaps smaller than 15 mm.
- Native or exotic species that correctly adapt to the climate are ideal.
- The height and size of species must be considered, as their proximity may generate interferences with adjacent residences and electrical cabling.
- Tree location must also take into account the position of street lights, so as not to block large areas of light in the sidewalk.

Figure 32 | Sidewalk surface damaged by tree roots

The wrong choice of tree species may jeopardize the sidewalk structure.



BENEFITS

- The presence of trees and vegetation increases ground permeability.
- Reduces the risk of flooding.
- Increases pedestrian comfort.
- Reduces the effect of urban heat islands, cutting energy costs related to the control of building temperatures.
- Provides the opportunity for animal life to inhabit urban areas.
- Protects pedestrians from vehicle traffic.
- Creates an impression of a narrowing street for drivers, leading to speed reductions.
- Creates a positive aesthetic, drawing customers to local commercial establishments.
- Increases the value of adjacent property.

APPLICATION

- Vegetation should not be planted on walkways with a width equal to or less than 1.50 m.

- Trees should be planted in areas with permeable ground, such as in flower beds or in porous areas or paving, allowing for water to seep into the ground and ensuring soil aeration.
- Correct and ongoing urban forest management is essential and includes planting, caring for saplings, pruning and removal.

CASES AND EVIDENCE

The city of Maceió, Brazil, conducted an urban environment analysis to study the importance of vegetation in cutting energy spending. It involved measuring climate variables in urbanized green areas and in areas lacking vegetation, considering the urban layout and tree species. The study identified the positive impact of urban vegetation on improving microclimatic conditions for human comfort. Specific findings from the study included:

- an analysis of the heat profiles for studied areas found that the presence of vegetation reduced the air temperature, especially during the period between 9 a.m. and 3 p.m.;
- the biggest temperature differences between points with vegetation and arid locations occurred at 9 a.m.;
- areas with trees heat more slowly, with air temperatures up to 2.5°C lower than areas with no vegetation (Barbosa et al., 2003).

ADDITIONAL REFERENCES AND GUIDELINES

- Manual técnico de arborização urbana. Secretaria Municipal do Verde e do Meio Ambiente, Prefeitura de São Paulo, 2016. Available at: <http://projetar.org/concurso_ver/32/>.
- Manual para elaboração do plano municipal de arborização urbana. Barcellos, A. et al., 2012.
- Tree planting standards. City of New York, 2014.
- Vegetação urbana: análise experimental em cidade de clima quente e úmido. Barbosa, R. et al., 2003.

5.2. URBAN FURNITURE

There is an array of elements that can be installed on sidewalks, such as newsstands, post boxes, public telephones, fire hydrants, planter boxes, garbage bins, benches and bus stops, among others. Some are for utility purposes, while others serve to encourage people to occupy public spaces. When well-planned and installed in an orderly fashion, urban furniture improves the experience of walking along city streets. However, if poorly positioned, it can form physical obstacles or even barriers that interrupt pedestrian traffic and visibility among road users.

PROJECT PRINCIPLES

- Urban furniture should follow the concept of universal design, ensuring safe use for all people regarding their conditions.
- Such equipment must be placed outside of the pedestrian zone, preferably occupying only the sidewalk furnishing zone.
- To preserve visibility between drivers and pedestrians, no urban furniture should be installed on corners, except for road signs, signs with street names, utility posts and fire hydrants.
- Large pieces of urban furniture must be placed at least 15 m from corners.
- Urban furniture should not interfere with sidewalk curb ramps.
- Hanging elements between 0.60 m and 2.10 m in height from the ground and which have a larger volume at the top than at the base, must be signalized with a tactile warning surface.
- When advertising is included as part of urban furniture, it must be regulated, to avoid visual pollution.





BENEFITS

- Each piece of urban furniture has a function and specific benefit for the population and city, such as benches, which encourage people to occupy public spaces; garbage bins, which help maintain city cleanliness; street lighting, which increases public safety; and bicycle racks, which encourage the use of bicycles as a means of transport, among others.
- Street furniture design and other elements of visual communication can be used to create an identity for the neighborhood or city, transmitting a positive message to residents and visitors. It enhances landscaping and generates both a greater sense of value in the place, and a greater sense of self-worth for the people who use it regularly.
- To promote a discussion on the value of installing urban elements in public spaces, and to provide opportunity for local professionals, public competitions can be held to select urban furniture designs.

APPLICATION

- Urban furniture must be used to encourage the use of public space in a way that leverages public safety, urban sanitation, the use of public transport, and a sense of belonging among members of the population.
- Garbage bins should be located near commercial areas where they can be emptied more than once a day and in predominantly residential areas along routes served by garbage collection services.
- Benches and chairs are best located in spaces with a pleasant microclimate, a wide view of the surroundings – preferably with people’s backs protected – and free of pollution.
- Urban furniture can also be sited in “parklets”, created in reclaimed parking bays along public roads that are converted into temporary or permanent recreational spaces.

CASES AND EVIDENCE

In 2016, São Paulo City Council organized a National Contest of Ideas for Urban Furniture for the City of São Paulo, calling for the participation of architects and urban planners, engineers and designers to create a municipal catalog of elements such as benches, restrooms, drinking fountains, kiosks and bicycle racks. Almost 70 projects were submitted for the contest. The judging committee included technicians from city administrations as well as university representatives (Gestão Urbana SP, 2016a).

The Recife #014 Bicycle Rack Contest aimed to mobilize students to design a bicycle rack for a location close to Recife Central Station. The initiative was geared towards integrating bus and bicycle transport, while improving infrastructure dedicated to cyclists. The winning project proposed a multipurpose bicycle parking facility that combined other convenient features such as seating, bike maintenance and shower facilities (Projetar.org, 2016).

ADDITIONAL REFERENCES AND GUIDELINES

▫ Centro Aberto. Experiências na escala humana. Prefeitura de São Paulo, 2015.

- Concurso Público Nacional de Ideias para Elementos de Mobiliário Urbano da Cidade de São Paulo. Gestão Urbana SP, 2016a. Available at: <[http://gestaourbana.prefeitura.sp.gov.br/rede-de-espacos-publicos /concurso-mobiliario-urbano/](http://gestaourbana.prefeitura.sp.gov.br/rede-de-espacos-publicos/concurso-mobiliario-urbano/)>.
- Concurso 014: Bicicletário. Projetar.org, Recife, 2016. Available at: <http://projetar.org/concurso_ver/32/>.
- Pedestrian Comfort Guidance for London. Transport for London, 2010. p. 26-32.
- Street Design Manual. Department of Transportation NYC, 2015. p. 170-183.

Other principles of the sidewalk related to attractive spaces:

3. SAFE CONNECTIONS

3.1 Connectivity

4. CLEAR SIGNAGE

4.1 Informative signage

6. PERMANENT SECURITY

6.1 Public lighting

6.2 Active frontages

Urban furniture must be used to encourage the use of public space in a way that improves public safety, urban sanitation, the use of public transport, and a sense of belonging among people.

Figure 34 | Bicycle parking design

The winning project for Contest #014, by Lucas de Menezes Pereira, Ruan Henrique Lima de Araújo and Leonardo Fernandes.



Source: projetar.org.



Salvador/Brazil

CHAPTER 6.

PERMANENT SECURITY

Sidewalks are a public space open to people, day or night, throughout the entire week. However, the intensity of use changes according to the surrounding amenities and the time of day or week. These spaces become unsafe through a lack of vigilance – not necessarily due to a lack of public safety agents such as police, but due to a lack of people living, working and circulating in different parts of the city, leaving spaces dangerously deserted. Adopting strategies to positively influence pedestrians to walk has the potential to make sidewalks more alive and safer for all.

The design of ground floor building frontages, close to which pedestrians pass, also has a direct link to urban safety. Adequate lighting, ease of interaction between the street and private spaces can ensure a constant flow of people that makes them feel safer on sidewalks, even among so many strangers. Strengthening the relationship between private buildings and public spaces has a direct impact on the quality of pedestrian mobility.



Fortaleza/Brazil

Figure 33 | Permanent security



Source: prepared by the authors.

6.1. PUBLIC LIGHTING

The key function of street lighting is ensuring minimum conditions for people to walk in the absence of natural light. A public lighting project must, therefore, prioritize pedestrians, since unlike vehicles they don't have their own means of lighting the way. Besides sidewalks, pedestrian crosswalks, intersections, footbridges and other sections of the pedestrian route must also be well lit. Guidance on appropriate light levels for public lighting in urban areas is given in Table 3.

PROJECT PRINCIPLES

- The placement of light posts must not obstruct access for emergency or maintenance vehicles.
- Posts should not be placed close to trees that may obstruct their light.
- The height of street lights depends on the type of route and its function.

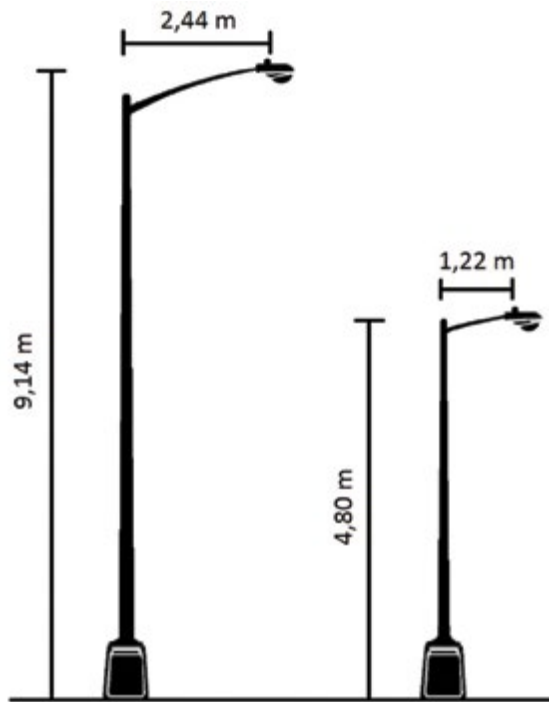
- Public lighting requires ongoing maintenance. Inspections must be conducted at night to identify missing lamps and to plan their replacement.

