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English version

Manual for the design of cyclepaths in Catalonia

Generalitat de Catalunya
Departament de Política territorial i Obres Públiques

Manual for the design of cyclepaths in Catalonia

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Printing
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Government of Catalonia
Ministry of Town and Country Planning and Public Works
Av. de Josep Tarradelles, 2-6
08029 Barcelona

First edition: May 2008
Issues number: 1.000
ISBN: 978-84-393-7754-2
Legal regulations:

PRESENTATION

In the development of Bill 9/2003 13 June 2003 on mobility the Catalan Government approved national Directives on mobility as another sign of its commitment to sustainable transport and the health state of citizens.

As one of the main priorities the Directives set to promote transport by non-mechanical means, which will bring more safety and comfort to pedestrians and cyclists. Emphasis has been put on the need for the introduction of measures to prepare the urban road network for bicycle routes and to create a network of interconnected greenways throughout Catalonia, which will be connected with the Eurovelo routes. The objective of this is to make the bicycle one of the axes of future policies, which go together with the new public commitment for the research of more sustainable transport mobility.

The transport infrastructure plan also offers a bicycle route network, which is based on the strategic plan for bicycles in Catalonia. There are three levels (basic, regional and municipal) and the connections with transeuropean networks of cyclist routes.

The Government provides this Manual aimed at those professionals in positions of responsibility in the fields of design, construction and the maintenance of cyclist, urban and interurban routes. The manual covers, among other things, methodology design, types of cyclist routes and related crossroads and associated technical requirements, also regulations and functional requirements for the parking facilities, criteria for traffic signals system and other issues related to the maintenance of the routes.

Joaquim Nadal i Farreras,

Minister of Town and Country Planning and Public Works

1. INTRODUCTION

1.1. Background

The rapid growth of the automotive industry and importation of motor vehicles in the last few decades has resulted in repeated congestion in big cities. This is due to the fact that cities lack a road network with sufficient capacity for the number of vehicles in circulation.

On the other hand the tendency towards environment protection and recovery of public spaces has made a positive change towards non-motor transport possible and resulted in a significant growth in the bicycle market.

The new situation has created a need for this manual, covering the design of bicycle routes, which will ensure the correct development of the implantation of the bicycle network throughout the territory.

Firstly, it is necessary to establish a conceptual and methodological basis, which will give indications for the planning of the bicycle network. Subsequently, technical conditions will be established for the elaboration of all the aspects of the projects for bicycle routes. They will include, among others: geometry, pavements, traffic signals, lighting, maintenance and management.

1.2. The role of the bicycle

From an economic point of view and because of the cost of maintenance, a bicycle is a vehicle accessible for the whole population.

On the other hand the use of motor driven vehicles has had a very big effect on the environment, which can no longer be accepted especially in the metropolitan areas of cities.

In order to maintain the mobility of the automobile significant investments in road infrastructure have been made, while other means of non-motor transport have been kept out of planning, in marginal areas within the road system.

The energy crisis, the perspective of climatic change and worsening of air quality have resulted in an increasing consciousness in favour of a more energy-saving and environmental friendly means of transport.

This is why it is necessary to establish favourable conditions for the use of bicycles, which will be done via the construction of new bicycle routes and the pacification and prioritising of transport.

Recognising the role of bicycles and the creation of an adequate place within territory planning is fundamental for the successful promotion of the use of the bicycle.

A bicycle may become an important means of transport for the population, especially when covering distances less than 3 km. The revaluation of the bicycle as a means of transport, arises not only from environmental and energetic needs, but is also a social conquest, which does not imply high expenses, but one which is closely related to the determination and coordination of all the efforts of all the parties involved.

1.3. Foundations for a policy for the bicycle as a form of transport

The planning of a network of short-distance transport requires the knowledge of various fields: parking facilities for vehicles, territorial structure, topography, climate and the population's lifestyle.

In any case, the solutions must include all the components of transport – motor vehicles, private and public vehicles, and non-motorised traffic (cyclists and pedestrians).

The need to extend or build a bicycle route derives from the following issues:

- Traffic data: intensity of motor vehicles, cyclists and pedestrians
- Existence of other means of transport
- Accident rate

- Structural characteristics
- Existence of universities, schools and job centres
- Location of shopping centres
- Tourism and leisure areas
- Geometric characteristics
- Junctions
- Uphill paths and road structure

A cyclist, as a road user, is defined by a series of physical and psychological characteristics:

- Propelling a bicycle by their own physical force implies metabolic limitations due to the surface characteristics
- As a general rule a cyclist cannot cover a daily distance of more than between 7 and 8 km per day. Longer distances are less representative
- Uphill paths are limited and in general represent less then a 5% inclination over short stretches. The effort a cyclist has to make should not exceed their tolerance level, both from a physiological and mental point of view
- Bicycles with assisted pedalling and improvements in material and gear change have considerably decreased the effort of pedalling, however, in order for this means of transport to be used on a daily basis there is a need to further reduce the cyclist's effort.
- The behaviour of a cyclist in traffic differs from that of a pedestrian and from a driver, however it is more similar to the former.
- On the one hand the average speed of a cyclist is between 15 and 20 km/h, which again puts a cyclist closer to the group of pedestrians than to drivers.
- On the other hand, cyclists identify themselves with their vehicles, considering bicycles to be the extension of their bodies.

- However, controlling a cyclist is more difficult as there is a tendency not to obey the rules and regulations and they often opt for a shorter route, which implies a higher risk.

Apart from contributing to the health of the cyclist, bicycles have other characteristics, which make their use recommendable:

- Low cost of acquisition and maintenance and petrol cheap fuel
- Reduced use of a public space
- Low environmental impact
- Easy to use

However, the use of a bicycle also has its limitations:

- Distance covered per day is between 5 and 6 km
- Sensitivity on inclines
- Vulnerable to theft

Thus in order to make the use of bicycle more favourable we have to minimise the inconveniences by using the promotional measures, which will make the use of a bicycle as a means of transport more attractive:

- To separate motor vehicles via the design of routes meant exclusively for bicycles and pedestrians
- To establish shared roadways, with lanes exclusively for bicycles on the same road
- To take steps to pacify traffic in cities and to reduce collisions with motorised traffic
- Traffic signals at junctions where motorised traffic is and to design crossroads on different levels
- To construct bicycle parking facilities and to establish steps to prevent theft
- Educating driving schools

1.4. Bicycle network

The design of a bicycle network depends on historical characteristics, territorial evolution and planning.

The most adequate solution for bicycles is to mark off a path for bicycles from roads for motor driven vehicles, which are parallel or do not belong to the road system. However this solution seems to be difficult to implement in areas with dense traffic and in city centres.

In these cases a solution to share roadways is chosen, however, first a pacification of traffic must be undertaken.

Special attention must be paid to junctions as in all the road networks they are always critical as regards safety and collisions between different types of vehicles.

Another problem is the lack of the continuity of the bicycle network.

When a route lacks continuity a cyclist will opt for another route – they will probably join the general traffic or to get onto the pavement for pedestrians thereby infringing on the harmony of a city.

As general criteria a bicycle network should reduce collisions with motor vehicles to a minimum. However, considering our experience when designing bicycle networks it is recommended that a high number of crossroads be avoided.

Thus, in residential areas a coexistence with other means of transport is preferred; however measures to pacify traffic must be undertaken.

When designing a network of bicycle routes those routes usually chosen by its users must be taken into consideration in order to comply with their demand. Thus, depending on their use, different roads should be established:

- Main bicycle routes to cover long distances
- Secondary routes connecting adjoining neighbourhoods
- Short routes – routes within neighbourhoods for short distances

1.5. Planning bicycle routes

When planning the network of bicycle routes in a given territory a series of conditions must be taken into consideration – principles for territorial planning, which will determine the most appropriate route bearing in mind the economic situation, the opportunities it may bring and its use:

- Superficial examination of the topography so as to try to ensure the development of the network in accordance with the natural curves of the terrain
- The free areas reserved for urban planning as the possible routes for the bicycle network
- Traffic density, which might disrupt the public transport services, will become an advantage for implementation of bicycle routes
- Industrial parks and the concentration of services will be an advantage for an increase in the use of the bicycle
- Adapting to the cyclists needs
- The cost of building
- Integration with other means of transport, especially with public transport
- The continuity of the bicycle route network

Planning, which does not take the aforementioned conditions into consideration risks being ineffective as it might lead to the use of the infrastructure for bicycles not being that expected.

