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# TACTILE PAVING SURFACES AT BUS STOPS. THE NEED OF HOMOGENEOUS TECHNICAL SOLUTIONS FOR ACCESSIBLE TOURISM

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***Abstract*:** Accessible tourism promotes the right of all citizens to visit places and experience tourism. Therefore, universal accessibility must exist within the tourism value chain, where the public transport system is an important element. The research project "Accessibility for All in Tourism" focused on the attributes of inclusive bus stops and considered "Universal Design" and “Age Sensitive Design” approaches. In the built environment, products and spaces must consider the needs of all people to the greatest extent possible. In particular, adequate wayfinders to help people with visual disabilities in terms of orientation and danger alerts. Tactile paving surfaces are one of the fundamental elements of accessibility for people with visual disabilities, ensuring they have an independent life, whether they are residents in their city or tourists in another country. However, when considering these tactile surfaces, the needs of elderly people and individuals with visual disabilities are divergent. This study is intended to present international examples of tactile surfaces used at bus stops, in some cases based on bibliographic research and direct observation. For a better understanding of the constituent elements of tactile surfaces, established examples were compiled. The results indicate that there is a great diversity of technical solutions for tactile surfaces at bus stops that attend to the needs of people with visual disabilities, some more age-friendly than others. In a context of equitable use and accessible tourism, homogeneous technical solutions, inclusive for all, should be implemented in all countries.

***Keywords:*** social equity, universal accessibility, bus stops, tactile surfaces, people with visual disability, older tourists.

## Introduction

The United Nations Convention on the Rights of Persons with Disabilities adopted the social/environmental model of human functioning, assuming that disability is intrinsically related to the interaction between people's characteristics and the behavioural and/or environmental barriers that exist in society and that interfere with their inclusion and participation (United Nations Organization, 2006). The person with disability or incapacity, able to lead an independent life, aspires to direct his/her own life in a process of self-determination.

The concept of "self-determination" corresponds to the right of the person with disability to take control of his/her life and to be able to make choices, know how to request, make decisions, develop self-knowledge, autonomy and independence (Nirje, 1972). The process of self-determination depends on the development of the individual and his/her interaction with the built environment.

This emphasis on environmental factors external to the person determines that the built environment has to be designed take to into account the concepts of "social equity" and "social inclusion" that are considered in social sustainability (Rosa, 2018). This is associated with values of justice and solidarity, equal opportunities in access to goods and services, access to the city and information, alternative forms of communication and the participation of all in decision-making and governance processes. Thus, ensuring universal accessibility is fundamental for the exercise of rights and duties under equal conditions.

According to the European Concept for Accessibility, “accessibility is the characteristic of an environment or object which enables everybody to enter into a relationship with, and make use of, that object or environment in a friendly, respectful and safe way” (Aragall & EuCAN members, 2003). This is connected with the “universal design” concept which is ‘‘The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design’’ (Center for Universal Design, 1997). More recently, services were integrated into this approach, as well as transportation, information and communications.

The built environment must be usable by people with diverse abilities. It is an issue related to equitable use, as a democratic principle of equality, and so every person should have equal access to built and urban environments, making environments secure and safe to use by all (Story, 2001). Universal Design is seen as a significant component for sustainable life and social development (Kadir & Jamaludin, 2013).

So, in many European countries, over past decades, universal accessibility conditions for all have been implemented, including access to employment for people with disabilities. The subsequent financial autonomy has led to people with disabilities having an interest in tourism experiences in foreign destinations. This tourism for all participation is progressively perceived in countries as a right for all citizens.

Consequently, universal accessibility began to be considered in the field of tourism in England, and the Tourism for All project (Agovino, Casaccia, Garofalo & Marchesano, 2017) emerged.

In parallel, the promotion of sustainable and inclusive mobility prioritizes universal accessibility of public spaces, vehicles, products and equipment associated with transportation, adapted services, communication and information technologies.

An accessible city considers citizenship and the qualification of urban spaces, seeking to include everyone, regardless of their physical, mental or psychological abilities, valuing the city itself and making it more comfortable, sustainable and competitive. This approach has also been taken in tourist cities.

Presently, many tourist destinations have considered this accessibility according to the Universal Design approach, providing accessible tourism that guarantees trips in which people with disabilities can have autonomy. However, there is a focus on providing barrier-free access for people with physical disabilities, for example, wheelchair users.

The concept of “accessible tourism” meets this attribute as it “enables people with access requirements, including mobility, vision, hearing and cognitive dimensions of access, to function independently and with equity and dignity through the delivery of universally designed tourism products, services and environments. This definition is inclusive for all people including those travelling with children in prams, people with disabilities and seniors” (Darcy & Dickson, 2009, 34). Tourists with trolleys and luggage can be included in this reduced mobility group of people.

Regardless of the significant advances in accessibility, barriers to accessing public transport persist (Cerdan-Chiscano, 2020). Accessible stops are essential for people with motor disabilities and are useful for people with prams or baggage (Fearnley et al., 2011).

Accessible transport often correlates to step-free access, which is not the solution for most people with a visual disability (Low, Cao, De Vos & Hickman, 2020).

Concerning visually impaired people, consistency in the layout and design of the entire transport infrastructure is important to ensure that they can move safely and confidently (Quinones, Greene, Yang & Newman, 2011).

Bus stops constitute one of the fundamental elements of the transport network and must guarantee universal accessibility for passengers to the vehicles, so they must be integrated into the urban space and, consequently, into the pedestrian network and modal interfaces. Thus, bus stops must be accessible to guarantee conditions of autonomy for all pedestrians to satisfy their travel needs. For this to be possible, it is necessary to provide these spaces with adequate information and resources to allow the movement of all. This is a challenge in tourist destinations, mainly considering the needs of people with visual disabilities.

Environmental characteristics should facilitate all users' lives in terms of their activities, but there is little information available for designing products and spaces considering the perspective of people with visual impairments (Rey-Galindo, Rizo-Corona, González-Muñoz & Aceves-González, 2020).

It is known that the ability of people with visual disability to orient themselves is a highly complex issue since they are by no means a homogeneous group (Silverstone, Lang, Rosenthal & Faye, 2000).

In fact, there are a great diversity of problems when considering people with low vision: decreased acuity and visual field, photophobia/light sensitivity problems, inability to distinguish colours, difficulty in adapting to light and darkness, difficulty in distinguishing contours due to the absence of peripheral vision, among others.

According to Pindado (2006), in the specific case of visually impaired people, they have difficulties with: (a) identification of spaces and objects; (b) detection of obstacles (such as unevenness, protruding elements or holes); (c) determination of directions and monitoring of routes; and (d) obtaining written information (such as texts or graphics).

In the built environment, many countries worldwide introduced tactile ground surfaces to facilitate the safe movement of people with a visual disability since they were created in Japan in 1965 (Mizuno, Nishidate, Tokuda & Arai, 2008).

Tactile warnings are an effective tool to aid the wayfinding process (Rosburg, 2008). As in the built environment, pedestrian crossings and platform edges have tactile ground surface indicators, which are a set of square tiles with raised patterns to indicate direction, change of routes, warnings or change of ground level.

Sometimes, tiles have no raised patterns. For example, in Brussels (Belgium), tactile blocks are installed at bus stops, and rubber warning blocks are used where directional blocks intersect (Mizuno et al., 2008).

Christophersen & Denizou (2011) specify that guide paths may be created by architectural elements, components, or markings which, due to their form, colour, or texture, aid people with cognitive or sensory disabilities and other users. People with low vision must be able to see the guide paths and blind people should be able to perceive them via the feet or long canes.