Table 3 | Height and spacing between street lights for public lighting in accordance with the type of light bulb

TYPE OF LIGHT BULB	STREET LIGHT HEIGHT	MAXIMUM SPACE BETWEEN POSTS	COMMENTS
70 W high pressure sodium-vapor	6 to 8 m	34 m	Generally used in residential areas
150 W high pressure sodium-vapor	6 to 8 m	34 m	Generally used in mixed use areas
250 W high pressure sodium-vapor	8 to 12 m	40 m	Standard for traffic routes and city center
400 W metal halide	8 to 12 m	On each side of the street, at pedestrian crosswalks	Used at pedestrian crosswalks
20 W and 40 W LED	6 m	25 m	Longer lasting and can save up to 50% in energy when compared to conventional types.

Source: adapted from National Transport Authority, 2017.

Figure 35 | Comparison between standard public lighting for car traffic and public lighting for pedestrians



Source: New York City Department of Transportation, 2013.

BENEFITS

- When well designed, public lighting increases the attractiveness of sidewalks.
- Lighting improves visibility and increase the sense of public safety for pedestrians.
- Public lighting contributes to reducing the risk of cars hitting pedestrians as well as pedestrians falls.

APPLICATION

- Public lighting must ensure the visibility of the path ahead as well as of any fixed obstacles on the surface or upcoming intersections and crosswalks.
- The location of posts for public lighting on pedestrian stairs and access ramps must ensure that any change in level is clearly visible.
- Due to the recurrence of vehicle crashes involving pedestrians at night, pedestrian crosswalks must feature special lighting, particularly in areas lacking public lighting. The same is true for areas prone to heavy pedestrian traffic, such as around schools, public transport terminals and hospitals.

Figure 36 | Lighting for pedestrians

Lighting in Pelourinho, Salvador, Brazil features lights fixed to buildings.



CASES AND EVIDENCE

The city of Manaus, in the state of Amazonas, Brazil, invested in a public lighting restoration program for the sports complex of Vila Olímpica. The program was part of a series of actions to improve pedestrian safety in the area. White metal-halide bulbs were used with the goal of generating energy savings of up to 30% for the city. The sense of security increased the self-esteem of people practicing sports in the complex (Amazonas Notícias, 2015).

Increasing light intensity along streets improves pedestrian visibility at night, especially at crosswalks. This measure has been associated with significant decreases in traffic crashes involving pedestrians. A study in Australia showed that crashes involving pedestrians dropped by 59% on roads with improved public lighting (World Health Organization, 2013).

An opinion survey conducted by the São Paulo City Traffic Engineering Company (CET) found that 90% of pedestrians and 91.1% of drivers believed that public lighting on crosswalks made crossing roads much safer. An analysis of effectiveness showed a 50% drop in the number of nighttime traffic crashes involving pedestrians in the first year following implementation of the measure in São Paulo (CET, 2016).

ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, BRASIL, 2017a.
- Faixa de Pedestres Iluminada. CET-SP, 2016. Available at: <<http://www.cetsp.com.br/consultas/seguranca-e-mobilidade/faixa-de-pedestres-iluminada.aspx>>.
- Iluminação nova e investimentos na segurança reforçam a revitalização da Vila Olímpica de Manaus. Amazonas Notícias, 2015. Available at: <<http://www.amazonasnoticias.com.br/iluminacao-nova-e-investimentosna-seguranca-reforcam-a-revitalizacao-da-vila-olimpica-demanau/>>>.
- Manual de Distribuição. Projetos de Iluminação Pública. CEMIG, 2012.
- National Cycle Manual. National Transport Authority, 2017. Available at: <www.cyclemanual.ie>.
- NBR 15129: Luminárias para iluminação pública – Requisitos particulares. ABNT, 2012a.
- NBR 5101: Iluminação pública – Procedimento. ABNT, 2012b.
- Segurança de Pedestres: Manual de Segurança Viária para Gestores e Profissionais da Área. OMS, 2013.
- Standard Highway Specifications. Department of Transportation NYC, 2013.
- Street Design Manual. Department of Transportation NYC, 2015. p. 134-160.

6.2. ACTIVE FRONTAGES

Figure 37 | Active frontages

Building frontages that offer a variety of visible activities are more inviting to pedestrians and provide a sense of security in urban spaces. Curitiba, Brazil.



Frontages that provide a view into the interior of the building via storefront windows and a high frequency of building entrances, as well as buildings in close proximity to the sidewalk, have a strong link to urban public safety. Stores, services and cultural spaces encourage neighborly coexistence and foster the relationship between public open spaces and the built environment, leveraging social interaction. A community that shares experiences and interacts on a daily basis tends to have better public safety. In addition, active building frontages make a vital contribution to the experience of the city. An architectural design that values the relationship between the building and street increases the complexity of frontages and their ground floors, humanizing the experience and breaking the monotony of walking. Environments like these are more inviting and contribute to encouraging people to walk and spend more time in public spaces.

PROJECT PRINCIPLES

- Commercial ground floors that open onto sidewalks should have at least 60% of their main frontages occupied by transparent structures, such regular or display windows or doors.
- Around 40% of all housing should present transparent perimeter walls or frontages, in the form of windows, doors or fences.
- To enhance the transition between private and public space, walls or fences surrounding residential buildings should be lower than 3 m.
- Governments should facilitate the construction of commercial ground floors, even for residential buildings, by establishing regulations that support development approaches suitable for an urban environment, such as mixed commercial and residential, without necessarily imposing preconditions specific to the type of frontage.
- Varied and well-designed building frontages are essential to public safety and increasing the perceived value of urban spaces. Property owners and commercial associations, and city design experts and regulators must work together to achieve this.

BENEFITS

- Well-designed frontages promote a sense of security through “eyes on the street”: people inside buildings can see what is happening in the streets outside.
- On commercial streets, narrow units with many doorways provide more opportunities for integration and interaction between retailers and customers.
- They add life to streets, contributing to a pleasant environment and the development of social ties.
- They improve the transition between private and public spaces.
- Mixed use of an area, combining residential and commercial properties, ensures occupation at different times throughout the day.

APPLICATION

- Commercial ground floors should be integrated in regions with mixed activities, in areas with a high-density urban fabric and in the central areas of neighborhoods, such as the main street in a residential neighborhood.

- The effect of commercial ground floors is enhanced when the relationship between community activities, facilities and mobility patterns is taken into account. Commercial establishments should relate to the needs of the local population and nearby activities (stationary stores close to schools, banks next door to commercial centers, cafeterias in office blocks, ice-cream parlors in front of parks, etc.)

CASES AND EVIDENCE

The São Paulo Strategic Master Plan establishes urban planning parameters to stimulate public spaces and thoroughfares. To encourage the construction of active frontages, the plan exempts land taxes for the area of the property dedicated to these, up to a limit of 50% of the land lot. In the case of open areas designed for public use on the ground floor of buildings, lot owners can receive an increase in the permitted floor-area ratio of their development, equivalent to the area made available for public use (Gestão Urbana SP, 2016b).

The design of building frontages and urban density may impact security and promote social support and daily activities for the elderly (City of New York, 2010).

ADDITIONAL REFERENCES AND GUIDELINES

- A cidade ao nível dos olhos: lições para os plinths. Karszenberg, H. et al., 2015.
- Active Design Guideline. Promoting Physical Activity and Health Design. City of New York, 2010.
- DOTS Cidades. Manual de Desenvolvimento Urbano Orientado ao Transporte Sustentável. EMBARQ Brasil, 2014.
- Novo PDE – Fachada Ativa, Fruição Pública e Cota Parte Máxima. Gestão Urbana SP, 2016b. Available at: <<http://gestaourbana.prefeitura.sp.gov.br/novo-pde-fachada-ativafruicao-publica-e-cota-parte-maxima/>>.

Other principles of the sidewalk related to permanent security:

5. ATTRACTIVE SPACES

5.2 Urban furniture

A community that shares experiences and interacts on a daily basis tends to have better public safety.



São Paulo/Brazil



CHAPTER 7.

QUALITY SURFACES

The sidewalk surface is important both for aesthetics and pedestrian safety. Data from São Paulo University's Orthopedic and Trauma Hospital shows that of 197 cases of people treated for sidewalk falls in 2012, 18% occurred due to the poor conditions of sidewalk surfaces.

The choice of paving material depends on several factors, such as the use of the sidewalk, the flow of pedestrians, local topography, the type of subsoil, the regularity of maintenance works and ground use and occupation. These factors must be considered by cities when selecting the range of materials appropriate for local sidewalks, as the chosen material must offer quality, durability and easily replacement. It is also important to differentiate the base layers necessary in the sections that motorized vehicles will cross because these must be more able to endure the pressure of heavier loads.

Regardless of the surface selected, the pedestrian zone of the sidewalk must guarantee complete accessibility: an even, firm, stable and non-slip surface, in both dry and wet conditions. People with reduced mobility depend on level surfaces that do not snag or impede equipment with wheels while also offering comfort and security. The presence of uneven surfaces on sidewalks, even small irregularities, restricts pedestrian movement and can cause serious accidents.

Regular maintenance of sidewalk paving is fundamental to ensuring a quality surface. In most Brazilian cities, both the construction and maintenance of sidewalks are the responsibility of adjacent lot owners. Some municipalities have programs to ensure adequate construction and maintenance of sidewalks, in accordance with the rules established by the city council. In specific cases, there are initiatives for shared responsibility between the public authority and lot owners for repairing sidewalks.

Regardless of the
chosen surface, the
pedestrian zone of the
sidewalk must guarantee
full accessibility.