2. TYPES OF BICYCLE ROUTES

The classification of bicycle routes is defined in Bill 19/2001 of 19 December of the amendment to the text of the Bill on Traffic, Circulation of Motor Vehicles and Road Safety Act (BOE number 304, 20 December) to which the following paragraphs were added as an annex:

70. Cycleway: specially equipped lane for bicycle traffic with the corresponding horizontal and vertical traffic signals, where the width of the lane allows for a safe use of these vehicles

71. Cycle path: one or two way bicycle lane alongside a carriageway

72. Protected cycle path: bicycle lane with lateral elements, which physically separate it from the rest of the roadway and from the pavement

73. Cycle track: cycle route with signalling on the pavement

74. Cycle lane: cycle lane separated from the motorised traffic, with an independent lane from the roadways

75. Rideable path: a path for pedestrians and bicycles separated from motorised traffic, which goes through open spaces, parks, gardens and forests

In accordance with this classification, cycle ways are defined with two characteristics in mind:

- The level of separation of the bicycle traffic from the motorised traffic and pedestrians
- The bicycle route in relation to the main road

These definitions should not be considered as limitations to the circulation of bicycle traffic. Roads where there is no specific prohibition of bicycles can also be considered as part of the bicycle routes network, even thought it would be convenient to take necessary steps to reduce motor traffic, or to establish a positive coexistence with pedestrians.

Table 1. **Types of bicycle routes**

Greenway	**A path for pedestrians and cyclists, separated from traffic, which goes through natural spaces and forests**
Cycle lane	**A lane for cyclists, separated from traffic, with an independent lane separated from the roadways**
Protected cycle path	**A lane especially for cyclists, with physical separations from the rest of the road**
Cycle path	**A lane for cyclists alongside a road**
Road of 30 km/h zone	**Road not separated from the traffic where speed limit is 30 km/h**
Cycle track	**A cycle route with signalling marked on the pavement**
Shared-use path	**A path shared with pedestrians and vehicles not exceeding speed limit of a 20 km/h and with the right of way for pedestrians**

It is necessary to treat each route accordingly so as to meet the requirements of the movement of cyclists. Whether we are able to do so or not will depend not only on the mobility of the cyclist, but also on motor traffic, public transport and pedestrians.

2.1. Greenway

A greenway is a “multiuse” path reserved for non motorised users. It is independent path from the main roads.

The adjective “green” refers to the fact that it should go through open spaces, parks, gardens and forests and it should respect the surrounding environment.

This concept has been greatly adapted to disused railway tracks, which have been converted into green routes. However, greenways can also be developed along other routes, such as canals or rural and forests paths.

Photo 1. A pedestrian and a cyclist on a greenway.

Thus, these types of routes are completely independent from the road network and are very often surrounded by nature. They are designed to suit various types of users: cyclists, pedestrians, people with reduced mobility, roller-skaters, etc.

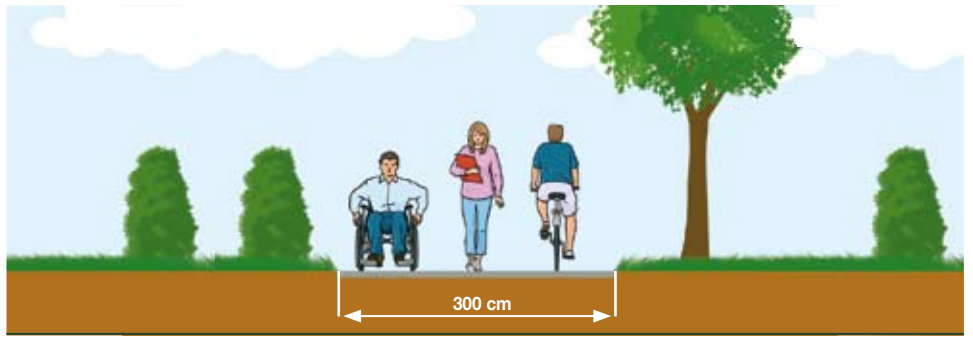


Figure 1. A greenway with an ordinary level of traffic

The main difference between a greenway and a bicycle lane is the fact that there is a greater variety of the users in case of the greenways than with bicycle lanes.

The pleasant surrounding of a greenway will attract not only cyclists, but also many other types of users.

Sharing by cyclists and pedestrians the same stretch may cause some collisions/ conflicts when a path is very busy and when there are a lot of cyclists cycling on the same route at the same time.

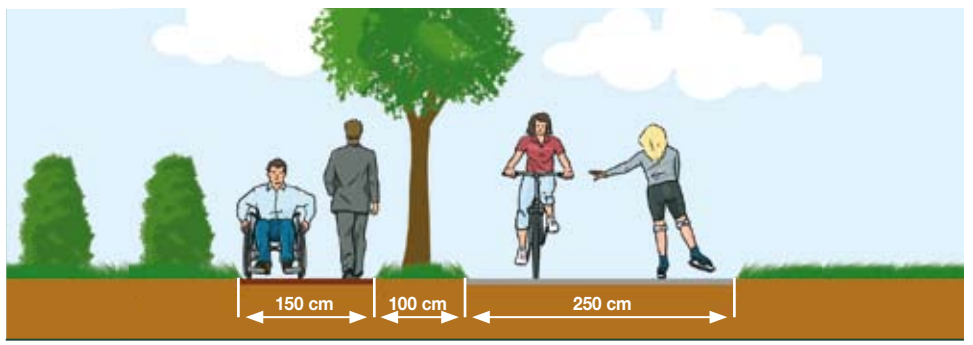


Figure 2. A greenway next to built-up urban areas with a high level of traffic

This is characteristic of places in built-up urban areas.

In such cases the use of transversal parts with a physical separation between the different parts meant for different users is recommended, always keeping their respective speeds in mind.

The dimensions, the distribution of space and information shall be the key elements for the good functioning of greenways.

2.2. Bicycle lane

A bicycle lane is designed for the exclusive use of the bicycles. Its route was designed for bicycles and is separated from the main roads.

They do not necessarily go through green areas. These routes are meant for cyclists, who use a bicycle daily within an area of a city.

As the cyclists do not have to share the route with other slower users, the speed here will be higher than on the greenways.

When designing bicycle lanes one of the most important aspects that should be taken into consideration is reducing the length of the routes

and the geometrical and construction characteristics, which should be appropriate for the high level of bicycle traffic.

Figure 3. Bicycle lane

These types of routes should receive maintenance daily.

It should be highlighted once again that when building a bicycle lane the project should include a corresponding path for pedestrians. If such consideration is neglected, it will be inevitable that the other non motorised users will start using the path designed for bicycles.

2.3. Protected cycle lane

Protected cycle lanes are designed exclusively for bicycles with a physical separation from motorised traffic.

Usually the route of this type of lane is exactly the same as the one of a main road and it permits an increase in the safety of cyclists.

In general, neither pedestrians nor roller skater are allowed on this type of lanes.

The cycle lane may be:

- One-way: a lane on each side of a main road
- Two-way: a lane with both directions on only one side of a main road

A protected cycle lane is appropriate when it is alongside a road with a high level of traffic, with a high level of motorised traffic or a significant number of heavy vehicles.

They are also appropriate near to schools.

The protective elements of a cycle lane should be solid enough to avoid any intrusion onto the cycle lane from motor vehicle on the main road.

Any type of material with sharp edges that could pose a risk to the cyclists if they fall should also be avoided.

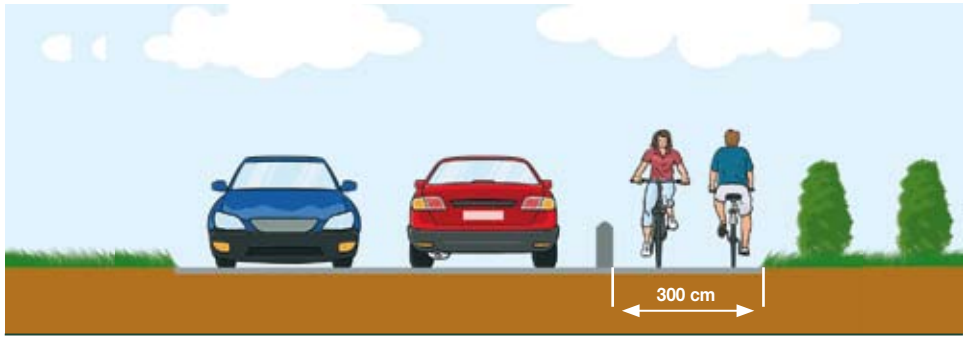


Figure 4. Protected two-way cycle lane in an interurban area

Although the aforementioned type of a cycle lane is safer than the ones without any physical separation they are more dangerous at intersections, as the motorists' perception of what the cyclists are doing is very restricted in these places.