Tactile floors must be specific textured surfaces, in general with contrasting colours, perceptible and identifiable by touch with the feet or with a white cane or through residual functional vision. They are used to guide and inform visually impaired people about a certain situation that requires guidance or attention.

However, accessibility for people with visual disability is often broken by the non-existence of tactile and/or chromatic floors that provide guidance and information to these users of urban spaces.  The general quality of the barrier-free pedestrian infrastructure is also important.

A recent study that considered the participation of a target group of users with visual disability concluded that the main hazards identified by them were parked cars, the presence of external obstacles (e. g. planter boxes), irregular ground surface, i. e. all the physical attributes that prevent good accessibility in urban spaces (Campisi, Ignaccolo, Inturri, Tesoriere & Torrisi, 2020).

Considering bus stops, blind and vision impaired residents and visitors find the boarding point difficult to locate (Golledge & Marston, 1999). When there are platforms, tactile paving is a critical safety requirement, as it warns that they are approaching the platform edge (Jones & Jain, 2006).

In this context, bus stops offering comfort, safety and information, conditions favourable to greater use of public transport by people with a visual disability must be ensured.

However, tactile paving can be uncomfortable for some elderly people (Ormerod et al., 2015) and also for wheelchair users and ambulant disabled people that may be at greater risk of tripping (Dales & Priestley, 2020).

From the perspective of elderly tourists, particularly older individuals (+ 80), there is a lack of interest in tactile surfaces, so the needs of elderly people and individuals with visual disabilities are divergent (Pinto, Assunção & Rosa, 2020).

Previous research gave some attention to this problem. The tactile installation design must take into account the people with a visual disability, wheelchair users and elderly people (Mizuno et al., 2008). Other established studies from the point of view of older people in the outdoor environment inferred fear of falling or feeling unstable on tactile surfaces, mainly on dropped kerbs (Chippendale & Boltz, 2014). Tactile surfaces are being investigated, from the perspective of other people, as there is some criticism of their use by people with motor difficulties, specifically older people (Omerod et al., 2015).

According to Mizuno et al. (2008), installations with an excessive number of warning block protrusions were observed in many countries, a situation that could confuse people with visual disability and be considered obstacles for the elderly and for those using wheelchairs or strollers. So, there is no need for huge rectangles of tactile paving, as this kind of installation is not helpful to blind people and is an annoyance for others (Duncan-Jones, 2015).

Recently, Dales and Priestley (2020) developed research on tactile paving, considering users' perspectives. There was a general recognition of the need to consider the concerns of other people with disabilities, especially those likely to experience discomfort or a trip hazard, as some blister dimensions are too high, affecting buggy and wheelchairs users, and others.

Interpretation of these findings can come from health research through the concept of "minimum toe clearance" (MTC), or more generally "minimum foot clearance" (MFC), which translates a measure of the risk of the foot swing contacting the walking surface or other object during the swing phase of walking (Winter, 1992). This author reported the MFC = 1.12cm in healthy elderly people. Group standard deviation in MFC has been reported as 0.68cm for elderly adults by Karst, Hageman, Jones & Bunner (1999), and so the height of 4.40mm looks admissible.

So, the dimension of 4mm can be considered adequate for all people. Being only 3mm in height, these protrusions seem likely to go unnoticed by people with visual disabilities (Mizuno et al., 2008).

The acceptable height to be detectable by touch with the feet is 4mm. This height of 4mm could be more convenient for the movement of wheelchair users or elderly pedestrians.

The present study is integrated into the Research Project ACCES4ALL - Accessibility for All in Tourism (2017-2019), in which the main goal was to design an accessible, smart and sustainable bus stop to be located at Faro International Airport, Algarve, Portugal. In 2016, more than 7 million passengers used this airport (Domingues, 2019), so it is the most important modal interface in this region. There is a traditional bus stop used by tourists and residents. The bus routes run between this airport and Faro city centre, as well as to some Spanish destinations.

This research considered the “Universal Design” and “Age Sensitive Design” approaches. The hypothesis posed at the beginning of the research project was whether older people are considered in universal design or whether they have specific needs that differ leading to the need to trigger age-sensitive design processes.

The present paper studies tactile surfaces implemented at bus stops, where possible raised bus stops, a necessary solution when the bus has a low floor but no kneeling system. So, it is not possible to bring its front end to ground level to eliminate the vertical gap.

This paper aims to present international examples of tactile floor routing systems located at bus stops, using bibliographic research and direct observation, when possible. The specific goal is to understand which of the researched tactile surfaces is more age-friendly.

## Methodology

The study made an in-depth literature review of documents, mainly laws, decrees, standards, manuals and/or technical guides, in order to understand the various tactile surfaces used at bus stops and specially raised bus stops, when this kind of information was available.

The analysis focused on European countries that send the most tourists to Faro International Airport. More than 90% of the air traffic at Faro airport consists of international flights with origin and destination in Europe. The countries with the most direct routes between the Algarve Airport are from the United Kingdom, followed by Germany, the Republic of Ireland, the Netherlands, Spain and France (Padinha, Miguel & Almeida, 2014).

From the perspective of senior tourism, elderly tourists surveyed in the ACCES4ALL Project came mainly from Europe: The United Kingdom 340 individuals (40.6%), Germany 116 (13.8%), Ireland 72 (8.6%), France 65 (7.8%), The Netherlands 38 (4.5%), Italy 28 (3.3%) and Belgium 27 (3.2%) (Gameiro, Rosa, Sousa & Mestre, 2019).

This research confirmed, as expected in the ageing process, disability increases significantly with age. Of the 835 valid inquiries, 209 (25.0%) of the elderly have a disability. The nature of the disability is mainly related to motor problems (61.6%), hearing problems (15.2%), visual problems (14.8%) and orientation problems (1.7%) (Rosa, Gameiro, Sousa & Pinto, 2020). Four individuals used a white cane (Gameiro, et al., 2019). So, the needs of visually impaired people are also pertinent to elderly people.

This information influenced the study of tactile solutions considered at bus stops in the United Kingdom, Germany, Spain and France. Belgium was also considered, because rubber warning blocks are used as tactile surfaces, as seen before.

In addition, Dubai was considered, as this emirate of the United Arab Emirates has one of the most complete and recent universal design standards recognized internationally.

This review consolidates information collected from different mediums, such as laws, decrees, standards, manuals and/or technical guides, prepared by different institutions and participants. This process has taken time due to the diverse national sources of information in the various countries, as there are also technical standards on a regional scale.

The aim of the literature review was to answer the following research question: "what are the types of tactile paving surfaces that are used at bus stops, mainly raised bus stops, for providing information to people with visual disability, in different countries?".

The research team conducted a literature review of relevant institutional documents to understand the various technical solutions. The main documents, considered to be more complete in terms of technical information about tactile paving at bus stops, were:

- Guidance on the Use of Tactile Paving Surfaces (DETR, 1998);
- *Barrierefreie Verkehrsinfrastruktur* / Infrastructure for barrier-free transport (ADAC, 2018);
- *Guia Técnica para la instalación de sistemas de encaminamiento en las infraestructuras de transporte público en la Comunidad de Madrid* /Technical guide for the installation of guidepath systems in public transport infrastructures in the Community of Madrid (Accesible, without a reference date);
- *Guide de bonnes pratiques pour l'aménagement de cheminements piétons accessibles à tous. Les manuels du MET.* /. Guide to good practice for the development of pedestrian walkways accessible to all. The MET manuals (GAMAH, 2006);
- *Guide d'aménagement des quais bus accessibles Schéma Directeur d'Accessibilité/Guide to the layout of accessible bus platforms Accessibility Master Plan* (SMT, 2009);
- Dubai Universal Design Code (Government of Dubai, 2017).