Rio de Janeiro/Brazil



Box 5 | INVISIBLE SIDEWALKS COMPONENTS

Correct preparation of all sidewalk pavement layers is fundamental to guarantee a robust structure. The lower layers act as a foundation and, when poorly executed, compromise the integrity of the construction. The dimensions, materials, and number of layers can vary according to the surface to be laid on top of them and the type of soil base below. Examples of layer types and their properties are:

- Subgrade (compacted soil): This can be constructed using the natural, native soil or that from another region, as long as it does not expand when wet. The layer must be compacted to ensure a surface free of holes and feature adequate water drainage. When porous concrete paving is used, or for places where the water will not fully seep into the ground below, the drainage network is installed on top of this layer. Most paving types include this layer.
- Subbase: This is a layer of granular material compacted on top of the subgrade. To guarantee good compaction, it is fundamental that it is clean, free of dirt, and that the granules are of varied sizes.
- Base: Like the subbase, this is a layer of granular material, which must be clean, free of dirt, and have granules of varied sizes to guarantee good compaction. When applicable, such as in the case of locations to be used for vehicle traffic, a steel grating is installed on the base layer.
- Paver base: This layer goes on top of the base, immediately under the sidewalk surface. It can be made of concrete (structural or otherwise), sand or gravel. A paver base of concrete is used for a surface paving of cement tiles or concrete slabs. A paver base of even and constant sand is used for a surface paving of concrete pavers.

Source: ABCP, 2010a; 2010b; 2010c; 2010d.

Figure 38 | Quality surfaces



Site-cast concrete

Porous concrete

Interlocking pavers

Precast concrete slabs

Cement tiles

Source: prepared by the authors.

7.1.

SITE-CAST CONCRETE

A surface using site-cast concrete is executed by spreading wet concrete directly on site and vibrating it mechanically to achieve a smooth surface. The material can be produced on-site or at a centralized location such as a factory. Stamped concrete is executed much the same way, with the addition of a surface treatment by special finishing products that can produce a range of shapes, colors and textures.

PROJECT PRINCIPLES

- For pedestrian zones, the minimum thickness of concrete recommended is 7 cm, with a minimum strength of 20 Mpa (megapascals of pressure resistance).
- Site-cast concrete must include a non-slip, leveled or “broom swept” finish.
- Site-cast concrete requires a subgrade layer using the natural, native material or that from

another region, depending on local conditions, compacted into 15 cm layers, and a base of granular material with a minimum thickness of 10 cm, compacted after finishing the subgrade.

- The minimum thickness of the concrete should be 12 cm to 15 cm at points of vehicle access, and reinforcement may be required using steel grating in the base layer.
- Joints between sections of concrete must be planned at intervals of 1.20 m to 1.50 m.
- For maintenance, the surface should be cut out around the area to be replaced, at the point of the nearest joints, so that the cut outs align with the original joints and do not create new divisions in the concrete.
- The use of plastic sheeting between the base and the concrete is recommended. The plastic

sheeting forms an impermeable layer, protecting the structure from water seepage, while also reducing friction with the base. This allows the concrete to move freely as it settles and prevents the formation of cracks. The plastic sheeting must not have any folds or tears and must be applied over an even and compacted base.

BENEFITS

- Results in sidewalks with an even and durable surface, with a good friction coefficient to lower the risk of slips and falls.
- Site-cast concrete is a widely available low-cost material.
- Provides a solid base for installing furniture in the furnishing zone.

Figure 39 | Sidewalks produced using site-cast concrete

Material selected for the sidewalks on the busy Avenida Paulista guarantees durability and facilitates maintenance, São Paulo, Brazil.



A surface using site-cast concrete is executed by spreading and mechanically vibrating wet concrete directly on site.

APPLICATION

- When correctly applied, the surface of site-cast concrete is appropriate for vehicle accessways on sidewalks due to its excellent strength properties.
- In the furnishing zone of the sidewalk, site-cast concrete can be constructed in modular sections, facilitating access to underground services.

CASES AND EVIDENCE

The sidewalks along Avenida Paulista, in São Paulo, Brazil, were restored in 2007 using site-cast concrete and equipped with brass expansion joints between modular sections of concrete. The decision to use these materials took into account durability, ease of maintenance

and comfort while walking. In the event of public service network providers needing to undertake maintenance works on their underground networks, this type of surface facilitates reconstruction of the sidewalks. The material selection process also took into account aesthetics, in this case the contrasting tones of the gray concrete and the golden hue of the metal expansion joints (Gazeta Mercantil, 2007).

ADDITIONAL REFERENCES AND GUIDELINES

- Gazeta Mercantil. Edição de 24 de julho de 2007, pág. 11. In.: Clipping ABCP. São Paulo, 2007. Available at: <<http://notes.abcp.org.br:8080/producao/clipp/clipp.nsf/59dac160bc7df2ba03256aef00407549/eb59f56330bd820e83257322005042f8?OpenDocument>>.
- Manual de concreto estampado e concreto convencional moldado in loco: Passeio Público. ABCP, 2010a.
- NBR 12255: Execução e utilização de passeios públicos – Procedimento. ABNT, 1990.

Box 6 | URBAN HEAT ISLANDS

Walking on sidewalks can be uncomfortably hot if they lack shade and are surrounded by asphalt and concrete. These characteristics increase local temperatures and transform urban centers into heat islands, with significant thermal discomfort, in contrast to areas with more trees and located further on the outskirts of urban areas. This phenomenon causes increases in energy consumption due to intensive use of air conditioning during the hottest seasons. To lessen the effects of heat islands on sidewalks, it is possible to use paving that reflects the sun's rays and that allows rainwater to permeate. They remain much cooler in comparison to traditional paving and can absorb 80% to 95% of solar rays. The use of vegetation on sidewalks also helps reduce local temperatures by means of shade and evapotranspiration.

The use of reflexive and porous paving on sidewalks fosters increased comfort due to the lower temperatures of the paving and the air immediately above it. A concrete surface – whether cast on site or made of pavers or precast slabs – is considered a cool pavement as it naturally reflects solar radiation. Furthermore, the addition of pigments, aggregates and agglomerates of different light colors can increase reflectivity.

Source: Environmental Protection Agency, 2005; Mcgrath, J. 2016.



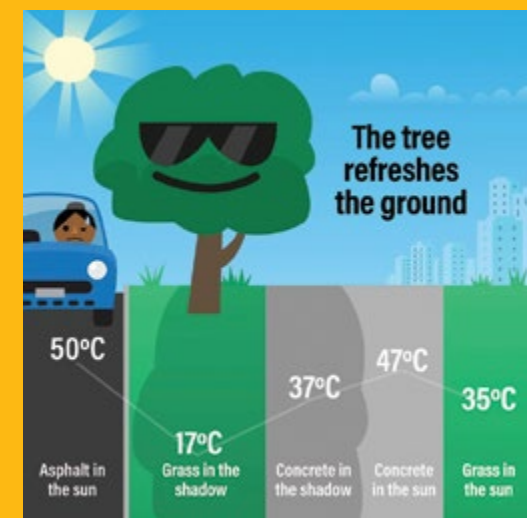
Planting trees along sidewalks can be part of the strategy to mitigate urban heat islands, both to increase thermal comfort for pedestrians and reduce the impact of cities on climate change. Researchers from the Federal University of Paraná, Brazil, measured air temperature variations, relative humidity and wind speed on streets with and without trees in Curitiba. Meteorological data was collected for each of the four seasons of the year. Results showed lower air temperatures on streets with trees when compared to those without, and the reverse for relative humidity. Wind speed showed no variation for either scenario. Based on these results, the study concluded that planting trees along streets fosters a milder microclimate throughout most of the day.

Figure 40 | Image from a thermographic camera

Hotter areas are shown in lighter colors and milder temperatures appear in darker colors.



Figure 41 | Comparison between pavement temperatures



Source: Kalil e Bojarczuk, 2014.

7.2. POROUS CONCRETE

Concrete is porous when it is mixed with cement, gravel and water, but little or no sand. As such, the tiny spaces between the gravel that would usually be filled by sand remain empty, allowing water to filter into the ground. Porous concrete can be cast on site or come in precast slabs or pavers.

PROJECT PRINCIPLES

- Porous paving installations should be capable of draining 100% of rainwater falling in the area as well as 100% of stormwater runoff from adjacent impermeable surfaces.
- Porous concrete should maintain a void content of 15% to 20%, meaning that it contains 15% to 20% air.
- A gravel base is recommended for underneath the porous paving, to allow seepage of rainwater and stormwater runoff. The grain size of the gravel used should be determined according to the drainage needs of the whole area.
- The gravel base must be at least 60 cm above the level of the groundwater table and the bedrock.
- The thickness of the concrete layer can vary according to the type of finish selected. For concrete pavers with expanded or hollow joints, porous concrete pavers and porous concrete slabs, the thickness should be 6 cm for pedestrian traffic only and 8 cm for light vehicle traffic (vehicle accesses, for example). For porous site-cast concrete, the minimum thickness should be 6 cm for pedestrian traffic and 10 cm for light vehicle traffic.
- Porous concrete may require regular maintenance because the gaps can become filled with dirt, which reduces their percolation capacity.
- The gravel used in the mixture should have an even grain size to guarantee a good void content, in line with the technical regulations.
- Porous concrete should not be used for surfaces above underground utility services, such as water, sewage and gas lines.
- When porous concrete is being cast onsite, the expansion joints must be positioned every 6 m at a depth of $\frac{1}{4}$ of the thickness of the concrete slab, soon after consolidation of the concrete.
- The application of a permeable fabric above the subgrade is optional to prevent fine materials from penetrating the subbase layer.

BENEFITS

- Increased surface permeability compared to standard concrete, increasing water seepage into the ground.
- Reduces the rate of flooding during storms.
- Helps reduce urban heat islands.
- Helps reduce the formation of puddles on sidewalks.

APPLICATION

- Porous concrete sidewalks must have even surfaces to allow for water percolation.
- This type of paving is most effective in locations with a running slope of less than 5%.
- The use of porous concrete above ground that does not have water drainage properties should be complemented with a drainage system.
- Porous concrete can be used to pave either entire sidewalks or a specific zone.
- Porous paving should not be used in locations susceptible to soil and groundwater contamination.