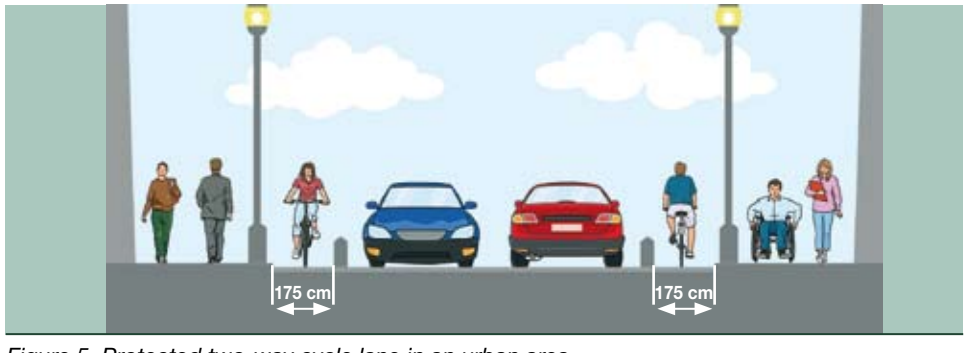


Figure 5. Protected two-way cycle lane in an urban area

In the case of one-way cycle lane it is advisable not to install any protection on the side between the intersections in order to increase the level of safety. In determined conflictive areas, with a high density of traffic, such as roundabouts, incorporating cycle lanes in the middle of a pavement could be another solution to increase the level of safety.

2.4. Cycle lane

A cycle lane is specifically reserved for bicycles, located on a road and separated from the rest of the circulation by determining markings.

Figure 6. One-way cycle lane in an urban area

A cycle lane is meant for roads with reduced speed and not much transit by heavy vehicles. It is very easy to create and their construction is recommended within the programming of pavement restructuring.

Neither people with reduced mobility, nor roller skaters should use this type of cycle lane.

Other vehicles should maintain discipline and not park on the cycle lanes.

Figure 7. Cycle lane in the opposite direction to motorised traffic

There is a possibility to design bicycle lanes going in the opposite direction to the motorised traffic. In such a case the minimum width of such a bicycle lane should be of 200 cm.

2.5. Road in a 30 km/h zone

Under determined conditions (low traffic and reduced speed limit) a road for motorised vehicles could be good support for a cyclist route network.

In such case both bicycles and cars should share the same roadway without any restrictions of access. In order to guarantee safety, specific norms must be established, as well as physical elements in order to establish a reduction to the maximum speed limit of 30 km/h.

Such a solution is possible, when the intensity of traffic is less than 1,000 vehicles per day and at low speeds. In an area with a plan to establish a 30 km/h zone that does not have the aforementioned conditions, steps to reduce a speed limit and to diminish traffic intensity must be taken. It might be done by taking decisions about the traffic regulations, changing circulation directions, reducing the width of the road, etc. All these should be done before establishing a 30 km/h zone.

Photo 2. A road in a 30 km/h zone

2.6. Cycle track

In this case both pedestrians and bicycles share the pavement. The part designed for cycling must have the relevant traffic signposting.

In order to be able to opt for cyclist route, the pavement must be at least four metres wide. If the pavement is narrower this option is not advisable as it may pose a threat to pedestrians.

It is necessary to accurately define the use of the pavement by all of its users. The cycle track must have traffic signals incorporated in order to clarify its use. This should especially be done in points of conflict, such as when a cycle track crosses pedestrian paths.

Figure 8. Cycle track

Given the high number of pedestrians, bicycles, the use of wheel chairs, roller-skates, etc, often present it is subsequently difficult to separate the use of the bicycle. It is also difficult for the transport authorities to strictly apply the exclusive use of the track for bicycles.

Thus it is more convenient to create cycle tracks in pedestrian areas or in shared-use paths where the speed limit for cyclists is 20 km/h.

It is not advisable to construct two way cycle tracks. If necessary each direction of the bicycle circulation should be allocated to different pavements.

2.7. Shared-use paths

The shared-use paths are those areas of circulation where pedestrians can use the whole area for circulation and have the way of right on the whole pavement.

These streets are also adequate for cycling, but with maximum speed limit for cycling of 20 km/h and with pedestrians always having right of way as they can use the whole area of circulation and practice of sports and games is allowed.

Photo 3. Shared-use path in a city

In this case there is no physical separation between the users – it is the example of total sharing of the space.

The street becomes an element which contributes to the energising of a neighbourhood, a meeting place for the elderly, a play area for children, a place for walking or cycling, without stopping circulation.

The urbanization and introduction of traffic signals on a shared street must clearly demonstrate that vehicles take second place to pedestrians.

Traffic signals system on shared-use paths is determined by the traffic regulations and made with the signs S-28 and S-29 at the beginning and at the end of each path and at junctions.

Figure 9. Traffic signals system on a shared-use path

An urbanisation should give a friendly image. There should be no separation between the road and the pavement, and vertical and horizontal elements which slow vehicles down should be incorporated.

2.9. Circulation speed

On the one hand a general speed limit on cycle routes is defined, which to a large extent conditions the majority of the route of the lane.

On the other hand there is a minimum speed limit in those instances in which, for different reasons (orography, landscape, construction, etc.) it is not possible to attain the general speed limit in particular parts of the route. In these cases, specific signs requiring a reduction in speed must be installed.

In Table 2 Speed for different types of cycle ways

In case of intersections, roundabouts, flyover, underpasses and any other constructions with specific characteristics there will be specific criteria applied for speed reduction.

Table 2. **Speed limits for cycle ways**

	GENERAL SPEED (km/h)	MINIMUM SPEED (km/h)
Greenway	30	20
Greenway with separation for pedestrians	50	30
Bicycle lane	50	30
Cycle track	20	10
Protected cycle lane	The same speed limits as fixed for connected main roads	
Cycle lane		
Road in 30 km/h zone		
Shared-use path		

2.9. Criteria for the application of different types

In order to be able to apply one of the aforementioned types of cycle ways we should consider the following criteria:

- Traffic density and speed - it will define the kind of protection on a cycleway
- Foreseen number of cyclists - it will define the appropriate width of a cycleway
- Existing space - it will define the basic types of the cycleway
- Urban surroundings - it will define the type of a cycleway and its special characteristics

Depending on the road safety criteria, accessibility for different types of users and the components of foreseen mobility on a cycleway (bicycles for daily use, used for leisure, for tourism, etc.) the most adequate types will be chosen, in relation to their corresponding building characteristics, traffic signals system and services described in this manual.

It should be highlighted once again that although the cycleways must be continuous and homogeneous in their routes, different types of cycleways on one route in relation to the changing characteristics of the surroundings of a given cycleway is acceptable.

A cycleway may have different types incorporated, but a route cannot be interrupted and the users should receive all the necessary information about the kind of cycleway they are travelling on.