Additionally, two types of qualitative field research methods were developed focusing on capturing information from existing bus stops: direct observation and participant observation.

In direct observation, information was gathered primarily through close visual examination of bus stops and observation of their use by people with disabilities and the elderly. The main form of recording information was writing field notes, which detailed the urbanistic characteristics of the bus stops (with emphasis on tactile surfaces). Taking photographs was another form of data collected, avoiding people for ethical reasons.

In participant observation, the main researcher used, in a systematic way, the public transport system, which, as a user, contributed to a more detailed understanding of the existing inclusive solutions.

Some of this research on accessible bus stops was developed prior to the present investigation. As in the case of a visit in Nice (France), on 5th November 2013, with a field study undertaken on a rainy afternoon.

More recently, observation to identify the elements of tactile paving surfaces at bus stops was undertaken in certain countries: the United Kingdom (visit Bristol, 10th June 2017, field study on a sunny morning) and Spain (visit Barcelona, 7th April 2017, field study on a sunny afternoon). In each city visited, walks were undertaken to find, observe and photograph examples of how tactile paving surfaces were implemented at bus stops. This fieldwork brought into awareness that there are different tactile paving surfaces and specific elements in their composition.

Technical drawings are presented in this study to perceive the different layouts used at bus stops in the studied countries.

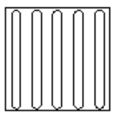
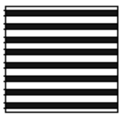
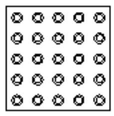
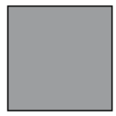
## Results

### Types of Tactile Surfaces

There are many different tactile surfaces in the countries researched, but four styles are more present in the researched documents. Tactile blocks of ribbed floor (with different purposes – guidance or warning), blister surfaces (purpose - warning) and neoprene rubber, a smooth and/or soft floor (purpose - informative), usually, with colour contrast (Figure 1).

The ribbed floor has a linear relief, with salient elevations (ribs or bars), parallel to each other, generally flat, whose edges and ends may be straight or slightly rounded, and whose spacing may or may not be regular. According to the form of application - whether longitudinal or transverse to the walkway - the type of flooring assumes different purposes and communicates different information.

*Figure 1. Some examples of tactile surfaces. Source: Own elaboration*

| Element | Ribbed surface | | Blister surface | Neoprene rubber or surface with contrasting colour |
|---|---|---|---|---|
| Purpose | **Guidance surface** | **Warning surface** | **Warning surface** | **Information, indication** |
| Plan |  |  |  |  |

When the ribbed floor is applied longitudinally, it generally takes on the function of direction/guidance to guarantee orientation for blind people and is used to indicate paths and routes. It is generally recommended to be applied in a few circumstances on public roads. In Spain, its use is recommended in the absence of a façade line. In Belgium, when a situation can lead to disorientation, for example, walking in a complicated transport terminal, finding a specific bus or train line.

When the ribbed floor is applied crossways, it generally takes on the function of warning, caution, danger, or is used to indicate a change of direction, points of interest (bus stop, information point, crossing points), change of levels (stairs and ramps), pedestrian level crossing or approaching unevenness on platforms at train stations (danger). The floor has a greater number of ribs with less spacing between them.

The warning floor has a "pythoned" (button or dot) relief profile, composed of protruding domes (rounded, usually with a flat top), generally regular spacing and sufficient height to be detectable by touch with the feet or a white cane.

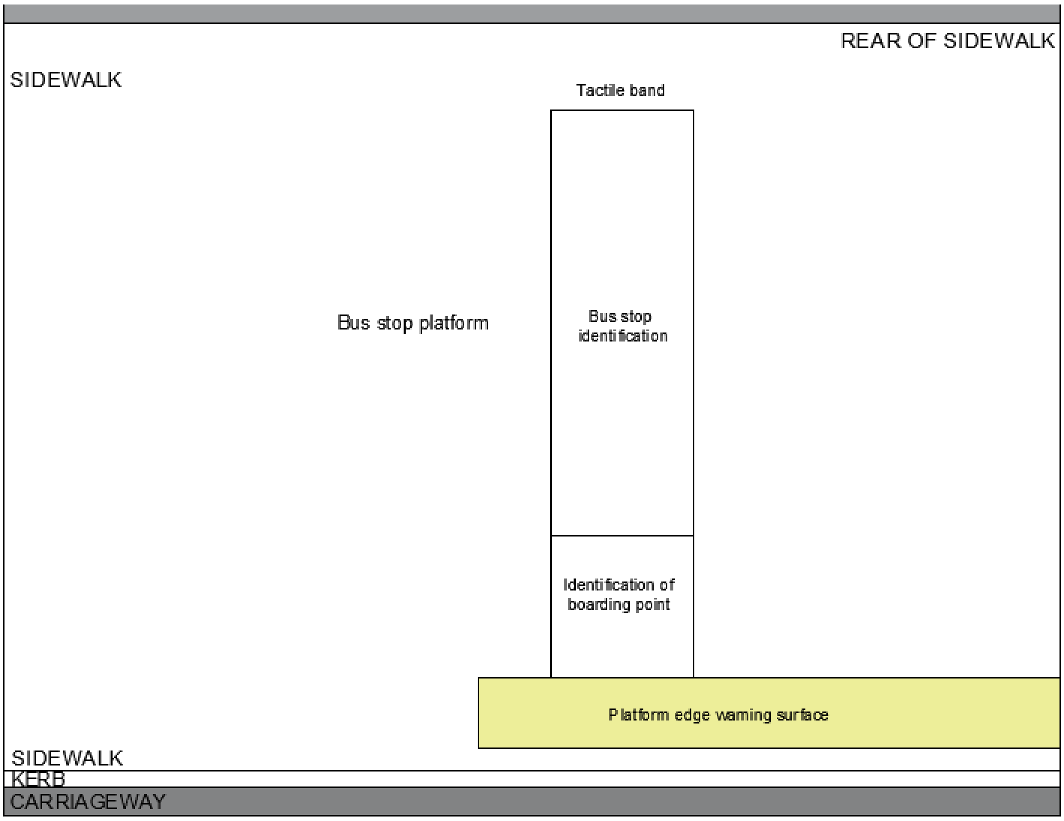
It can be used to indicate a change of direction, presence of obstacles, change of level (stairs and ramps), pedestrian crossing points, the approach of unevenness on rail or bus platforms (danger). In some cases, the positioning of the pythoned floor can indicate the direction of travel.

In the United Kingdom, floors with soft rough surfaces (not tactile) and contrasting colour were observed.

## Layouts of Tactile Surfaces at Bus Stops

The use of tactile and/or chromatic differentiated tactile surfaces at bus stops, consider specific situations: a) identification of the localization of the bus stop; b) identification of the place of boarding; c) identification of the edge of the platform (Figure 2). Plus situations where only strips with chromatic differentiation are used.