CASES AND EVIDENCE

The city of Seattle, in the USA, implemented a pilot project using porous concrete to reconstruct Avenue 32 Southeast. One of the objectives was to increase the permeability of the route by 10%. A 10 cm layer of concrete was laid on a 15 cm layer of subbase to construct the sidewalks. Lesson learned from the project were:

- control of erosion and the stormwater flows of adjacent areas is vitally important to the functionality of the paving;
- constructing the entire sidewalk area from porous concrete (rather than combining multiple types of pavement) provides flexibility in installation due to the opportunity for a simplified process, minimizing labor time and guaranteeing concrete stability;
- both laborers and inspectors working on porous concrete projects should undertake certification courses (Gwilym, 2006).

ADDITIONAL REFERENCES AND GUIDELINES

- City of Seattle Porous Pavement Case Study. SvR Design Company. Gwilym, K., 2006.
- NBR 16416: Pavimentos Permeáveis de Concreto – Requisitos e Procedimentos. ABNT, 2015b.
- Projeto Técnico: Pavimento permeável. Soluções para Cidades. ABCP, 2013a.
- Street Design Manual. Department of Transportation NYC, 2015.

Figure 42 | Sidewalks produced in porous concrete

Sidewalks with porous paving allows rainwater to filter through. Seattle, United States of America.



7.3.

INTERLOCKING CONCRETE PAVERS

Interlocking concrete pavers, or “segmental pavers”, are pieces of pre-shaped concrete that interlock and require only sand to fill the joints. Sidewalks constructed with this material allow different designs due to the variety of shapes, sizes and colors available.

PROJECT PRINCIPLES

- For paving pedestrian zones, the dimensions recommended for interlocking concrete pavers are 20 x 10 x 6 cm for pedestrian traffic only, and 20 x 10 x 8 cm in access areas for motorized vehicles.
- The minimum resistance recommended for the interlocking concrete pavers is 35 Mpa (megapascals of pressure resistance).
- Pavers are laid on a layer of sand or crushed rock spread over a base layer. They do not require adhesives, as the weight and interlocking system keep them secure.

- The space allowed for joints between pavers should be a minimum 3 mm, due to the irregular edge surfaces of the pavers, formed during the molding process.
- Once the pavers have been laid, they are compacted and covered with a layer of fine sand to fill the joints, followed by a final compaction stage.
- Edging, usually in the form of curbs, must be placed on the sides of the interlocked paving section. This is vital to preventing vertical, horizontal and rotational movement, and guarantees excellent performance and durability.

BENEFITS

- Interlocking concrete pavers have the non-slip properties of concrete, fostering pedestrian safety, even when wet.

- Concrete pavers treated with a light-colored pigmentation absorb less heat, improving thermal comfort.
- Due to the production and curing process of the concrete, the pavers offer excellent resistance, increasing pavement durability.
- Concrete-based products can be fully recycled and reused, making this type of paving more ecological, as limestone deposits are preserved and landfill saturation is curbed.

APPLICATION

- Interlocking concrete pavers are recommended for paving sidewalks, as long as their texture does not interfere with the perception of tactile surfaces.

Interlocking concrete pavers feature the non-slip properties of concrete, fostering pedestrian safety, even when wet.

CASES AND EVIDENCE

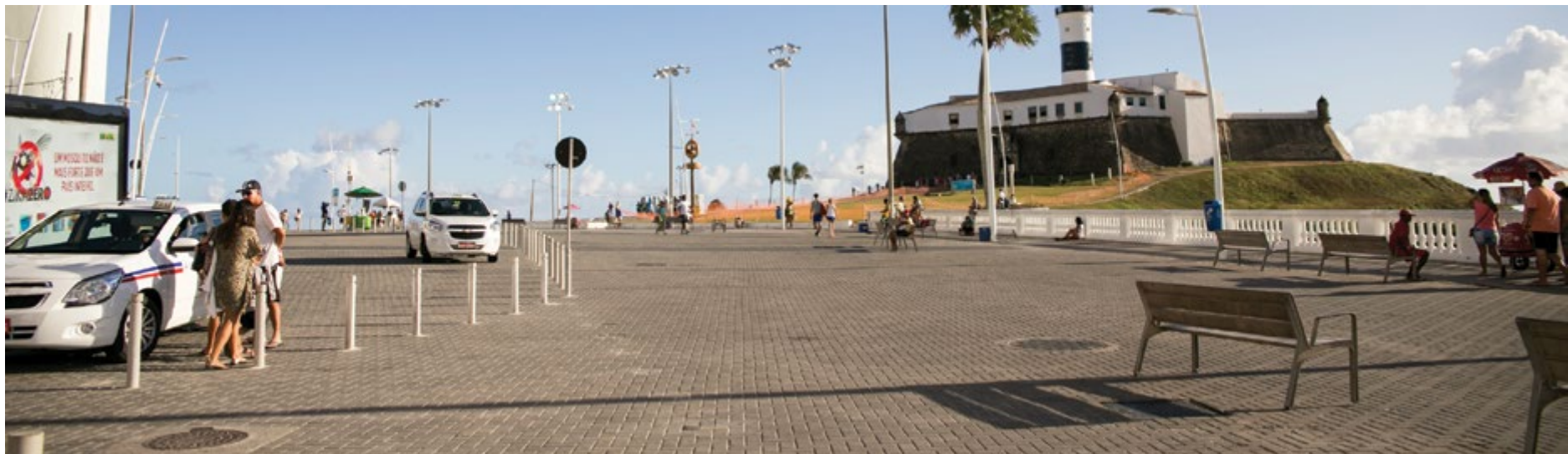
Interlocking concrete pavers were used for the restoration of the Barra Waterfront in Salvador, Brazil. The goal was to create a shared environment with the characteristics of a plaza, giving priority to pedestrians and cyclists by creating an area for social interaction and recreation. Besides the interlocking concrete pavers, pieces of granite were also used to create a pattern on the surface (Siquera, 2014).

ADDITIONAL REFERENCES AND GUIDELINES

- Manual de Pavimento Intertravado. ABCP, 2010c.
- NBR 15953: Pavimento Intertravado com Peças de Concreto – Execução. ABNT, 2011.
- NBR 9781: Peças de Concreto para Pavimentação – Especificação e métodos de ensaio. ABNT, 2013a.
- Nova Orla da Barra é entregue com piso de uso compartilhado, que modifica sistema viário do bairro e prioriza pedestres e ciclistas; projeto integra plano da Prefeitura de Salvador de revitalizar toda a faixa marítima da cidade. Infraestrutura Urbana, 2014. Available at: <<http://infraestruturaurbana.pini.com.br/solucoes-tecnicas/44/artigo329941-1.aspx>>.
- Street Design Manual. Department of Transportation NYC, 2015. p. 115.

Figure 43 | Sidewalks produced with interlocking concrete pavers

Paving using concrete interlocking concrete pavers creates a setting with characteristics of a plaza at Orla da Barra, in Salvador, Brazil.



7.4.

CEMENT TILES

Cement tiles are precast slabs with high resistance to wear and can be finished with either a smooth or textured surface. They can also be produced in a variety of colors and shapes. The use of cement tiles must take into account the main use of the specific sidewalk, including the possibility of friction, the level of pedestrian traffic, the possibility of snagging on wheeled equipment and resistance to the elements.

PROJECT PRINCIPLES

- The minimum thickness of a standard cement tile paving for the pedestrian zone of a sidewalk should be 2 cm, with a flexural strength of 5 Mpa (megapascals of pressure resistance). In the case that unusually shaped cement tiles are used, they may need to be thicker in order to achieve the necessary Mpa.
- The concrete base on which cement tiles are bedded should be 10 cm thick, with a minimum strength of 15 Mpa if the tiles will be used by pedestrians only. For locations in

which light motor vehicles will pass (vehicle accesses), concrete with a strength of 20 Mpa must be used, reinforced with a steel grating of 4.2 mm rods and a grid structure of 100 x 100 mm. In the case of use by heavy vehicles (trucks and armored vehicles, for example), additional reinforcement should be included.

- Cement tile paving is made of precast parts, quick and easy to implement, requiring trained labor but not heavy or specialized machinery. The paving can be opened to traffic after 48 hours or, if an adhesive mortar has been used to speed up the process, traffic can be permitted after only 24 hours.

BENEFITS

- Concrete pavements have non-slip surfaces, fostering pedestrian safety even under wet conditions.
- Sidewalks constructed with cement tiles provide increased comfort for people walking and facilitate

wheelchair and stroller mobility, because of the even surface and the small joints between the tiles.

- Tiles with lighter pigmentation absorb less heat, providing greater thermal comfort.
- Due to the treatment that concrete undergoes during the production and the curing process, cement tiles offer excellent friction resistance, increasing paving durability.
- Cement-based products can be fully recycled and reused, making this type of paving more ecological, as limestone deposits are preserved, and landfill saturation is curbed.

APPLICATION

- Cement tile paving can be used in areas with intense traffic, due to its high degree of durability.
- Besides sidewalks, this type of paving is recommended for public walkways, plazas and vehicle ramps.

Box 7 | THE TALE OF A SÃO PAULO ICON

In 1966, Mirthes dos Santos Pinto was a designer for the São Paulo City Council Public Works Department. The mayor, Faria Lima, famed for his dynamic approach, created a public contest to select a standard surface material for the city. Mirthes took a chance and studied a number of alternative designs, one of which she submitted. She was pleased to discover that she was among the finalists. Samples from four projects were implemented along a stretch of Consolação Street and, following a vote, an even bigger surprise: her proposal was announced the winner.

The design, which represents a stylized map of the state of São Paulo, was subsequently adopted for city sidewalks. Thanks to local government incentives, this design was installed on the sidewalks of major avenues. Over time, the cement tiles were produced by several manufacturers and were eventually used on the sidewalks adjacent to stores and homes as well. Within a decade, the technique had spread throughout the urban landscape. The design had become an icon of São Paulo.

Those who thought that the pavement surface was merely to cover the ground were sorely mistaken. Mirthes dos Santos Pinto's design became a dominant

feature, with the pattern eventually applied to the most diverse elements, well beyond sidewalks. It went as far as being used as the sole on sandals, on store frontages, patterns on fabrics and even a beer label. It was a hit!