In order to establish the effective use of the cycleways some basic principles must be established. An initial reflection on this aspect will lead us to create a list of basic principles governing the design of a cycleway:

- The cycleway must be direct – a good way of evaluating the quality of a cycleway is the speed in design and the difference in the time needed to cover the route in comparison to alternative routes with similar density of traffic with motor vehicles. A difference of 15 seconds per km on interurban roads is acceptable, and so is 20 seconds per km on urban roads. Longer delays make the direct route more attractive even though they have to be shared with general traffic; and in these circumstances the cycleway may not be used.
- It has to be accessible - if a cyclist has to cover a distance superior to that they would cover when using a road not for bicycles, they will not use the cycleway. The distance between the starting point and the destination of the bicycle ride (residential areas, schools, shopping centres, industrial areas, etc.) on a cycleway cannot exceed 600 - 800 metres in interurban areas and 200 – 400 metres in urban areas.
- It should be continuous - the cycleway network should have no interruptions in its route. Despite changes in types of a cycleway, the user should have a feeling of continuity. If this is not the case, a large number of cyclists will abandon this cycleway network, or will not use it at all.
- It should be comfortable and attractive - a cycleway should have special services for its users; its visual aspect should be pleasant, it should provide a comfortable surface for cycling and shelters against wind, rain, strong sunshine and other adverse weather conditions.
- It must have as few as possible stop points - cyclists find the need to put their feet on the ground very inconvenient. Such situations very often make cyclists break the rules on cycleways. Stopping once every 2 km in an interurban area and once every 1 km in an urban area is considered sufficient for cyclists.
- It must be safe – areas of conflict between the cyclists and motor vehicles must be reduced to a minimum. In order to be able to maintain the optimum level of road safety a physical separation between the lanes of the routes is necessary. It is also recommended to include a minimum number of cross points with motorised traffic and pedestrians and particularly sensitive treatment of intersections which connect with bicycle traffic.

3. BUILDING CHARACTERISTICS

3.1. Route

3.1.1. Design speed

The speed of circulation of a cyclist depends on many factors: the type of a bicycle and its conditions, the reason for the journey, location of the cycleway and its condition, speed and direction of the wind, physical condition of the cyclist, among others.

The speed that a cyclist can cycle safely and comfortably depends on the technical conditions of the cycleway they are travelling on and also on its curvature, cant, incline length and the width of cycleway.

Table 3 shows the design speed for different types of cycleways with routes independent from the main roads.

The speed of a cycleway will be determined by the radius and cant of the curves, distance of visibility, lateral visibility on curves, distances between stops and the width of a lane. Most cyclists can maintain speed of 20 km/h, however depending on the technology of the bicycles and the type of a cycleway being used (whether or not separated from the rest lanes) the speed between 30 and 50 km/h is nothing extraordinary and can be considered usual.

Table 3. **Speed on different cycleways**

	GENERAL SPEED (km/h)	MINIMUM SPEED (km/h)
Greenway	30	20
Greenway with separation for pedestrians	50	30
Bicycle lane	50	30

Long descending slopes or other conditions can lead to the cyclist exceeding the general speed limit of the project, used when designing the cycleway. It is recommended that for continuous slopes (of more than 500 m) there is an increase of 2 km/h for every 1% of the average incline.

3.1.2. Radii of turn

The minimum radius of a turn on a curve on a cycleway depends on the speed of the bicycle, on the cant of the curve and the transversal friction coefficient. It is calculated according to the following formula:

$$R = \frac{v^2}{127 \cdot (p + f)}$$

R = Minimum radius of a curve (m)
V = Speed (km/h)
p = Cant of the curve (multiply by 1)
f = Transversal friction coefficient

The following is the comparison of the values of the transversal friction coefficients on paved roads and the speed of circulation:

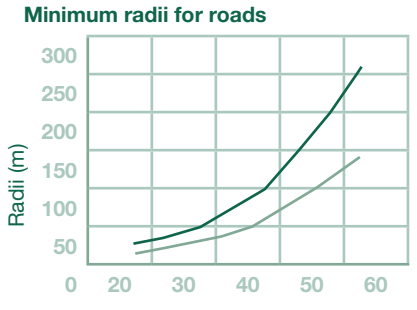
Table 4. **Comparison of transversal friction coefficients**

SPEED (km/h)	f ON PAVED ROADS	f ON UNPAVED ROADS
20	0,31	0,16
30	0,28	0,14
40	0,25	0,13
50	0,21	0,11
60	0,18	0,09

It is recommended that the value of the cant of the curve ranges between 2% and 3%. The surface drainage of a road is guaranteed with a minimum cant of 2%.

In the following table there are minimum radii of different general speeds limits on cycleways with a distinction between paved and unpaved roads.

Table 5. **Minimum radii for cycleways**



SPEED (km/h)	MINIMUM RADII (m)	
	f ON PAVED ROADS	f ON UNPAVED ROADS
20	10	17
30	24	44
40	47	84
50	86	151
60	142	258

3.1.3. Visibility distance

Another factor that should be taken into consideration in the process of designing cycleways is a distance a cyclist needs to make a complete stop when they see an obstacle. This distance also depends on the time the cyclist needs to perceive and react, the horizontal friction coefficient, the inclination of an incline and the speed of the design.

3.1.3.1. Stopping distancea

The stopping distance (Dp) is the total distance covered by a cyclist obliged to stop as soon as possible, which measured from the moment the object comes into sight. This is made up of the distance covered from the moment of perception, reacting and braking.

The stopping distance for cycleways is calculated in the same way as for roads. If we assume that part of traffic will not stop at intersections, it is convenient to use conservative stopping distance values.

Table 6. **Stopping distance on descents**

SPEED (km/h)	STOPPING DISTANCE PLUS DISTANCE OF REACTION (m)		
	INCLINATION		
	0%	-5%	-10%
15	14	15	16
20	20	22	25
30	35	40	45
40	55	60	70
50	75	85	100

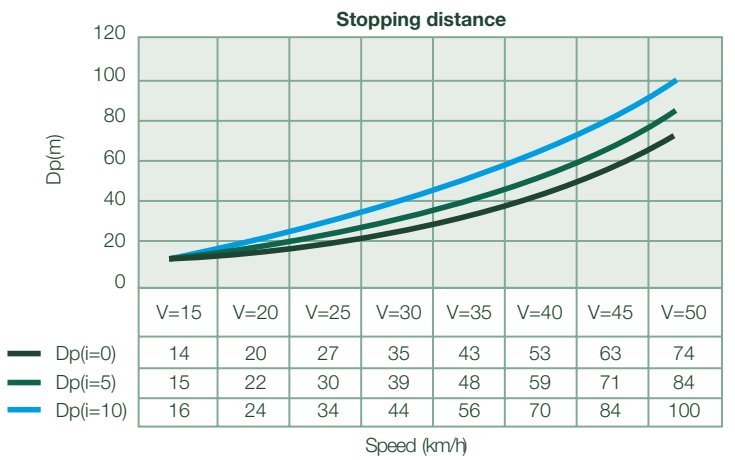
The values in the tables are derived from considering the friction coefficient of 0.25, the time between perception and reaction of 2.5 s, an eye-level of 1.40 m and the obstacle height of zero metres.

The minimum stopping distance is calculated according to the following formula.

$$D_p = \frac{v^2}{254 \cdot (f \pm i)} + \frac{v \cdot t_p}{3{,}6}$$

F = Minimum lateral visibility (m)
R = Radius of road axis (m)
D_P = Stopping distance (m)
b = Width of the road (m)

Table 7. **Stopping distance in relation to speed**



3.1.3.2. Distance of visibility on curves. Lateral visibility

The stopping distance will be equal or superior to the minimum stopping distance on the whole of the track of the total cycleway. Thus in order to guarantee that there is sufficient visibility on circular curves certain lateral visibility is necessary.

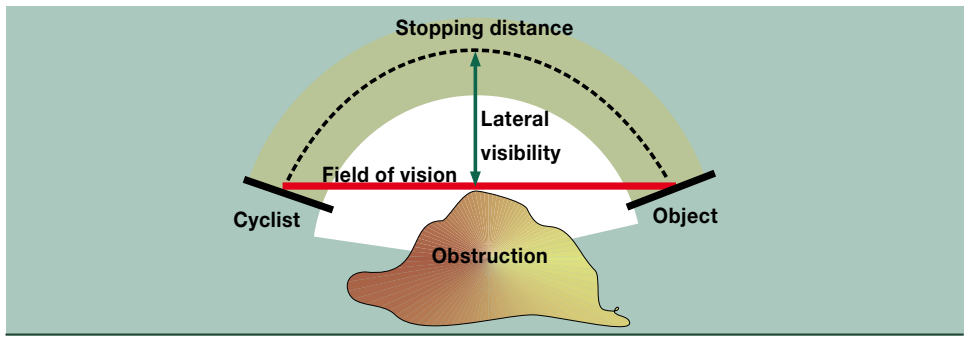


Figure 10. Chart of a curve for the calculation of lateral visibility

The necessary lateral speed inside a horizontal curve is in relation to the speed, the radius of the curve and the inclination.