*Figure 2. The layout of tactile surfaces at bus stops. Source: Own elaboration*



## United Kingdom

In the United Kingdom (UK), the Department of the Environment, Transport and Regions has a specific guide on the use of tactile floors that defines the scope, application, maintenance and design of seven different types of tactile floor and provides guidance on which colours should be used (DETR, 1998). Considering blister surfaces, the profile of the comprised rows of flat-topped 'blisters' is 5mm (±0.5mm) high. In this document, the lower tolerance (4.5mm) guarantees that people with visual disabilities will still perceive the surface. But if the blisters fall below that height, the effectiveness of the surface will be significantly reduced and can become undetectable. Below 3mm, the material is likely to be virtually undetectable.

It mentions not to use tactile flooring at raised bus stops without justifying the reason. The Department of Transport also developed recommendations for the design of accessible bus stops and confirmed not to use tactile surfaces (DfT, 2002).

However, Dales & Priestley (2020) recently developed a collaborative research regarding tactile paving and proposed that on the platform edge (on the street), lozenge tactile surfaces should be used on raised bus stop platforms to warn people with visual disabilities of the edge.

In the UK, to draw attention to installations, an information surface can be used, which has no relief, but is made of a material that is slightly softer than conventional paving materials, for example, neoprene rubber or similar elastomeric compound.

This kind of information surface is used to highlight the main elements of street furniture that exist in pedestrian environments, such as telephone boxes and automated teller machines (ATMs), which visually impaired people may have difficulty to locate. This material should contrast in colour and texture with the surrounding area.

A smooth and soft strip (0.10m yellow line), parallel to the kerb, at a distance of 0.45m (DfT, 2002), should be provided on the waiting platform (Figure 3) to provide guidance to bus drivers and to indicate to passengers that they should stay away from the edge of the platform. In the fieldwork it was observed that on bus stop platforms, there are sometimes warning strips (but not tactile) parallel to the kerb, in the form of surface marks (Figure 4).

There are many situations where local authority practitioners in towns or cities implement technical solutions on bus stop platforms but with non-compliance with the existing Guidance on the Use of Tactile Paving Surfaces (Greenshields, Wells, Barham & Dales, 2018).

*Figure 3. The layout of warning paving on a bus stop platform in the UK. Source: Own elaboration.*

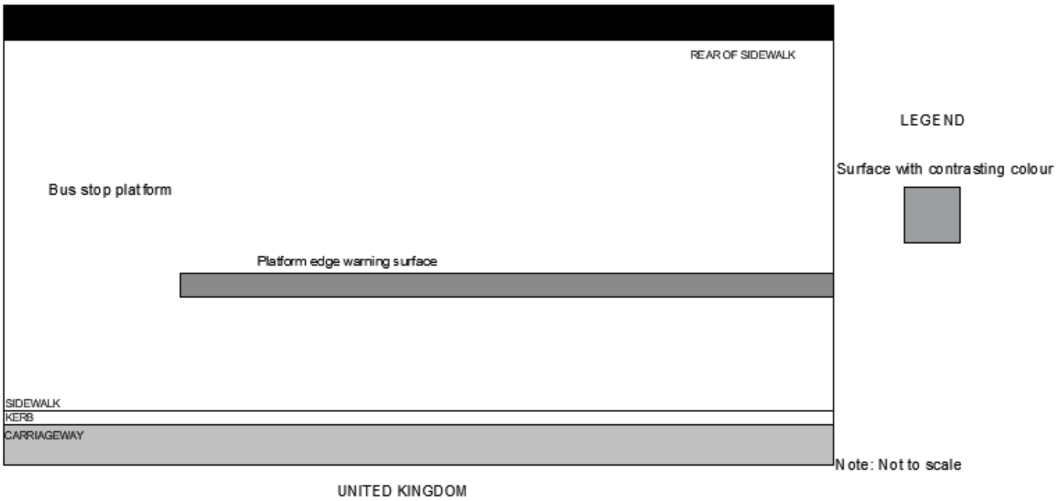



*Figure 4. Soft rough surfaces and chromatic contrast floors and strips on a raised bus stop platform in the UK. Source: Personal file with photographs.*

## *Germany*

In Germany, the General German Automobile Club (Allgemeiner Deutscher Automobilclub) developed the document "Barrierefreie Verkehrsinfrastruktur" (ADAC, 2018), meaning "Infrastructure for barrier-free transport".

The design of tactile guidance systems is regulated by the standard DIN 32984 (2011). Considering blister surfaces, the profile of the comprised rows of flat-topped blisters is 4-5mm high.

The tactile strips (*Auffindestreifen*) or directional or localization strip are used in any context where lateral points of interest, or the route itself, are to be indicated. This typology can be used to communicate the presence of a bus stop, in association with another typology, used to identify the boarding point (*Einstiegsfeld*), which acts as an indication of the place of embarkation at the bus stop. This is identified by means of ribbed plates, placed parallel to the kerb, which indicate the waiting point for boarding directly at the front door of the bus or tram. This boarding point can be identified at the end of the directional lane and have an extension of about 0.60 metres (DBSV, 2016).

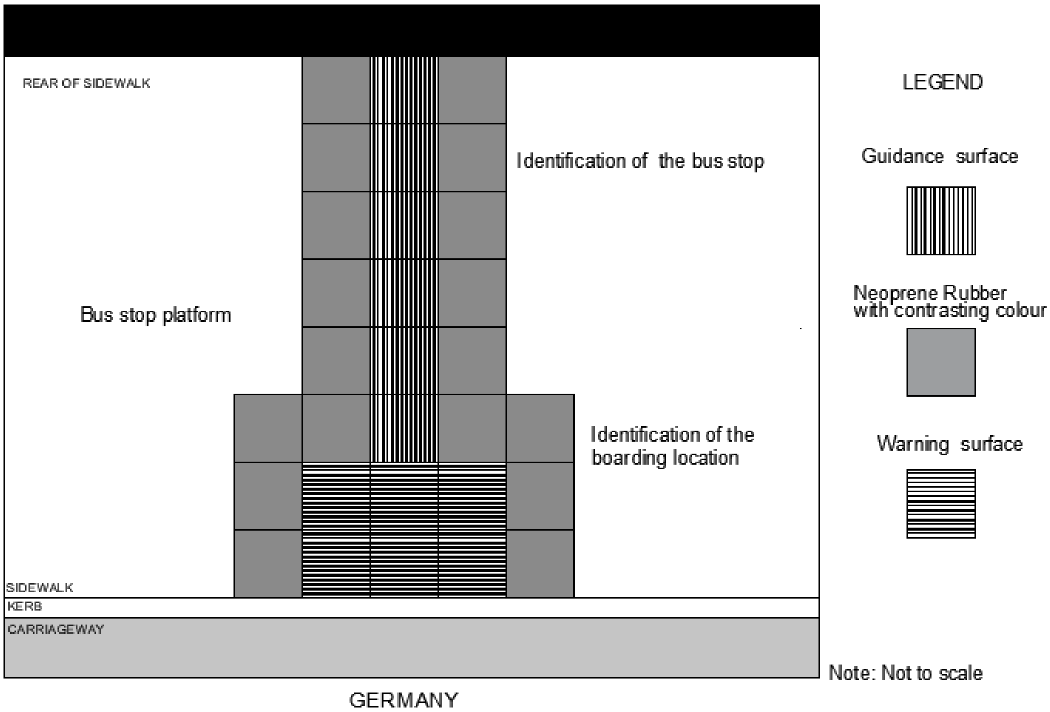
An example of tactile flooring application at a bus stop in Germany can be seen in Figure 5.  This kind of technical solution is presented in Figure 6.