However, it wasn't all joy for dos Santos Pinto – now Bernardes, her married name – as, almost forty years later, she has yet to receive a single cent for the design. It's true that seeing your creation take over the world provides a deep sense of satisfaction, but... not even a cent in compensation is taking things a little too far. This is a noteworthy example of a design falling into public domain soon after creation.

Up until 2004, this story wasn't widely known. Many architects and engineers, all with long careers tied to the public sector, were consulted and not one knew the origin of the design. Mirthes came forward after reading an article published in the magazine *Projeto/Design* on the origin of the famous design, which explicitly stated that the author of the project was unknown.

This project was São Paulo's response to the famed Copacabana tiled sidewalk project in Rio de Janeiro. Its austere design is an ingenious solution that uses just

three different square slabs – one white, one black and one black and white, split diagonally. When arranged correctly, they produce an infinitely repeating pattern. It is easy to produce and install using only simple cement tiles yet is so distinct that it was rapidly established as a renowned design widely recognized by the public.

The design is a good portrayal of São Paulo's pragmatism: in contrast to the curves representing ocean and mountains in the Copacabana sidewalk design, it invokes the strict geometry of the map of the state of São Paulo. It can be seen as an echo of the Brazilian neo-concrete movement (1959-61), which had roots in São Paulo. Using the design opportunities presented by positives and negatives, it plays with what is the image and what is the background. Sometimes the white shapes jump to the fore, and at others the black. This geometric construction represented the symbols of successive state governments, in addition to the previously mentioned transformation into a graphic pattern, applicable to so many other elements.

Its biggest triumph is its simplicity of composition, apparent through its clarity and legibility. Pavement design is typically subliminal and easily overlooked. This design surpasses this status and was embraced as an icon of São Paulo.

Source: Melo, 2005.

Figure 44 | Cement tiles

Cement tiles forming the stylized shape of the map of the state of São Paulo, Brazil.



ADDITIONAL REFERENCES AND GUIDELINES

- Crônica de um ícone paulista. Melo, C. H., Minha Cidade, Vitruvius, 2006. Available at: <<http://www.vitruvius.com.br/revistas/read/minhacidade/07.075/1937>>.
- Manual de Ladrilho Hidráulico. ABCP, 2010b.
- NBR 9457: Ladrilhos Hidráulicos para Pavimentação – Especificação e métodos de ensaio. ABNT, 2013b.

75.

PRECAST CONCRETE SLABS

Flat, precast concrete slabs can be set using a bound or unbound system, depending on the intended use. To provide more compression resistance, the concrete may include special additives, and the slabs can be reinforced with fibers, grating or mesh.

PROJECT PRINCIPLES

- When paving the pedestrian zone, it is recommended to use reinforced concrete slabs with a width equal to the pedestrian zone, split into modular sections no larger than 1 m wide and with a minimum characteristic flexural strength of 3.5 Mpa (megapascals of pressure resistance).
- The expansion joints between the slabs should be placed transversally to the direction of movement and not exceed 1.5 cm.
- An unbound system for laying slabs is recommended for those with dimensions greater than 40 x 40 cm. Slabs are laid on a

layer of granular material, such as sand and can be easily removed with a “slab lifter”.

- In the bound system, the slabs are laid on a supporting layer of mortar. For maintenance work, the risk of damaging slabs is greater than in the unbound system, as they need to be torn out.
- Precast concrete slab paving is quick and easy to implement because it is comprised of precast parts, requiring trained labor but not heavy or specialized machinery.
- The paving can be opened to traffic after 48 hours or, if an adhesive mortar has been used to speed up the process, traffic can be permitted after only 24 hours.

BENEFITS

- Pavements featuring concrete have non-slip surfaces, fostering pedestrian safety even under wet conditions.
- Sidewalks constructed with cement tiles provide increased comfort while walking and facilitate wheelchair and stroller mobility, due to the even surface and the small joints between the tiles.
- Tiles with lighter pigmentation absorb less heat, providing greater thermal comfort.
- Due to the treatment that concrete undergoes during production and the curing process, cement tiles offer excellent friction resistance, increasing paving durability.
- Cement-based products can be fully recycled and reused, making this type of paving more ecological, as limestone deposits are preserved and landfill saturation is curbed.

APPLICATION

- The unbound bedding system for concrete slabs is recommended for sidewalk areas dedicated to pedestrian traffic only.
- The bound bedding system is recommended for sidewalks areas with pedestrians and light vehicles traffic. Because of the added pressure of vehicles, mesh reinforcement should be included in the construction design.

CASES AND EVIDENCE

Rua Oscar Freire, in São Paulo, Brazil is home to a number of stores, restaurants and coffee shops, creating the perfect environment for walking. Together the property owners restored the sidewalks to guarantee a consistent design. Sidewalks were finished in concrete slabs, uniformly applied in a single material of one color with no decorative designs. Appropriate materials were selected based on the need to be suitably durable to both pedestrian traffic and vehicle access to parking, with the goal of maintaining low maintenance costs and simplicity in the case of requiring replacement (Vigliecca & Associates, 2002).

ADDITIONAL REFERENCES AND GUIDELINES

- Manual de Placas de Concreto. ABCP, 2010d.
- NBR 15805: Placa de Concreto para Piso – Requisitos e métodos de ensaio. ABNT, 2010.
- Rua Oscar Freire, São Paulo. Vigliecca & Associados, 2002. Available at: <http://www.vigliecca.com.br/pt-BR/projects/oscar-freirestreet#tech_chart>.

Other principles of the sidewalk related to quality surfaces:

1. PROPER SIZING

- 1.1 The pedestrian zone
- 1.2 The furnishing zone

2. UNIVERSAL ACCESSIBILITY

- 2.3 Running slope

8. EFFICIENT DRAINAGE

- 8.1 Cross slope

Figure 45 | Precast concrete slabs

Concrete slab paving on Rua Oscar Freire, in São Paulo, Brazil.



Box 8 | PORTUGUESE PAVEMENT

The Portuguese pavement technique uses small, irregularly shaped stones that are set in a manner similar to a mosaic. First, a well-compacted bed is formed, after which a layer of gravel is spread, which is also compacted. This is covered by a layer of rock dust or sand, on which the stones are finally set. Once the stones have been laid, the surface is covered with rock dust, sand and, sometimes, a mixture of cement. This top layer is then swept to fill in all the joints as much as possible. The entire structure is then manually compacted, either using a mallet or a vibrating plate compacter. Designs are created and transferred to iron or PVC molds, with the surroundings filled in first and then the actual design.

This technique is considered a cultural heritage, and people are concerned it may fall into disuse. On the other hand, despite many Brazilian cities still permitting the construction of sidewalks using the Portuguese pavement technique, this material is not recommended for sidewalk paving, especially for the pedestrian zone. Due to the lack of specialized professionals to ensure correct execution, the majority of Portuguese pavement sidewalk surfaces are irregular, uneven and unstable. Furthermore, the types of stone used, typically limestone and basalt, are slippery even when dry. Tests are now being conducted by mixing stones with

non-slip properties in with the originals, in order to make this type of sidewalk more stable and safer for walking.

Just like Portuguese pavement, rustic natural stones such as miracema, sandstone, slate, quartzite luminária, mineira stone, and similar types, as well cobble stones, uncut basalt stone and turf block pavers are not considered suitable for pedestrian zones for pedestrian traffic.

However, as this type of paving is porous, the Portuguese pavement sidewalks can be used for furnishing zones and accesses, especially for those where regular removal and reconstruction are not necessary.

Source: Pereira, 2015.

Figure 46 | Good and poor examples of Portuguese pavements

A well-executed sidewalk using the Portuguese pavement technique, forming a mosaic in Copacabana, Rio de Janeiro, Brazil.



A Portuguese pavement style sidewalks missing stones around inspection manholes, Porto Alegre, Brazil.



Figure 47 | Sidewalk employing the Portuguese pavement technique

Portuguese pavement sidewalk being bedded in Lisbon, Portugal.

The Portuguese pavement technique uses small, irregularly shaped stones that are set in a manner similar to a mosaic.



Box 9 | ALTERNATIVES AND NEW TECHNOLOGIES

To improve the comfort and functionality of sidewalks, cities around the world have begun to explore alternatives to traditional paving. Some cities have begun taking innovative approaches to improve sidewalk implementation and maintenance while also achieving economic and environmental sustainability:

- **Flexible materials:** New materials are being studied that could minimize the damage caused by tree roots breaking up sidewalks. One piece of technology that is being tested is a flexible rubber slab. Typically comprised of recycled tires and plastics, this material is able to endure the pressure caused by tree roots without breaking, as it is far more flexible than concrete. Furthermore, the sidewalk surface is softer, though still firm enough to avoid giving the sensation of being slowed down, and ensure comfort while walking. The city of Santa Monica, California, has the highest rates of application of this type of sidewalk. Since the start of 2000, the city has built over 2,000 m² of rubber sidewalks. However, it has stopped installing this form of paving due to other durability issues.
- **Energy Generation:** There is a growing interest in using sidewalks – and the people that walk on them – to generate energy. Pavegen, a British company, has created a system using recycled rubber – mainly tires – that converts the pressure of people walking into electric energy. Sidewalks with these panels have been installed in the UK and France in public areas, such as plazas and train stations, where they are generating an alternative energy source for street lighting. Similarly, an area of 10 m² of walkway made of solar panels was installed in the yard of a tech campus at George Washington University, USA, which, during peak times, generates sufficient energy to power the 450 LED bulbs that illuminate the area.
- **Self-cleaning sidewalks:** Cities in the USA that have a lot of snow in winter, like New York and Minneapolis, are testing sidewalks with heated concrete. The concrete slabs look the same from above, but the difference lies in the hot water piping running beneath them. The added heat melts snow and ice, reducing the risk of people slipping – a common winter accident – while also reducing the effort required to shovel away accumulated snow. This system is still very expensive, however, costing as much as 100,000 dollars to install a section in front of a building.
- **Self-healing cracks:** Researchers from the Delft University of Technology, Netherlands, have created a self-healing bioconcrete able to regenerate thanks to live components. Bacillus bacteria is added to traditional concrete, forming spores that can survive for over 200 years. A feed mixture – calcium lactate – is added to these two principal components. When cracks appear, water penetrates and activates the calcium lactate. The bacteria then germinate and feed, resulting in the production of calcite within approximately three weeks.