In order to measure the length of the field of vision of a cyclist a central line is used, which separates the two inside lanes from the curve of the road.

The lateral visibility can be calculated as the sum of the distances between the stopping distances of the cyclists, who travel from the opposite directions to the curve.

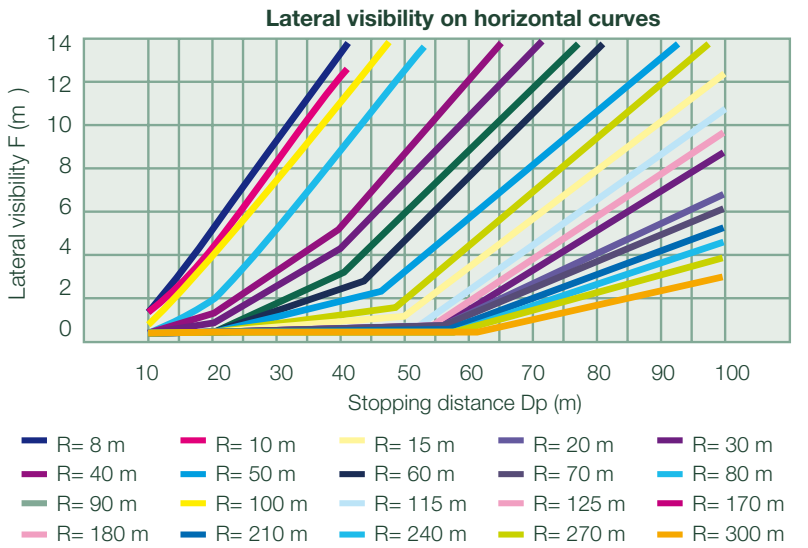
When this stopping distance cannot be applied, the bicycle lane must to be widened, or a continuous line must to be painted, which separates the two lanes along the whole of the curve plus an additional 10 m on the extreme of the curve. The value of the lateral visibility in order to have a determined level of visibility on a circular curve is calculated according to the formula below.

The angular value of the previous formula is expressed in degrees. The following graphic shows the values of lateral visibility for different values of stopping distance and radius of axis of the lane, considering the parameters of the width of the lane to be fixed (b = 1.25m), inclination of the cycleway (i=0) and cant of the curve (p = 2%).

$$F = R \cdot \left(1 - \cos\left(\frac{28{,}65 \cdot D_p}{R}\right)\right) - 0{,}5 \cdot b$$

F = Minimum lateral visibility (m)
R = Radius of the axis of the lane (m)
D_P = Stopping distance (m)
b = Width of the lane (m)

Table 8. **Lateral visibility in relation to the stopping distance**



3.1.4. Longitudinal inclinations

Longitudinal inclinations over 5% are not recommended both because the upward slopes are difficult for the large majority of cyclists and also because the descents can be dangerous due to the increase in speed the bicycles experience.

Even so, it will not always be possible to design a cycleway without longitudinal inclinations under 5% whether for reasons of orography, or because it is necessary to protect certain obstacles which require the building of ramps, or to gain access to elevated or lower levels, it is recommendable that the stretches with ramps over 5% should be as short as possible.

The table below has indications for maximum length in relation to the adopted longitudinal inclination.

Table 9. **Maximum length of stretches with ramps > 5%**

LONGITUDINAL INCLINATION %	MAXIMUM LENGTH IN m
Between 5% and 6%	240
Between 6% and 7%	120
Between 7% and 8%	90
Between 8% and 9%	60
Between 9% and 10%	30
More than 10%	15

Should there be a need to save an obstacle a maximum inclination above 25% shall not be used.

In order to be able to maintain a comfortable speed of 15 km/h or more, no parts of a route of over 4 km should have ramps superior to 2%, nor should there be parts over 2 km with ramps superior to 4%.

3.1.5. Vertical curves

The changes of a longitudinal inclination need to be softened with the use of a vertical curve. This will be a circular arch, which will provide comfort when cycling and which will allow to maintain the correct level of visibility for stopping.

In relation to concave vertical curves, the radius of the vertical curve will depend on the level of comfort while cycling.

In the table there are minimum radii of the concave vertical curves in relation to the cruising speed.

Table 10. **Minimum radii of vertical curves**

SPEED (km/h)	RADII (m)
20	10
30	20
40	40
50	70

As regards convex vertical curves the objective is to maintain stopping visibility.

In order to fulfil this condition the vertical curve must have a minimum length, which depends on the required stopping distance and on the inclinations of the entrance and exit of the curves.

In order to find a minimum stopping length the following models are used to se whether the maximum length of the vertical curve is bigger or smaller than the necessary stopping distance.

$$Si\ L \geq D_{p.....L} - \frac{A \cdot D_p^2}{280}$$

$$Si\ L \leq D_{p.....L-2} \cdot D_p^2 - \frac{280}{A}$$

L = Maximum length of a vertical acord (m)
Dp = Necessary stopping distance (m)
A = Algebraic difference between the inclinations of the entrance and the exit (%)

3.1.6. Widening of cyclepaths

The space used by a cyclist is described in the figure below with the following dimensions:
Width: 1.00 m
Length: 1.90 m
Height: 2.50 m

The width of 1.00 m results from adding the width of the handlebars (0.60 m) and the necessary space for the movement of arms and legs (0.20 m on each side).

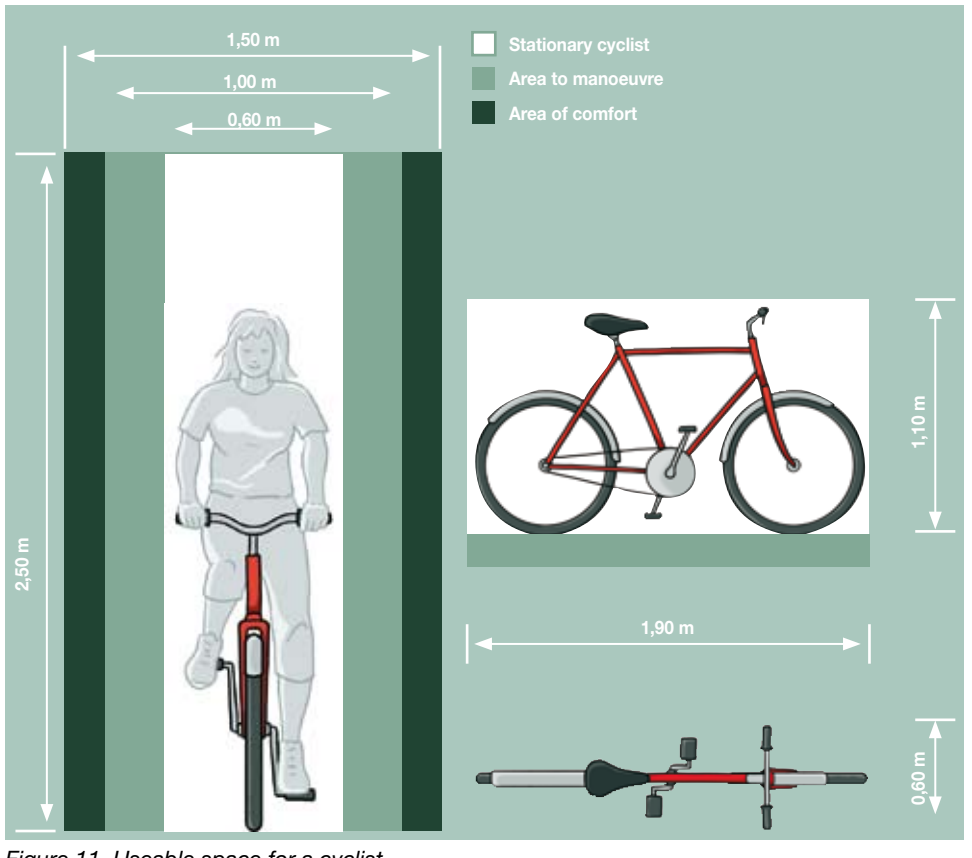


Figure 11. Useable space for a cyclist

The following outlines the minimum and recommended widths in relation to the types of cyclepaths:

Table 11. **Minimum and recommended width of cyclepaths**

TYPE OF A CYCLEPATH RECOMMENDED	MINIMUM RECOMMENDED (m)	WIDTH RECOMMENDED (m)
Greenway with separated path for pedestrians	4,00	5,00
Greenway shared with pedestrians	2,50	3,00
Two-way bicycle lane	2,00	2,50
One-way bicycle lane	1,50	2,00
Protected two-way cycle lane in an interurban area	2,50	3,00
Protected one-way cycle lane in an interurban area	2,00	2,50
Protected two-way cycle lane in an urban area	2,00	2,50
Protected one-way cycle lane in an urban area	1,50	1,75
One-way cycle lane in an interurban area	1,50	2,00
One-way cycle lane in an urban area	1,50	1,75
One-way counter-flow cycle lane	1,75	2,00
Two-way cycle track	2,00	2,25
One-way cycle track	1,50	1,75

3.1.7. Transversal inclinations

In straight stretches a transversal inclination will be designed in the direction of one of the sides of the road so as to make it easier for surface water to drain away and for it to be on the route for as little a time as possible. Thus it is recommended that the transversal inclination on cycleways be of 2%. In circular curves the transversal inclination will coincide with the cant of the curve.