## *Spain*

In Spain, a law regulates the basic conditions of accessibility and non-discrimination for access and use of means of transport for people with disabilities (Real Decreto 1544/2007, de 23 de noviembre). In this document, for urban and suburban transport by bus, the presence of the stops is indicated on the pavement, by placing a tactile, touch-visual detection strip, 1.20m wide and with considerable chromatic contrast to the adjacent areas of the floor. This strip is placed across the whole of the walkway, from the edge to the façade of the building, the garden area or the outermost part of the pedestrian path, to the kerb (Figure 7).  In addition, a strip will be installed next to the kerb of the bus stop, in bright yellow colour and with a minimum width of 0.40m.

*Figure 5. Example of tactile markings implemented at a bus stop in Germany. Source: Kohaupt (2014, p. 05)*

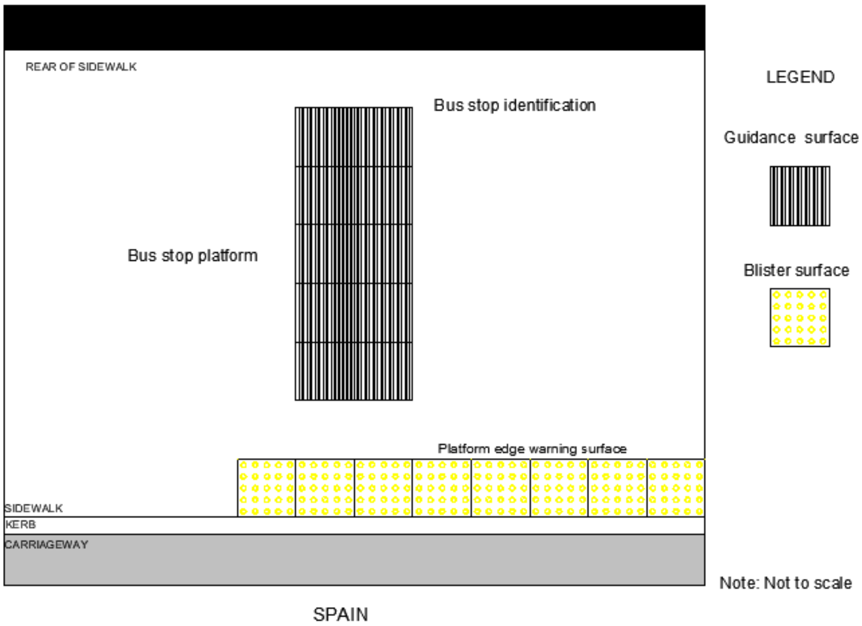
*Figure 6. The layout of tactile surfaces on a bus stop platform in Germany. Source: Own elaboration*




However, in Madrid, a Technical Commission on Accessibility of Modes of Transport presented additional criteria (Accesible, without a reference date). It considers that the orientation band is at least 0.40m from the façade line and extends to a distance of 0.90m from the kerb. At this distance of 0.90m, the warning strip (franja de advertencia de peligro de los andenes) is situated at a distance of 0.40m from the kerb, which consists of a line of attention blocks (button), parallel and close to the kerb, of a yellow, reflective and shiny colour, and whose width is ideally 0.50m (absolute minimum of 0.40m). This strip warns of the unevenness of platforms (train, bus) and has variable length depending on the size of the stop. This kind of technical solution is presented in Figure 8. Considering blister surfaces, the profile of the comprised rows of flat-topped blisters is 3.5-5mm high.

*Figure 7. Guide path on floor surfaces on a bus stop platform in Spain. Source: Personal file with photographs.*

*Figure 8. The layout of tactile surfaces on a bus stop platform in Spain. Source: Own elaboration*



## *Belgium*

The document "*Les manuels du MET. Guide de bonnes pratiques pour l'aménagement de cheminements piétons accessibles à tous*", developed by Ministério Wallon de Equipamentos e dos Transportes (MET) presents precise guidelines on the use of tactile flooring at bus stops (GAMAH, 2006).

The horizontal marks identifying the place of embarkation, for all types of bus stops, are placed on the front door axis of the bus, thus indicating the point of access to the vehicle. It corresponds to a square block of a smooth/soft floor, 0.60m x 0.60m, situated at a distance of 0.30m to 0.60m from the kerb, complemented by a strip of ribbed slabs 0.60m wide that cross the logical path of the pedestrian, placed along the entire width of the pavement, from the façade of the buildings to the smooth/soft floor (Figure 9). This kind of technical solution is presented in Figure 10.

This guide specifies that the height of the reliefs is between 4.5 and 5.5mm.

*Figure 9. The layout of tactile surfaces on a bus stop platform in Belgium. Source: GAMAH (2006, fiche 4.1)*

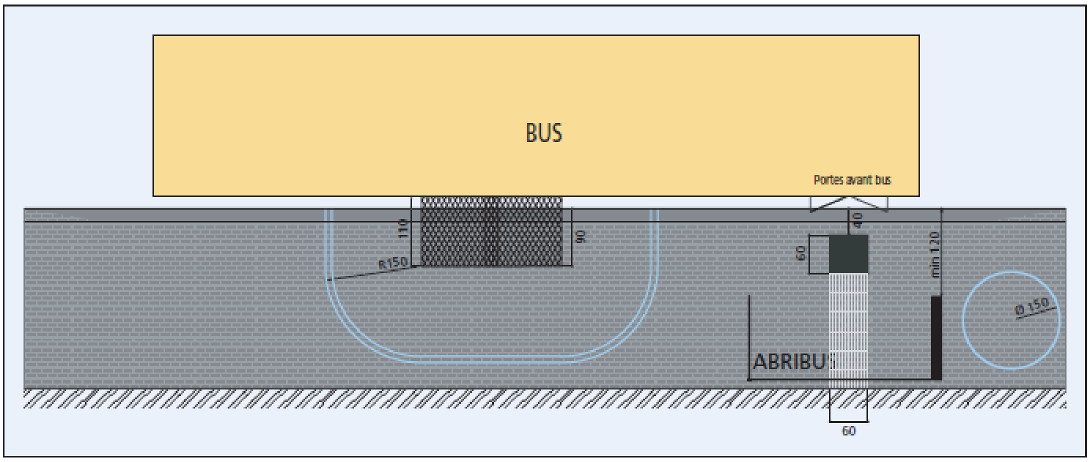
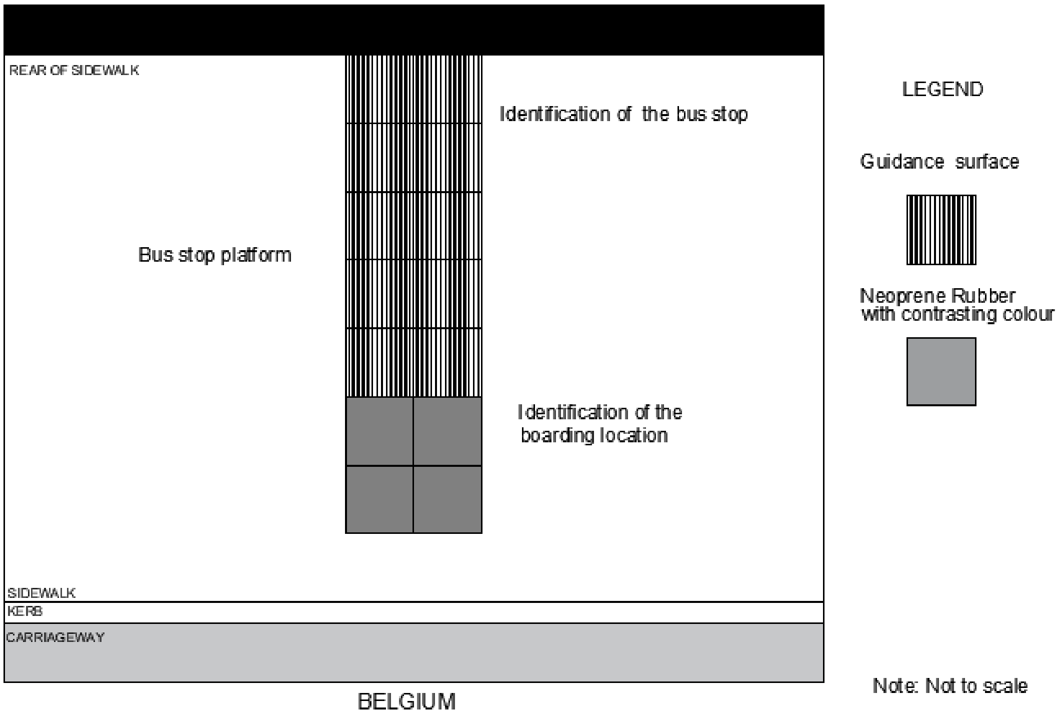