Source: Jonkers and Schlangen, 2008; Berg, 2014.



Porto Alegre/Brazil

CHAPTER 8.

EFFICIENT DRAINAGE

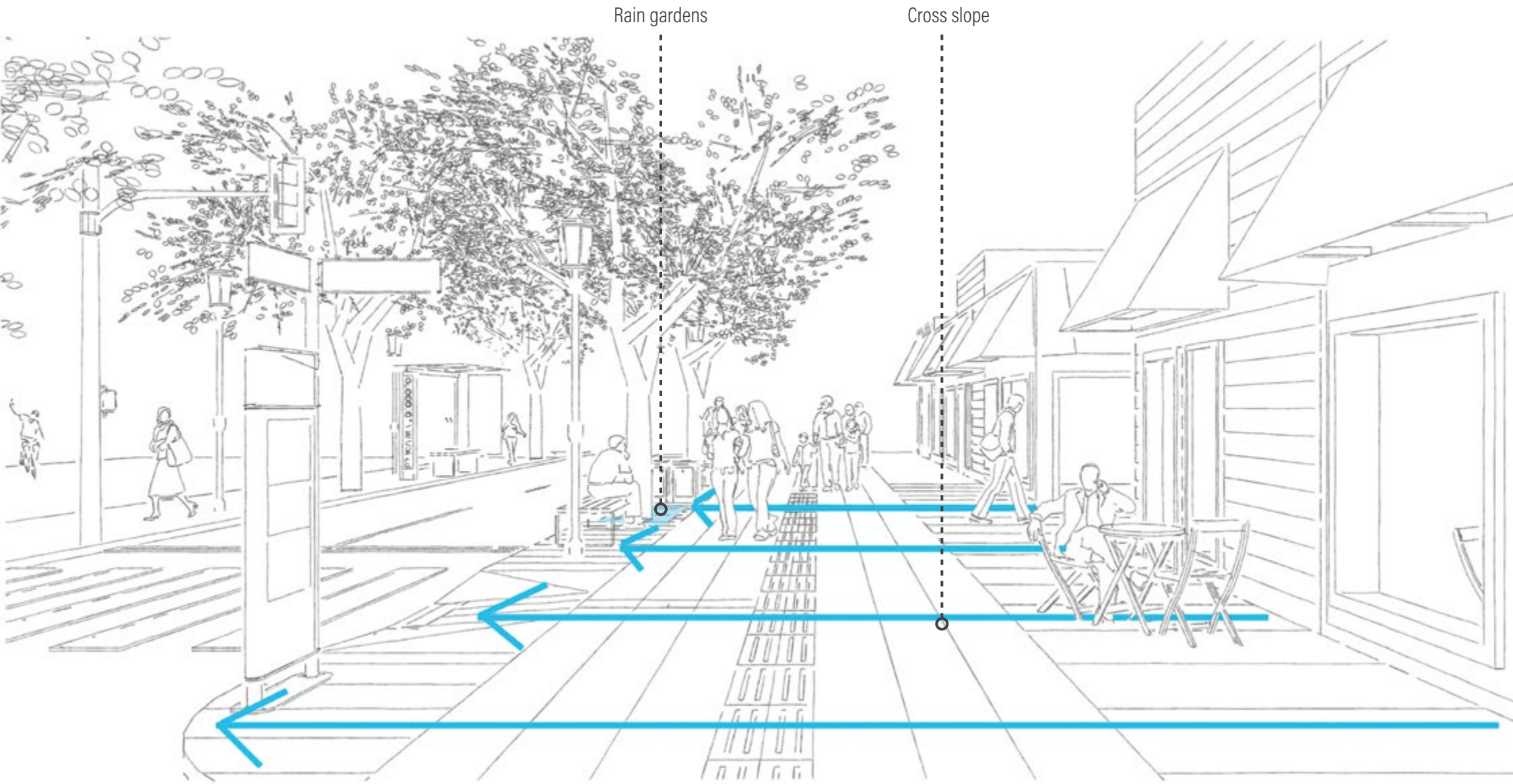
A flooded area is not suitable for pedestrian mobility. Sidewalks prone to the accumulation of water are unsuitable for walking. Pedestrian safety is further jeopardized when flooding forces people to detour, usually along vehicle lanes. Attention to details in executing paving is a determining factor when it comes to sidewalk quality. In the case of cross slopes, the maximum permitted degree is 3%, which should be verified several times during the construction of the surface. This degree of slope must be maintained to ensure a suitable runoff of rainwater that does not jeopardize pedestrian mobility.

Techniques for managing rainwater, also known as green infrastructure, such as bioretention in rain gardens, planting trees along sidewalks and the use of porous paving, reduce the surface flow of rainwater, easing the pressure on urban drainage infrastructure. Furthermore, they improve the quality of water that returns to the drainage basin or water catchment, reducing the need for treatment prior to consumption.



Philadelphia/USA

Figure 48 | Efficient drainage



Source: prepared by the authors.

8.1. CROSS SLOPE

Sidewalks require a cross slope in order to drain, as rainwater is carried to drains and collection points. However, the pedestrian zone of the sidewalk should not have a steep slope, as this makes it difficult to safely and comfortably walk.

PROJECT PRINCIPLES

- The cross slope of the pedestrian zone on a sidewalk should not be greater than 3%, in order to allow pedestrians and wheelchair users to travel safely and comfortably.
- The cross slope of a new sidewalk should be reviewed with the help of accurate measuring instruments.
- Any new sidewalk sections must be constructed in accordance with the elevation of the adjacent sidewalks and buildings, to avoid the construction of building access ramps.

BENEFITS

- Sidewalk slopes are important elements in draining rainwater, helping to prevent flooding.
- When used in combination with other elements, such as porous paving and rain gardens, sidewalk slopes also offer environmental benefits, which, in turn translate to social and economic benefits.

APPLICATION

- All sidewalks should be built with a cross slope that allows rainwater to flow into drains or rain gardens.
- Urban cleaning, especially the leaves from trees, is vital to drainage system operating properly.

Figure 49 | Sidewalk drainage design

A drainage design for an extended sidewalk along Paseo de la Reforma, Mexico City, Mexico.



CASES AND EVIDENCE

When sidewalks are extended or streets are pedestrianized in Mexico City, water is drained via a canal installed in the area where the gutter was previously located, in order to continue use of the same drainage system. This allows for an increase in the amount of space dedicated to pedestrians, while also preserving the slope of the existing sidewalk.

Figure 50 | Drainage system on a pedestrianized street

The drawings represent Calle Madero, in Mexico City, Mexico, prior to and after pedestrianization, with the new drainage system highlighted.



Source: prepared by the authors.

Sidewalks require a cross slope in order to drain, as rainwater is carried to drains and collection points.

ADDITIONAL REFERENCES AND GUIDELINES

- Caderno técnico para projetos de mobilidade urbana: Transporte ativo. Ministério das Cidades, Brasil, 2017a.
- Manual de Projeto Geométrico de Travessias Urbanas. DNIT, Brasil, 2010. p. 103.
- NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. ABNT, 2015a. p. 74.

8.2. RAIN GARDEN

A rain garden, or stormwater garden, is an unpaved area located within the furnishing zone on a sidewalk, characterized by a depression in the ground that forms a basin into which rainwater runoff flows, and is then absorbed into the ground. These spaces are also considered part of a bioretention system, as they use the biological activities of plants and microorganisms to remove pollutants from rainwater. To implement this measure, it is necessary to create a project design that takes into account the type of native soil, the areas appropriate for drainage, and any risks of blockages and flooding.

PROJECT PRINCIPLES

- Rain garden system should be designed to ensure that water is drained from a maximum area of 1 ha.
- The ground where the rain garden is to be installed must have the capacity to absorb between 7 and 200 millimeters of rainwater per hour (mm/h).

- In regions where the groundwater level is less than 1m from the base of the rain garden, rain gardens are only viable with permeable bottoms, thereby serving merely as water collection basins leading to an urban drainage system.
- Rainwater runoff that exceeds the garden drainage capacity must be redirected to a drainage system.

BENEFITS

- Serves as a landscape feature.
- Reduces the volume of surface runoff and the size of the downstream drainage system required.
- Removes fine sediments, metals, nutrients and bacteria from the water prior to absorption into the ground, improving water catchment quality and reducing the need for treatment.
- Reduces the risk of flooding.

APPLICATION

- Rain gardens should not be installed in areas where they reduce the size of the pedestrian sidewalk zone.
- Rain gardens can also be designed as part of curb extensions in areas that require reduced vehicle speeds, such as residential neighborhoods or near schools and hospitals.

Figure 51 | Rain garden

Rain gardens in front of properties in Portland, USA.



CASES AND EVIDENCE

A study by the University of São Paulo (USP) examined the performance of rain gardens in reducing contamination caused by rainwater runoff. Researchers built two prototypes made of gravel, soil and two different plant species to compare the level of contaminant retention and water treatment: one planted with grass and the other with plants and shrubs.

Over a period of one year, the models were fed by drainage systems from the adjacent roadways and then monitored, providing a comparative analysis of water quality before and after passing through the rain gardens. The study concluded that the



average retention of accumulated pollutant loads was 90% for the grass and 95% for the plant and shrub garden, with the latter more efficient in reducing the spread of pollution (Moura, 2014).

In Portland, USA, the city needed to find a way to meet new water quality criteria for stormwater and drainage runoff into the Willamette river, or else face a fine. Instead of spending approximately 150 million dollars to expand the drainage system, the city decided to explore alternative methods to reduce rainwater runoff volumes.