3.1.8. Stretches with overpasses and tunnels

In order to ensure the continuity of the roads, i.e. to cross obstacles such as motorways, dual carriageways, primary roads, railway tracks, overpasses will have to be designed for cycleways.

It is reasonable to think that an overpass or a tunnel should be two-way and that they should be destined for other users too (pedestrians, mopeds, people with reduced mobility, etc.).

With the aforementioned conditions the transversal section should be at least 5 m wide, with a 2 metre stretch reserved for pedestrians. In stretches with less traffic a narrower option can be considered.

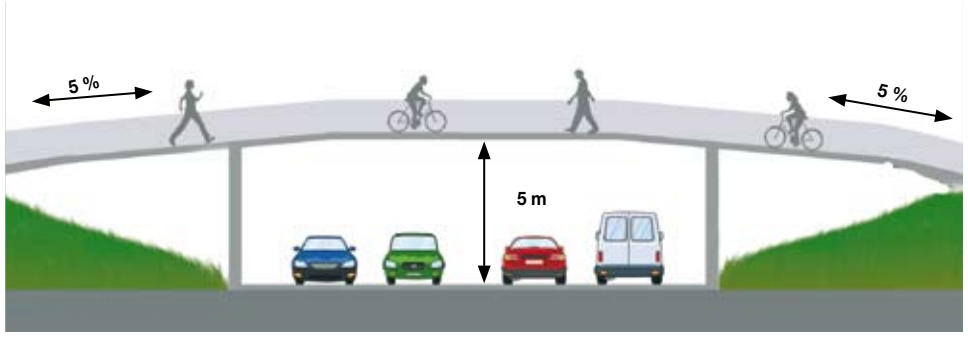


Figure 12. Flyover for cyclists and pedestrians

Photo 4. Footbridge for cyclists

The paved surface of the ramps must not be slippery and in case of a footbridge for pedestrians and cyclists regulations concerning people with reduced mobility will be observed.

The banisters on the footbridges must be 1.30 m high when used also by cyclists and 1 m high if the footbridge is only used by pedestrians.

Despite the fact that tunnels are associated with unsafe spaces, cyclists prefer to use them as it implies less effort, as there is no difference of levels.

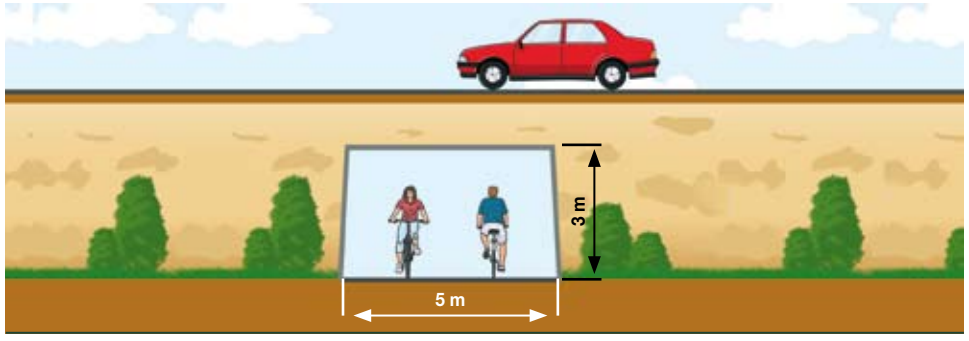


Figure 13. A minimum section in tunnels on cyclepaths

In order to diminish this unpleasant feeling, the length of a tunnel must allow the users to see from the entrance of the tunnel the exit.

The recommended minimum height in tunnels is 2.50 m and the recommended width between 3.50 m if the tunnel is used only by cyclists, and 5 m if the tunnel is for both cyclists and pedestrians.

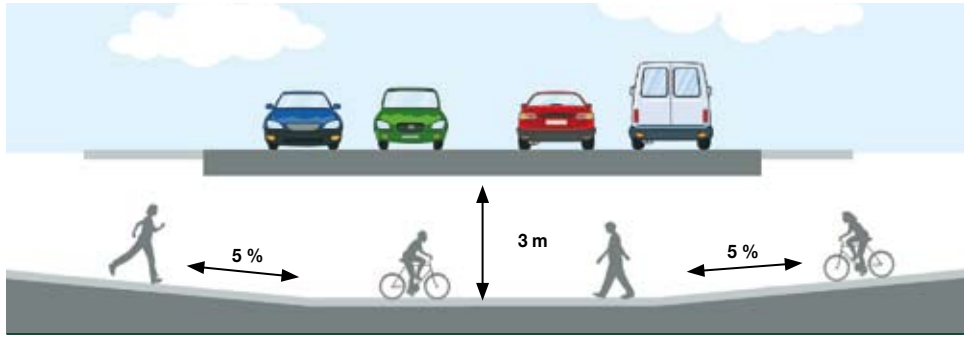


Figure 14. Underpass for cyclists and pedestrians

A smaller width of up to 3 metres will be sufficient for short tunnels (up to 10 metres).

We should also consider maintenance vehicles, which will need a minimum maximum height of 3 metres

Photo 5. Underpasses on the cyclepaths

3.2. Esplanades, road surfaces and paving

The type of road surface for a cycleway will depend on a series of factors such as the type of users, the level of use of the route, visual integration with the surroundings, safety, maintenance, etc.

To start we can make the following general considerations:

- The users' requirements: every user of a cyclepath will probably want the most adequate type of paving for their particular requirements. Depending on the type of the bicycle they have (BTT, recreational bicycle, etc.) the cyclist will have different tolerance depending on the paving. People with reduced mobility and roller-skaters require hard surfaces without flaws. Whereas, pedestrians do not have any special requirements as for the type of surface, however it is believed that they prefer softer surfaces.

- Visual integration: different types of surfaces may cause either rejection, or acceptance of a cyclepath depending on how it may influence the surroundings visually. Special attention must be put to sensitive areas, for example natural parks, places with artistic or cultural heritage, etc.

- Continuity: the different types of surfaces on a cyclepath give it special characteristics - coherence and continuity of materials, which is a fundamental aspect for good legibility for the users

- Maintenance: the new cyclepath should not need renovations for many years. A few aspects should be taken into account – the intrusion of plant and trees roots and dirt from rainfall. We should also remember about the access of maintenance vehicles and their influence on the surface.

- Cost: When analysing building and maintenance costs the type of surface to be implemented should also be considered.

- Taking into consideration the aforementioned points, a cyclepath should have the type of surface, which will be adequate for the use and the specific requirements of each area.

3.2.1. Esplanades

The dimensions of the esplanades will be determined in relation to the types of vehicles which will use the area and how often they will pass. It is impossible to establish a general rule, but the capacity of the terrain should be measured “in situ” for each section of a cyclepath.

Although the level of traffic by cyclist can be considered minor, the building machinery to be used during construction must be taken into consideration as well as maintenance and repair vehicles.

In general the constitution of the esplanade shall be natural, regulated and compact. This natural piece of land, once selected and deprived of vegetation, should fulfil minimum requirements and if necessary the existing surface layer should be replaced for one of better quality.

For both the correction of embankments and the foundation of the levelled area, the material should be classified as at least an adequate soil (in accordance with the PG-3 classification) and should have a minimum thickness of 50 cm.

The sufficient soil material can be used in the centre of base for embankments. The soil materials that have not been considered acceptable will not be used at all.