*Figure 10. The layout of tactile surfaces on a bus stop platform in Belgium. Source: Own elaboration*



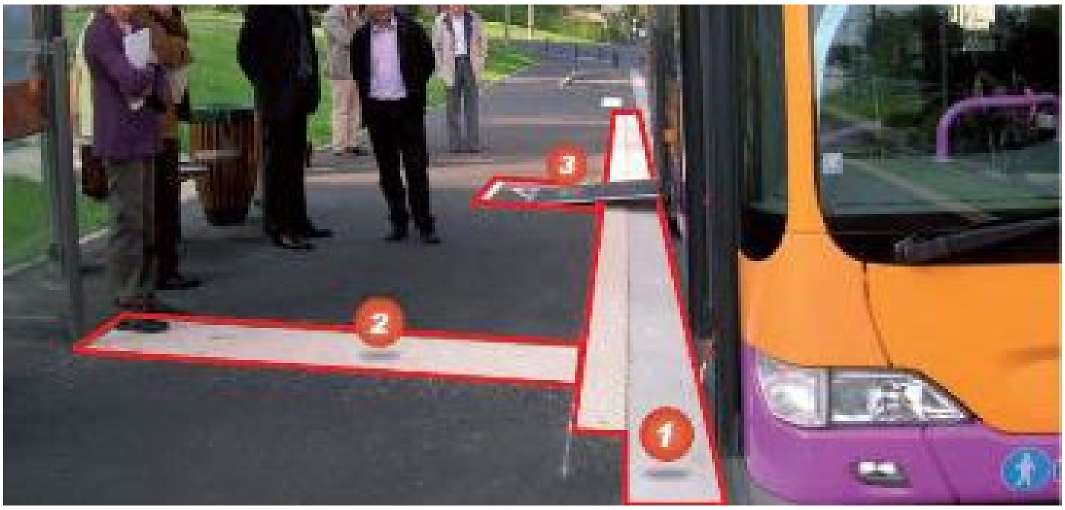

## France

The principles of accessibility of streets and public spaces are, mainly, defined by " l'arrêté du 15 janvier 2007 portant application du décret 2006-1658 et modifié par l'arrêté du 18 septembre 2012". In this document, accessible streets, public spaces and stopping places for public transport vehicles are considered fundamental in the travel chain. In the case of a guided transport stop raised more than 26 centimetres above the roadway, a warning strip shall be installed along the entire stop length.

In France, a wide variety of tactile flooring solutions have been observed in multiple documents. In the "Guide d'Aménagement des Quais Bus Accessibles Schéma Directeur d'Accessibilité" meaning Guide to the Layout of Accessible Bus Platform Accessibility Master Plan (SMT, 2009), the stop identification tactile band, located at the foot of the front door of the bus, has a width of 0.60m and its length varies according to the distance between the colour contrast band (Bande Contrastée) near the kerb and the façade of buildings or urban furniture when this exists. A contrasting tactile band of 0.50m wide is used along the entire length of the platform to signal the proximity of the kerb to alert people with visual disability in situations of raised platforms (Figure 11). This kind of technical solution is presented in Figure 12.

*Figure 11. Horizontal signalling at a bus stop in France.*
*Source: Adapted from SMT (2009, 13).*

*Legend (1) Tactile band with 0.50m visual contrast bordering the kerb along the entire length of the waiting platform (2) Tactile band with 0.60m visual contrast to signal the bus's boarding gate (3) Band with visual contrast to signal the central bus gate*

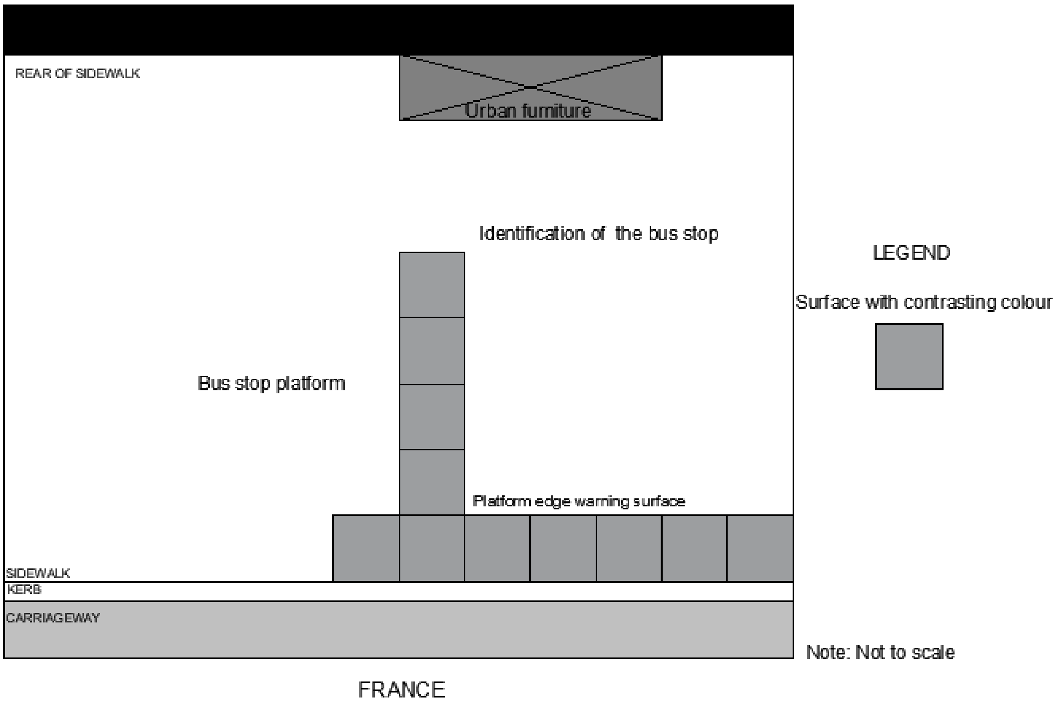



At a bus stop, the blind or visually impaired traveller should be able to identify the position of the vehicle's front door to be close enough to hear the announcement of the line and destination indication (which the fleet of vehicles provides) and be in verbal contact with the driver (CERTU, 2010).

The movement of people with visual disability must be ensured, assuming reliable auditory, tactile or architectural solutions (Cerema, 2014).