This led to the creation of the Green Streets Program, which implemented rain gardens and permeable pavements. These were designed to not only manage rainwater but also reduce speeds and organize vehicle traffic, to improve pedestrian and cyclist safety. In addition, tax breaks were offered to residents who built rain gardens in front of their properties.

Approximately 500 separate initiatives were undertaken, costing 11 million dollars which came from drainage taxes and other sources. The result was a reduction in peak flood periods of 85%, runoff volumes by 60% and diffuse pollution by 90%. As a result, the local rivers became appropriate for use as a water source for the population (Castagna, 2014).

ADDITIONAL REFERENCES AND GUIDELINES

- Biorretenção: tecnologia ambiental urbana para manejo das águas de chuva. Moura, N. C. B., Tese de Doutorado, FAU-USP, 2014.
- Drenagem vs. manejo sustentável de água de chuva: a experiência de Portland. Castagna, G., Infraestrutura Urbana, 2014. Available at: <<http://infraestruturaurbana.pini.com.br/solucoestecnicas/37/drenagem-vs-manejo-sustentavel-de-agua-dechuva-a-308750-1.aspx>>.
- Projeto técnico: Jardins de chuva. Soluções para Cidades. ABCP, 2013b.
- Street Design Manual. Department of Transportation NYC, 2015. p. 226-234.

Other principles of the sidewalk related to efficient drainage:

7. QUALITY SURFACES

- 7.2 Porous concrete
- 7.3 Interlocking pavers



Zeus Tattoo
COZINHOS
Culinária
Missa e Casamento
Bateu, Bateu, Bateu!

**RENSCER
GALERIA
DE ARTE**

**BARBICHA
ART BRASILEIRO**

**TEL
LOURINHO**

PROMOÇÃO
CADA PAR
DE TÊXTEIS
3 CANIESTROS
COM INVENTAR
ACTUALIS OS C
VISA

Salvador/Brazil

CONCLUSION

Today, over 50% of the global population is concentrated in cities. What makes urban centers such attractive places is their capacity to promote social interaction and, by doing so, catalyze development of cities and people.

Cities are home to millions of people around the world, striving daily for opportunities to improve their lives. Sidewalks play a vital role so that cities can be places of social interaction, creative development and economic growth. Prosperous cities with a high quality of life have sidewalks and public spaces that foster the urban vitality necessary for these processes to advance in a streamlined and sustainable manner.

A lack of good-quality sidewalks in Brazil is, without doubt, an obstacle to urban centers prosperity. Despite many Brazilian cities having developed economically, issues related to quality of life still leave much to be desired. Problems related to Brazilian cities sidewalks begin with a lack of adequate guidance on the conception, design and execution of the sidewalks. Exactly what constitutes a good-quality sidewalk

is still not completely clear in the minds of the population, designers and builders.

The eight principles presented herein serve as a guide to understanding the essential elements that make up a good-quality sidewalk. A detailing of each of these principles, together with their benefits and applications, provides the necessary information to ensure many more pedestrian infrastructure projects of excellence in the country. Thus, this publication provides a path towards the conception and construction of better sidewalk projects, helping to overcome the first major obstacle to good sidewalks in Brazil: a lack of concise and valid references that go beyond basic concepts such as width and paving techniques and help cities create sidewalk environments which will encourage people to walk on their daily commutes.

However, a reference alone is not enough to transform the conceptualization of sidewalk projects in the country. There are still many challenges ahead. Greater effort is required to raise awareness among the many players involved so that the concepts and parameters presented herein are successfully implemented in Brazilian cities in the coming years. Solving the challenge of sidewalk management is an important step, as the lack of clarity regarding who holds the responsibility for planning, execution and maintenance hinders efforts to reinforce the priority of pedestrian mobility. Furthermore, resources to improve sidewalks, as well as urban planning tools that can be used to this purpose, must be on the agenda for cities.

Improving incentives for pedestrian mobility not only depends on projects yet to be created and executed in the space between privately owned lots and adjacent curbs, but also on the transformation of the urban environment as a whole. Speed limits on city roads, the width of streets and the presence of public spaces for leisure are examples of factors that impact people's experience while walking in cities. Integrating pedestrian mobility needs into urban planning is fundamental. Master plans and urban mobility plans must take into account strategies and projects that improve walking conditions in the city. Mixed land use planning is an example of urban planning action that, together with well-executed sidewalks, can lead to a significant increase in the number of people who choose to walk in cities.



Canela/Brazil

REFERENCES

ABCP (Associação Brasileira de Concreto Portland). **Manual de concreto estampado e concreto convencional moldado *in loco*: Passeio Público**. São Paulo, 2010a.

_____. **Manual de Ladrilho Hidráulico**. São Paulo, 2010b.

_____. **Manual de Pavimento Intertravado**. São Paulo, 2010c.

_____. **Manual de Placas de Concreto**. São Paulo, 2010d.

_____. **Projeto técnico: Pavimento permeável**. Soluções para Cidades. São Paulo, 2013a.

_____. **Projeto técnico: Jardins de chuva**. Soluções para Cidades. São Paulo, 2013b.

ABNT (Associação Brasileira de Normas Técnicas). **NBR 12255: Execução e utilização de passeios públicos – Procedimento**. Rio de Janeiro, 1990.

_____. **NBR 15805: Placa de Concreto para Piso – Requisitos e métodos de ensaio**. Rio de Janeiro, 2010.

_____. **NBR 15953: Pavimento Intertravado com Peças de Concreto – Execução**. Rio de Janeiro, 2011.

_____. **NBR 15129: Luminárias para iluminação pública – Requisitos particulares**. Rio de Janeiro, 2012a.

_____. **NBR 5101: Iluminação pública – Procedimento**. Rio de Janeiro, 2012b.

_____. **NBR 9781: Peças de Concreto para Pavimentação – Especificação e métodos de ensaio**. Rio de Janeiro, 2013a.

_____. **NBR 9457: Ladrilhos Hidráulicos para Pavimentação – Especificação e métodos de ensaio**. Rio de Janeiro, 2013b.

_____. **NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos**. Rio de Janeiro, 2015a.

_____. **NBR 16416: Pavimentos Permeáveis de Concreto – Requisitos e Procedimentos**. Rio de Janeiro, 2015b.

_____. **NBR 16537: Acessibilidade – Sinalização tátil no piso – Diretrizes para elaboração de projetos e instalação**. Rio de Janeiro, 2016.

ADRIAZOLA-STEIL, D. H.; LINDAU, L. A.; JOHN, V. S. **Traffic Safety on Bus Priority Systemas: Recommendations for integrating safety into the planning, design, and operation of major bus routes**. Washington DC: EMBARQ/World Bank Group, 2015.

ALTAMIRANO, G. et al. **Calçadas verdes e acessíveis melhoram a mobilidade, a permeabilidade e embelezam a paisagem urbana**. São Paulo: Editora A9, 2008.

AMAZONAS NOTÍCIAS. **Iluminação nova e investimentos na segurança reforçam a revitalização da Vila Olímpica de Manaus**. Manaus, 2015. Available at: <<http://www.amazonasnoticias.com.br/iluminacao-nova-e-investimentosna-seguranca-reforcam-a-revitalizacao-da-vila-olimpica-demauias/>>. Accessed on: 23 out. 2016.

ANTP (Associação Nacional de Transportes Públicos). **Sistema de Informações da Mobilidade Urbana: Relatório Geral 2013**. São Paulo, 2015.

BARBOSA, R.; et al. **Vegetação urbana: análise experimental em cidade de clima quente e úmido**. Encontro Nacional e Latino-Americano de Conforto no Ambiente Construído. Curitiba, 2003.

BARCELLOS, A. et al. **Manual para elaboração do plano municipal de arborização urbana**. Comitê de trabalho interinstitucional para análise dos planos municipais de arborização urbana no estado do Paraná. Curitiba, 2012.

BERG, N. **The sidewalk of the future is not so concrete**. City Lab. Washington, DC, USA, 2014.

BHTRANS (Empresa de Transportes e Trânsito de Belo Horizonte). **Pesquisa apresenta Mapa de declividades de Belo Horizonte**. Belo Horizonte, 2016. Available at: <<http://www.bhtrans.pbh.gov.br/portal/page/portal/portalpublico/Temas/Noticias/Pesquisa%20apresenta%20Mapa%20de%20declividades%20de%20Belo%20Horizonte>>. Acesso em 14 fev. 2017.

BRASIL. Conselho Nacional de Trânsito. **Manual Brasileiro de Sinalização de Trânsito – Volume IV, Sinalização Horizontal**. Brasília, 2007.

_____. Departamento Nacional de Infraestrutura de Transportes. **Manual de Projeto Geométrico de Travessias Urbanas**. Publicação IPR – 740. Brasília, 2010.

_____. Secretaria Nacional da Promoção dos Direitos da Pessoa com Deficiência. **Cartilha do Censo 2010: Pessoas com Deficiência**. Brasília, 2012a.

_____. **Lei n. 12.587**, de 3 de janeiro de 2012. Política Nacional de Mobilidade Urbana. Brasília, 2012b.

_____. Conselho Nacional de Trânsito. **Manual Brasileiro de Sinalização de Trânsito – Volume V. Sinalização Semafórica**. Brasília, 2014a.

_____. Conselho Nacional de Trânsito. **Resolução nº495**, de 5 de junho de 2014. Brasília, 2014b.

_____. **Lei n. 13.146**, de 6 de julho de 2015. Lei Brasileira de Inclusão da Pessoa com Deficiência (Estatuto da Pessoa com Deficiência). Brasília, 2015.

_____. Ministério das Cidades. **Caderno técnico para projetos de mobilidade urbana: Transporte ativo**. Brasília, 2017a. Available at: <http://www.cidades.gov.br/images/stories/ArquivosSEMOB/Biblioteca/Caderno_tecnico_Transporte_Ativo.pdf>. Accessed on: 01 mar. 2017.

_____. Ministério das Cidades. **Caderno técnico para projetos de mobilidade urbana: Sistemas de prioridade ao ônibus**. Brasília, 2017b. Available at: <http://www.cidades.gov.br/images/stories/ArquivosSEMOB/Biblioteca/Caderno_tecnico_Sistemas_de_Prioridade_ao_Onibus.pdf>. Accessed on: 10 jan. 2017.