So as not to increase the price of the construction works the materials obtained during the process of digging the cyclepath, if possible, should be used during construction.

3.2.2. Types of surfaces and paving

Different layers of surfaces and paving are placed on the duly levelled and compact esplanade.

The level of quality of the paving should correspond to the type of road designed, the its function and also its future use and location.

The quality of cyclepaths depends to a great extent on the condition of the surface, and it has to guarantee comfortable and safe road traffic.

- The paved surface must have good road holding, especially when it is wet
- The lids of manholes and other protruding elements should be at the level of the surface of the road
- The joints of a compact paved surface should be in a good condition
- The persons responsible for maintenance should clean up grit, soil, dirt and anything else that could cause accidents
- The bars of the drains must be perpendicular to the direction of the road traffic. Furthermore, the spaces between the bars of the drains must be as small as possible in order to avoid bicycle accidents

There is a list of different types of the most adequate paved surfaces for cyclepaths presented below.

The materials to be used to build these paved surfaces as well as the whole process of their construction must comply with the regulations described in PG-3.

3.2.2.1. Bituminous road surface

A layer of a surface course consists of a hot bituminous mixture placed on top of a layer of a granular material.

The thickness of the layers may vary in relation to the types of traffic, the volume of the foreseen density and the quality of the esplanade.

The use of colourful bituminous mixtures is recommended – with iron oxide (red mixtures) and with chrome (green mixtures).

The type of paved surface and their advantages and disadvantages are described in the table below:

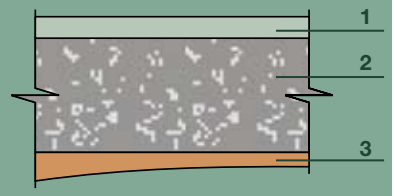
SECTION	ADVANTAGES	DISADVANTAGES
 1. Hot bituminous mixture (3 a 5 cm) 2. Wet mix macadam or soil cement (15 a 30 cm) 3. Esplanade	The surface is hard and flexible, with good grip and is for all uses	It is a petroleum derivative, which may not stop the growth and influence of roots of nearby trees
	It is not expensive, however the colourful products may cost even twice as much as the ordinary asphalt mixtures	Climatic and temperature changes may cause cracks on the surface
	When using colourful mixtures we may obtain very aesthetic and interesting visual results	Its chemical composition may have an influence on the environment as carbon related products may be released in the perimeter of the paving along the road pave surface

Figure 15. Bituminous road surface

3.2.2.2. Concrete road surface

The surface lays consists of piece of poured concrete (or of prefabricated concrete panels) and is placed directly on top of the esplanade or on top of a granulated material layer.

The thickness here may vary depending on the quality of the esplanade and on the existence of whether or not there is a layer of granular material between them.

The use of transversal retraction joints is recommended every 5 metres.

This type of paved surface and its advantages and disadvantages are described in the table below:

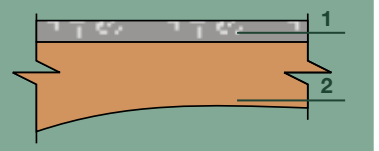
SECTION	ADVANTAGES	DISADVANTAGES
 1. Concrete slab (5 o 10 cm) 2. Esplanade	The surface is very resistant to traffic and skidding	The retraction joints diminish comfort level
	It is very easy to apply without the necessity of complex machinery	The price of implementation is much higher than of other types of paved surfaces
	Much lower maintenance of the surface than that of the bituminous paved surfaces	Climatic changes may cause cracks on the surface
	Long life–span, little aging of the materials	Movements of the natural terrain may cause braking of the concrete layer
	Due to its rigidity it limits the intrusion of nearby trees roots	

Figure 16. Concrete road surface

3.2.2.3. Treated paved surfaces

A bituminous seal coat is applied on top of the surface of a layer of artificial wet mix macadam followed by a layer of rough gravel.

The thickness of the paved surface prepared this way may vary depending of the type and volume of foreseen traffic and of the quality of the esplanade.

The use of colourful bituminous seal coasts with added iron oxide (red mixtures) or with chrome (green mixtures) is recommended.

This type of paved surface and its advantages and disadvantages are described in the table below:

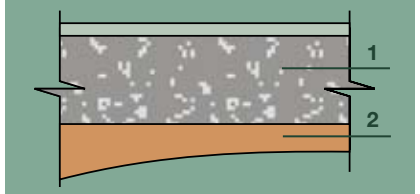
SECTION	ADVANTAGES	DISADVANTAGES
 1. Bituminous seal coat on top of a wet mix macadam 2. Esplanade	Low cost and longer durability of the wet mix macadam layer	Its durability over time is very limited
	With double surface treatment similar results to bituminous paved surfaces can be obtained	It is a petroleum based product, which may not stop the intrusion of the root of the nearby trees
	Visual effects when using colourful mixtures	It generates unpleasant vibrations. This type of paved surface is neither suitable for people with reduced mobility nor for skaters
		The chemical composition of this type of pavement may have a negative influence on the environment due to the infiltration of the carbonate products it contains

Figure 17. Treated paved road surface

3.2.2.4. Cement soil pavements

The transit layer consists in a layer of wet mix macadam or a mixture of sand, stabilised with a hydraulic gluing agent in varying proportions (from 3 to 6%).

The thickness of the layer of the granular material will also vary in relation to the quality of the esplanade.

The level of compactness of the layer of the granulated material will be at least 98% of the modified proctor test.

The types and advantages and disadvantages of these types of pavements are described below:

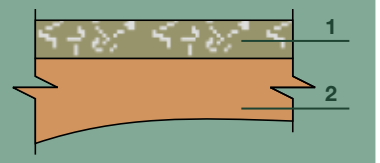
SECTION	ADVANTAGES	DISADVANTAGES
 1. Cement soil (15 a 20 cm) 2. Esplanade	The surface is flexible and is completely natural	Erosion may occur due to the effect of water
	Good visual integration and little influence on the environment	It needs more frequent maintenance. Short life - span
	Very inexpensive	It generates unpleasant vibrations. This type of pavement is not suitable for people with reduced mobility, skaters or for sport bicycles

Figure 18. Cement soil pavement

3.2.2.5. Concrete slabs or cobble stones

This type of pavement consists of a layer of concrete slabs or cobble stones placed on top of a layer of concrete, sand or Portland cement mortar, which is on top of the esplanade.

A particular type of concrete slab or cobble stone is chosen in order to achieve a good grip when the surface is wet.

This is recommended exclusively for short distances and for many aesthetic or for its good integration with the landscape or for places where the cycling speed should be reduced (crossings with streets, motorways or coexistence streets, etc.).

3.3. Drainage

The topography of a given territory will be used and applied for the drainage of the bicycle paths. It should adjust to the territory and avoid as much as possible the installation of complex networks to remove rain water.

The lateral inclination of the bicycle path will be 2%. As regards adjacent roads to existing ones, the inclination will always be the same as that of the existing roads. Advantage will be taken of the already existing drainage system of those roads.

The figures below show the adequate transversal inclines for the base of the road, embankment and mixed sections.

The drainage systems will always respect the environment along the bicycle road, thus it is important to ensure that the transit surface is always in good condition.

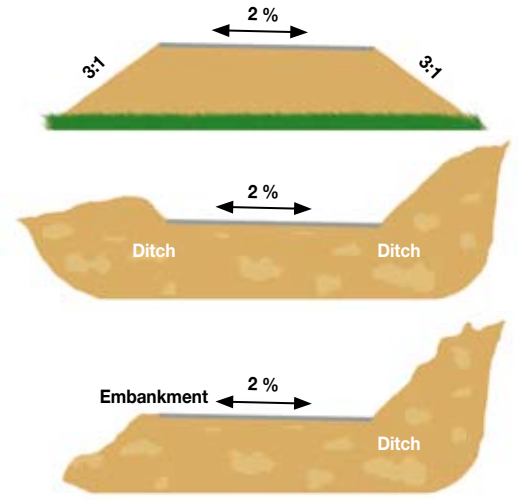


Figure 19. The drainage of a bicycle road

In order to support the drainage system different plants should be planted along the bicycle roads as they will help to absorb water and take advantage of the rainwater flow.

It is also recommended that in determined cases a ditch should be built in order to capture grit from crossroads with unpaved rural roads.