The central door of the bus can be identified by a visual contrasting floor with a white square (ideally white on black) and a wheelchair person logo (international access symbol). This last surface also serves as a stop mark to guide the driver in positioning the vehicle.

*Figure 12. The layout of tactile surfaces on a bus stop platform in France. Source: Own elaboration*




The Norme NF P98-351 frames the use of the tactile bands and considers that the profile of the blister podotactiles comprises rows of rounded blisters with a height of 5mm.

This standard does not recommend the use of tactile flooring at bus stops. It is considered that these strips should be reserved for platforms with a height of more than 0.26m for guided transport (rail) and pedestrian crossings. Putting them at a bus stop can mislead blind and short-sighted people by causing confusion with a pedestrian crossing, putting them at risk of falling.

In Nice, a raised bus stop was observed where the platform had a small tactile band near the kerb (Figure 13).

*Figure13. Small band of tactile surface on a raised bus stop platform in Nice. Source: Personal file with photographs.*

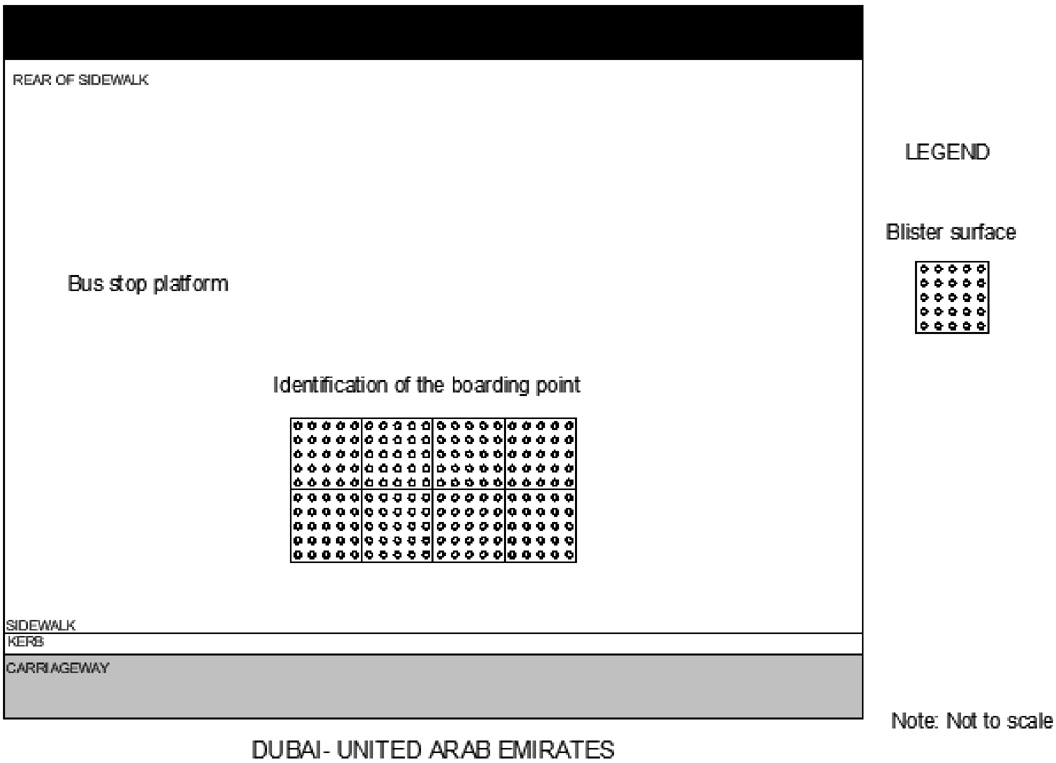

## Dubai

The Dubai Universal Design Code (Government of Dubai, 2017) is the reference document for universal design in public and private environments in Dubai. It recognises that the use of tactile guidance is very useful for people who are blind or short-sighted and use a white cane, but that guidance can also be achieved via walls, facades, doors or other texture changes on floors.

At bus stops, the tactile floor is used only to identify the place of boarding. It is recommended that a high contrast colour warning strip be placed on the surrounding floor (difference of at least 50 points in light reflectance value) so that it is better identified by a blind person or short-sighted people. The floor should be installed in parallel, at least 0.30m from the edge of the kerb, at the location corresponding to the front door of the vehicle when it is parked near the boarding platform (Figure 14). The warning surface shall be between 0.30m and 0.40m wide and not more than 4 mm high. This kind of technical solution is presented in Figure 15.

*Figure 14. The tactile surface at a bus stop in Dubai. Source: Government of Dubai (2017, p.182)*


*Figure 15. The layout of tactile surfaces on a bus stop platform in Dubai. Source: Own elaboration*




## Conclusion

The present study was integrated into the ACCES4ALL Project, whose main goal was to research the characteristics of universal accessibility of a raised bus stop to be installed in an important tourist transportation hub in the

Algarve. Universal Design and Age Sensitive Design approaches were developed.

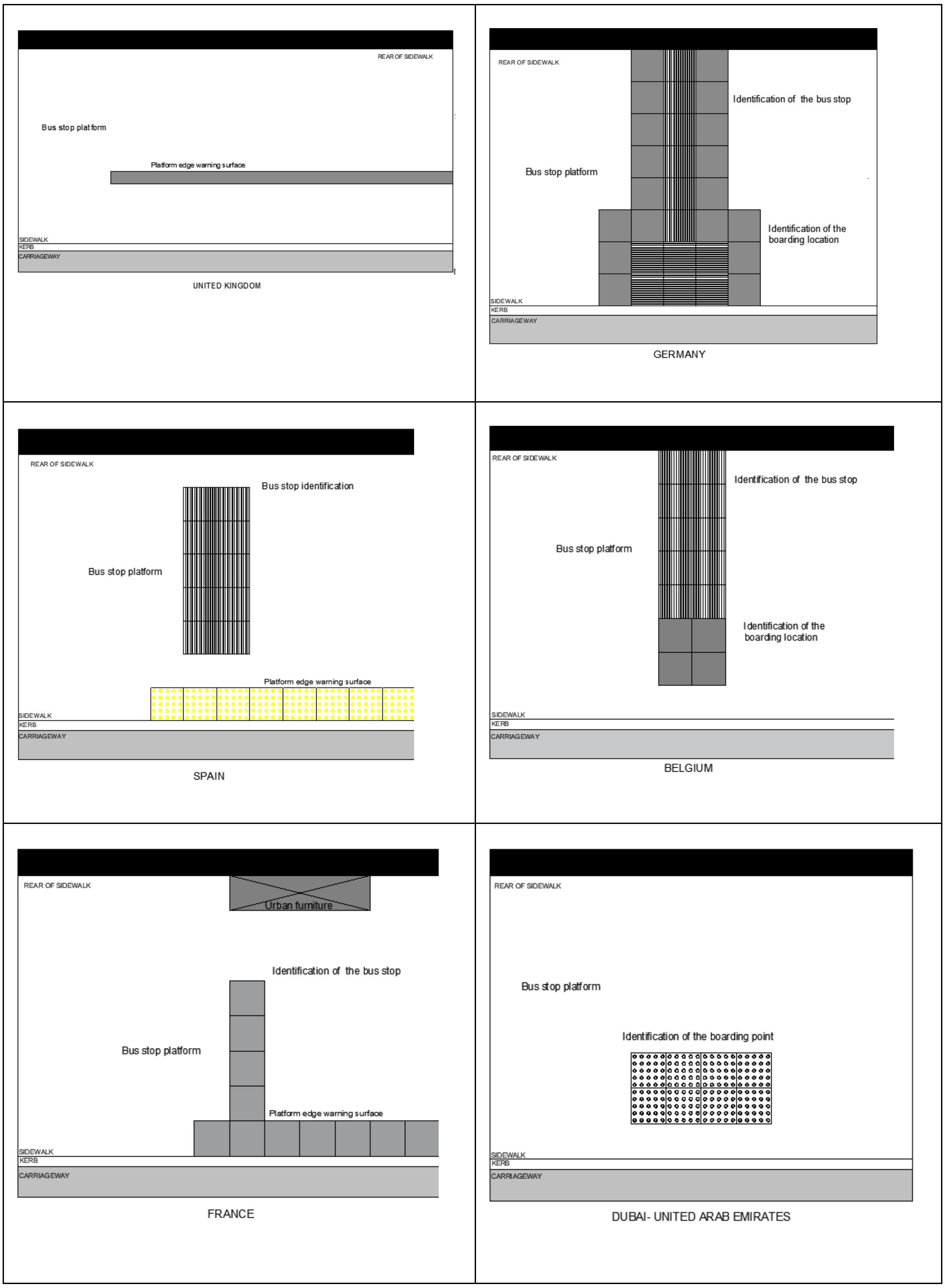
Considering accessible and inclusive tourism, specific needs of people with visual disability were recognised. So, international examples of tactile surfaces used at bus stops, were studied, using online research and, in some cases, direct and participant observation. The analysis was mainly focused on the standards and recommendations existing in European countries that send many tourists to Faro International Airport: The United Kingdom, Germany, Spain, France and Belgium. In addition, Dubai was also considered, as universal design standards there are recognised internationally.