CASTAGNA, G. **Drenagem vs. manejo sustentável de água de chuva: a experiência de Portland**. Infraestrutura Urbana. Projetos, Custos e Construção. São Paulo, 2014. Available at: <<http://infraestruturaurbana.pini.com.br/solucoestecnicas/37/drenagem-vs-manejo-sustentavel-de-agua-dechuva-a-308750-1>

aspx>. Accessed on: 23 out. 2016.

CEMIG (Companhia Elétrica de Minas Gerais). **Manual de Distribuição**. Projetos de Iluminação Pública. Belo Horizonte, 2012.

CENTRAL LONDON PARTNERSHIP. **Legible London. A wayfinding study**. London, United Kingdom, 2006.

CET-SP (Companhia de Engenharia de Tráfego – São Paulo). **Faixa de Pedestres Iluminada**. São Paulo, 2016. Available at: <<http://www.cetesp.com.br/consultas/seguranca-e-mobilidade/faixa-de-pedestres-iluminada.aspx>>. Accessed on: 23 out. 2016.

CIDADE ATIVA. **Olhe o Degrau Cotoxó: arte e cores para quem caminha**. São Paulo, 2017. Available at: <<https://www.cidadeativa.org.br/single-post/2017/02/06/Olhe-o-Degrau-Cotox%C3%B3-arte-e-cores-para-quem-caminha>>. Accessed on: 12 fev. 2017.

CIDADE ATIVA E CORRIDA AMIGA. **Como Anda**. São Paulo, 2017. Disponível em: <<http://comoanda.org.br/>>. Accessed on: 6 fev. 2017.

CITY OF NEW YORK. **Active Design Guideline**. Promoting Physical Activity and Health Design. New York, USA, 2010.

_____. **Tree planting standards**. NYC Parks. Parks & Recreation. New York, USA, 2014.

DEPARTMENT OF TRANSPORTATION NEW YORK CITY. **Standard Highway Specifications**. Second Edition. New York, USA, 2013.

_____. **Street Design Manual**. Updated Second Edition. New York, USA, 2015.

EMBARQ BRASIL. **DOTS Cidades. Manual de Desenvolvimento Urbano Orientado ao Transporte Sustentável**. Porto Alegre, 2014.

ENVIRONMENTAL PROTECTION AGENCY. **Reducing urban heat**

islands: compendium of strategies. Cool Pavements. Climate Protection Partnership Division. Washington, DC, USA, 2005.

GAZETA MERCANTIL. **Edição de 24 de julho de 2007, pág. 11**. In.: Clipping ABCP. São Paulo, 2007. Available at: <<http://notes.abcp.org.br:8080/producao/clipp/clipp.nsf/59dac160bc7df2ba03256aef00407549/eb59f56330bd820e83257322005042f8?OpenDocument>>. Accessed on: 19 out. 2016.

GESTÃO URBANA SP. **Concurso Público Nacional de Ideias para Elementos de Mobiliário Urbano da Cidade de São Paulo**. São Paulo, 2016a. Available at: <<http://gestaourbana.prefeitura.sp.gov.br/rede-de-espacos-publicos/concurso-mobiliario-urbano/>>. Accessed on: 23 out. 2016.

_____. **Novo PDE – Fachada Ativa, Fruição Pública e Cota Parte Máxima**. São Paulo, 2016b. Available at: <<http://gestaourbana.prefeitura.sp.gov.br/novo-pde-fachada-ativafruicao-publica-e-cota-parte-maxima/>>. Accessed on: 23 out. 2016.

GLOBAL NCAP (Global New Car Assessment Program). **Promoting safer cars worldwide**. London, United Kingdom 2016.

GOUVEIA, P. H. (coor.). **Plano de Acessibilidade Pedonal de Lisboa**. Lisboa, Portugal, 2013. Available at: <<http://www.cm-lisboa.pt/viver/mobilidade/acessibilidade-pedonal/plano-de-acessibilidadepedonal>>. Accessed on: 23 out. 2013.

GRUNWALD, M. (Ed.) **Human Haptic Perception: Basics and Applications**. Leipzig, Germany: Springer, 2008.

GWILYM, K. **City of Seattle Porous Pavement Case Study**. SvR Design Company. Seattle, USA, 2006.

HARA, K.; SUN, J.; MOORE, R.; JACOBS, D.; FROELICH, J. E. **Tohme:**

Detecting Curb Ramps in Google Street View Using Crowdsourcing, Computer Vision and Machine Learning.

Computer Science Department, University of Maryland, College Park. Maryland, USA, 2014.

HOWATT, G. **Sistema Rio a Pé**. Rio de Janeiro, 2016. Available at: <<http://sistemarioape.com.br/>>. Accessed on: 18 nov. 2016.

JONKERS, H.; SCHLANGEN, E. **Development of a bacteria-based self-healing concrete**. Taylor & Francis Group, London, United Kingdom, 2008.

KALIL, P.; BOJARZUK, T. **Árvore, Ser Tecnológico**. Rio de Janeiro, 2014. Available at: <<https://goo.gl/1SjGla>>. Accessed on: 6 fev. 2017.

KARSENBERG, H.; LAVEN, J.; GLASER, M.; VAN T'HOFF, M. **A cidade ao nível dos olhos: lições para os plinths**. Segunda versão ampliada. Porto Alegre: EdIPUCRS, 2015.

MCGRATH, J. **What is the urban heat island effect?** How Stuff Works Science. Atlanta, USA, 2016. Available at: <<http://science.howstuffworks.com/environmental/green-science/urban-heatisland1.Htm>>. Accessed on: 4 nov. 2016.

MELO, C. H. **Signofobia. Coleção Textos de Design**. São Paulo, Rosari, p. 52-54. In.: Homem de Melo, Chico. Crônica de um ícone paulista. Minha Cidade, São Paulo, 07075, Vitruvius, outubro de 2006. São Paulo, 2006. Available at: <<http://www.vitruvius.com.br/revistas/read/minhacidade/07075/1937>>. Accessed on: 7 nov. 2016.

MOURA, N. C. B. **Biorretenção: tecnologia ambiental urbana para manejo das águas de chuva**. Tese de Doutorado. Faculdade de Arquitetura e Urbanismo. Universidade de São Paulo. São Paulo, 2014.

NACTO (National Association of City Transportation Officials). **Urban Street Design Guide**. 2nd Edition. New York, USA: Island Press, 2013.

NATIONAL TRANSPORT AUTHORITY. **National Cycle Manual**. Dublin, Ireland, 2017. Available at: <www.cyclemanual.ie>. Accessed on: 14 fev. 2017.

OMS (Organização Mundial da Saúde). **Segurança de Pedestres: Manual de Segurança Viária para Gestores e Profissionais da Área**. Geneva, Switzerland, 2013.

PEREIRA, R. **A Calçada Portuguesa**. Archdaily. Santiago, Chile, 2015. Disponível em: <<http://www.archdaily.com.br/br/763989/a-calcadaportuguesa>>. Accessed on: 1 nov. 2016.

PIRTTIMAA, I. **Blindsquare App**. Software de computador, Apple App Store, MIPsoft. Bangalore, India, 2016.

PROJETAR.ORG. **Concurso 014: Bicicletário**. Recife, 2016. Available at: <http://projetar.org/concurso_ver/32/>. Accessed on: 23 out. 2016.

ROADS SERVICE AND TRANSLINK. **Bus Stop Design Guide**. Belfast, Northern Ireland, 2005.

ROSS ATKIN ASSOCIATES. **Responsive Street Furniture**. London, United Kingdom, 2015.

SÃO PAULO. **Centro Aberto. Experiências na escala humana**. Secretaria Municipal de Desenvolvimento Urbano. São Paulo, 2015.

_____. **Manual técnico de arborização urbana**. Secretaria Municipal do Verde e do Meio Ambiente. São Paulo, 2016.

SIQUEIRA, M. **Nova Orla da Barra é entregue com piso de uso compartilhado, que modifica sistema viário do bairro e prioriza pedestres e ciclistas; projeto integra plano da Prefeitura de Salvador de revitalizar toda a faixa marítima da cidade**. Infraestrutura Urbana. Projetos, Custos e Construção. Salvador, 2014. Available at: <<http://infraestruturaurbana.pini.com.br/>>

solucoes-tecnicas/44/artigo329941-1.aspx>. Accessed on: 20 out. 2016.

SISIOPIKU, V.P.; AKIN, D. **Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data**. Transportation Research. Kocaeli, Turkey: Elsevier, 2003.

TRANSPORT FOR LONDON. **Yellow Book. A Prototype wayfinding system for London**. Legible London. London, United Kingdom, 2007.

_____. **Pedestrian Comfort Guidance for London**. Guidance Document, first edition. London, United Kingdom, 2010.

U.S. DEPARTMENT OF TRANSPORTATION. **Manual of Uniform Traffic Control Devices**. Federal Highway Administration. Washington, DC, USA, 2009.

VIGLIECCA & ASSOCIADOS. **Rua Oscar Freire**. São Paulo, 2002. Available at: <http://www.vigliecca.com.br/pt-BR/projects/oscar-freirestreet#tech_chart>. Accessed on: 28 out. 2016.

WRI (World Resources Institute). **Cities Safer by Design: Guidance and Examples to Promote Traffic Safety through Urban and Street Design**. Washington, DC, USA, 2016. Disponível em <<http://wricidades.org/research/publication/o-desenho-de-cidades-seguras>>. Accessed on: 11 jan. 2017.

WRI BRASIL (World Resources Institute Brasil). **Acessos Seguros - Diretrizes para qualificação do acesso às estações de transporte coletivo**. Porto Alegre, 2017.

ZEGEER, C.V.; OPIELA, K. S.; CYNECKI, M. J. **Effect of pedestrian signals and signal timing on pedestrian accidents**. Transportation Research Record 847. Washington, DC, USA, 1982.

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