It was understood that the use of tactile and/or chromatic differentiated tactile surfaces at bus stops consider specific situations: a) identification of the localization of the bus stop; b) identification of the place of boarding; c) identification of the edge of the platform; d) situations where only strips with chromatic differentiation are used.

However, these different types of tactile floor compositions were generally associated with each other to better communicate relevant information at a bus stop to people with visual difficulties.

Through the analysis of digital drawings of bus stops' layouts, the study concludes that these countries present different technical solutions for the tactile surfaces of bus stop platforms (Figure 16). Although they use elements (ribbed, button plates, smooth, chromatic contrast) and similar tactile information in identifying the bus stop, identification of the place of boarding and marking line of the platform edge.

Figure 16. Synthesis of layouts of tactile surfaces on bus stop platforms.
Source: Own elaboration




So, this work reinforces the current lack of consistency in the layout of tactile surfaces at bus stops in different countries.

With literature review it was concluded that the consideration of an adequate area of rectangles of tactile paving (minimum) and the height of 4mm for the reliefs can be considered inclusive for people with visual disability and elderly persons.

In general, most of the studied bus stops have too much tactile surface tiling. The finding results indicate that some of the tactile surfaces that attend to the needs of people with visual disabilities are more age-friendly than others.

The technical layout of a small band of tactile surface on a bus stop platform presented in the Dubai Universal Design Code appears beneficial to everyone, including blind people. However, the implementation of small bands is possible because urban buses in Dubai are capable of kneeling, and so, no raised bus stops are required.

This study observed that, in some cases, in France and the United Kingdom, floors with colour and texture differentiation, without being tactile, are employed. Tactile surfaces are mainly implemented in kerb cuts or sidewalks ramps. Consequently, the information provided by tactile paving surfaces can be misinterpreted by blind people and generate dangerous situations. It is more common to observe the demarcation of the stop area with chromatic differentiation of the floor, to facilitate its location by users.

However, Dales & Priestley (2020) recommended that the platform edge should have a specific tactile warning on raised bus stop platforms, and further research is needed.

In the Dubai guide, the use of tactile guidance is considered useful, but the guidance can also be achieved via walls, facades, doors or other texture changes in floors. In fact, there are other wayfinders that help people with visual disability in a complex built environment; for example, using auditory or even olfactory signals may provide important information while commuting (Rey-Galindo et al., 2020).

According to the accessed documents, the present study analysed the height of the reliefs of tactile surfaces. In the United Kingdom it is 5mm (±0.5mm) and it is considered that the lower tolerance (4.5mm) guarantees that the surface will still be perceived by people with visual disabilities. In Germany the height of reliefs is 4-5mm, in Spain 3.5-5mm, in France 5 mm, in Belgium 4.5-5.5mm and in Dubai 4mm. Thus, the presented cases have different heights of reliefs for tactile surfaces. In Spain the minimum of 3.5mm high is assumed. Further research is needed to understand if people with visual disabilities perceive this last solution.

In addition, considering blister surfaces, the flat-topped form is considered in the UK, Germany, Spain and Dubai.

The pattern of relief distribution on the floor can be staggered or rectilinear and benefit all users. In most of these countries, this type of warning floor is arranged in such a way as to form an orthogonal grid oriented in the direction of travel, thus facilitating the passage of people in wheelchairs or other elements with wheels, such as prams and trolleys.

Considering the safety of older people, Mantilla & Burtt (2016) recommend that footpaths must be free from tripping hazards with non-slip surfaces, delineation of edges and consideration of impact absorbing materials. Lighting is also an important factor for older pedestrian safety.

In Belgium, smooth and soft floors are used on the bus stop waiting platforms.

The smooth and/or soft floors have smooth profiles, without relief. They adopt different characteristics from country to country, with differences in stiffness/flexibility and colour. They can be used to indicate a change of direction, presence of equipment, presence of information or, as in Germany, to reinforce the tactile-visual contrast between the tactile, ribbed and button floor and the adjacent floor.

In another way, wayfinding strategies consider solutions that recognise good conditions of perception and legibility for all pedestrians. In the built environment, it is possible to highlight the axis of circulation, intuitive location of accesses, architectural structures, contrast colours and lighting, guaranteeing space references that keep people oriented (Hunt, 2015).

Presently there is a context of social equity and accessible tourism which is considered in tourist policies and strategies. The right to decide to travel alone, with autonomy and independence, is associated with the self-determination of people with visual disability and all other persons.

The adoption of a common and universal language that can be used internationally in all contexts of urban public transport is considered fundamental. Flexibility for the multiplicity of tactile solutions triggers recognition problems by the visually impaired, who cannot perceive unity in the different reliefs and surfaces.

Designing with people with disabilities can guarantee a successful design of the urban transport experience (Cerdan-Chiscano, 2020).

Design with users (co-design) is needed to involve, first of all, people with visual disabilities in the design of new solutions for surfaces associated with raised bus stop platforms. In this collaborative process, multiple solutions need to be thought and implemented through prototypes and then, testing them by different people with functional diversities. The scope of users of bus stops and tactile floors needs to be increased, for example, by elderly people. Active ageing demands that older people can remain mobile and safe. This issue is relevant as the senior population grows in the years ahead. These demographic groups are not homogenous, and there is a combination of different functional aspects. Their needs must be considered, too.

User-sensitive design and responsive design architecture, that serves communities, are emergent concepts that must consider alternative designs and materials considering the different needs of people to be universal and inclusive.

The ACCES4ALL project contributed to a better knowledge of universal design principles considering tactile surfaces implemented at bus stops. Technical solutions for pavements can consider, simultaneously, the needs of different groups of people in a harmonized process. User-centred approach was considered in this inclusive design process that took into account the perspectives of people with disabilities and elderly persons. It reinforces the need and importance of harmonising podotactile solutions worldwide, considering a context of social inclusion and accessible tourism. It is expected to influence policies and global standards in universal design.

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