3.4. Environmental focus

The environmental criteria are an important aspect in the process of designing, building and using a bicycle road.

Whenever possible a route of a bicycle road should look for natural lineal systems.

Taking the aforementioned into consideration route design must respect the following systems:

- Rivers, brooks and other natural river beds
- Areas with lakes and ponds
- Borders of large forest area or woods
- Coastal lines
- Natural park areas
- Old road and railways routes

Other possible measures to guard and protect the environment are:

- Avoid bituminous pavements in special protection areas. The granular pavements blend with the natural surrounding and landscape better
- In order to integrate the bicycle road with the landscape plant trees, bushes, plants and incorporate mineral elements along the road
- Reduce soil movement in both excavations and embankments to a minimum
- Reduce manufactured products to a minimum, instead use wood or stone in structural elements
- Respect different species of trees, shrubs and bushes when planting vegetation

- Also use wood and stone for auxiliary constructions, in services and leisure areas
- Design urban furniture that respects the environment (rubbish bins, benches, fountains, etc.)
- Improve the signposting of the areas with a view of special interest
- Have adequate maintenance of the bicycle road and its surroundings as well as of the associated facilities
- Include elements and systems for the collection of rubbish generated by the users of the bicycle roads
- Provide drainage systems, which will respect the surrounding environment of the bicycle road and which maintain the good condition of the route at all times
- In order to avoid acoustic contamination of an area use materials, which do not cause potholes on the surface of the road
- In areas with trees, carry out the necessary pruning in order to maintain the correct maximum height

3.5. Intersections

The intersections of the bicycle roads with conventional roads need to be treated in a special way in order to reduce the number and the seriousness of accidents between bicycles and motorised traffic.

Firstly, it is important to highlight that a good conditions for reciprocal visibility is essential.

As such, the place chosen to cross the road is crucial.

Horizontal and vertical traffic signals together with the proper design of the intersection will be decisive in guaranteeing the safety of its users.

As general principles, in order to solve this question the following

premises must be established:

- In order to avoid points of conflict with motorised vehicle, limit to a minimum the number of intersections with a bicycle road
- Choose places on a conventional road with a reduced speed limit for the crossing points
- If possible move the crossroad to already existing crossing points, for example to roundabouts, where motorised vehicles are obliged to reduce speed
- Put up signs to reduce for motorised vehicles and clear traffic signals indicating a crossing with a bicycle road
- Facilitate easy manoeuvres for cyclists which require the least effort possible to help them avoid infringing existing regulations

The most effective solution for intersections with conventional roads with traffic intensity over 500 vehicles/hour and with motorways and dual carriageways is to make the crossing on a different level (intensity refers to two directions of circulation measured during the four hours of the peak traffic).

3.5.1. Intersection with a secondary rural road

In this case, generally speaking the bicycle road will maintain its priority, provided that the traffic on a rural road is not intense and has moderated speed.

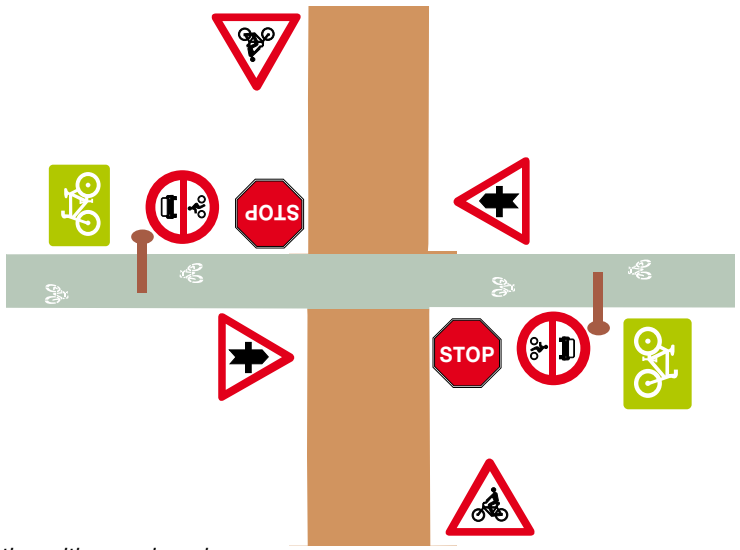


Figure 20. Intersection with a rural road

The motorised vehicles using this type of road will have to be duly informed that they are approaching a bicycle road.

Even so, the users of a bicycle road will have to have adequate traffic signals to increase their attention when approaching such an intersection.

Elements to restrict access of motor vehicles to the bicycle road will be installed. This way we will be able to avoid the interference of these vehicles whenever they are not authorised. However, the maintenance vehicles of the bicycle roads do have to be able access them.

In the case of paths with no artificial surface, it is advisable that the surface of the road be covered 10 m before the intersection with the bicycle road. This is also necessary in order to avoid the tyres of the vehicles putting dirt or grit onto the bicycle road.

3.5.2. Intersection with conventional roads with low levels of traffic

If a road, which is crossed by a bicycle road, has an intensity of traffic under 200 vehicles/hour (intensity refers to both directions measured during the four hours of peak traffic), the intersection should be designed to give right of way to the vehicles driving on the main road.

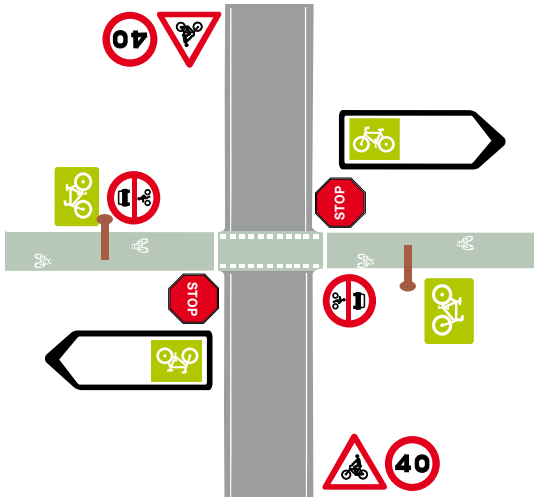


Figure 21. Intersection with a conventional with low level of traffic

3.5.3. Intersection with conventional road with high level of traffic

If a road, which is crossed by a bicycle road, has the intensity of traffic between 200 and 500 vehicles/hour (intensity refers to both directions measured during the four hours of peak traffic), the intersection should also be designed to give right of way to the vehicles driving on the main road.

Due of the level of traffic the cyclist will not be able to cross this road all at once.

This is why a 5 m wide central island will be built and the width of the lane for motor vehicles will be reduced.

It is also advisable to establish measures to reduce speed when necessary in the surroundings of the junction.

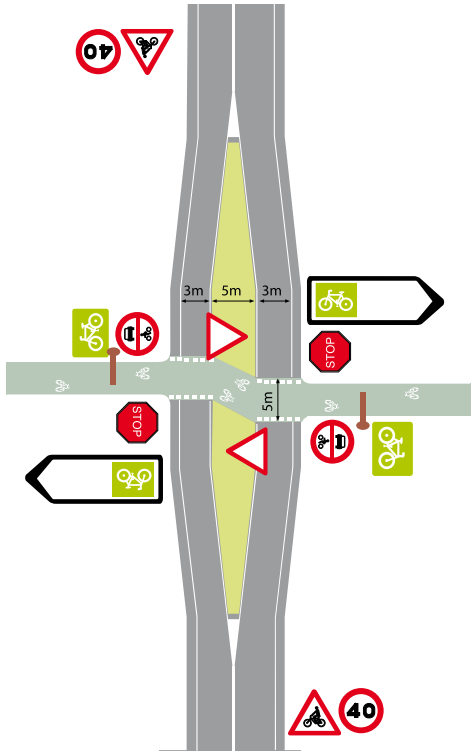


Figure 22. Intersection with a conventional road with high level of traffic

3.5.4. Roundabouts

Roundabouts are especially problematic for cyclists.

In designing roundabouts special attention must be paid to cyclists in order to provide safe cycling conditions for them.

It is advisable to divert the bicycle traffic to a separate route near to the roundabout.

It will also be necessary to build a 2.5 m wide ring around the roundabout with two-way lanes for bicycle traffic. This way we will be able to ensure safe manoeuvring and cyclists will be able choose the most convenient way for them to cycle.

The roads will cross on a 2 metres wide lane built next to the lane for pedestrians.

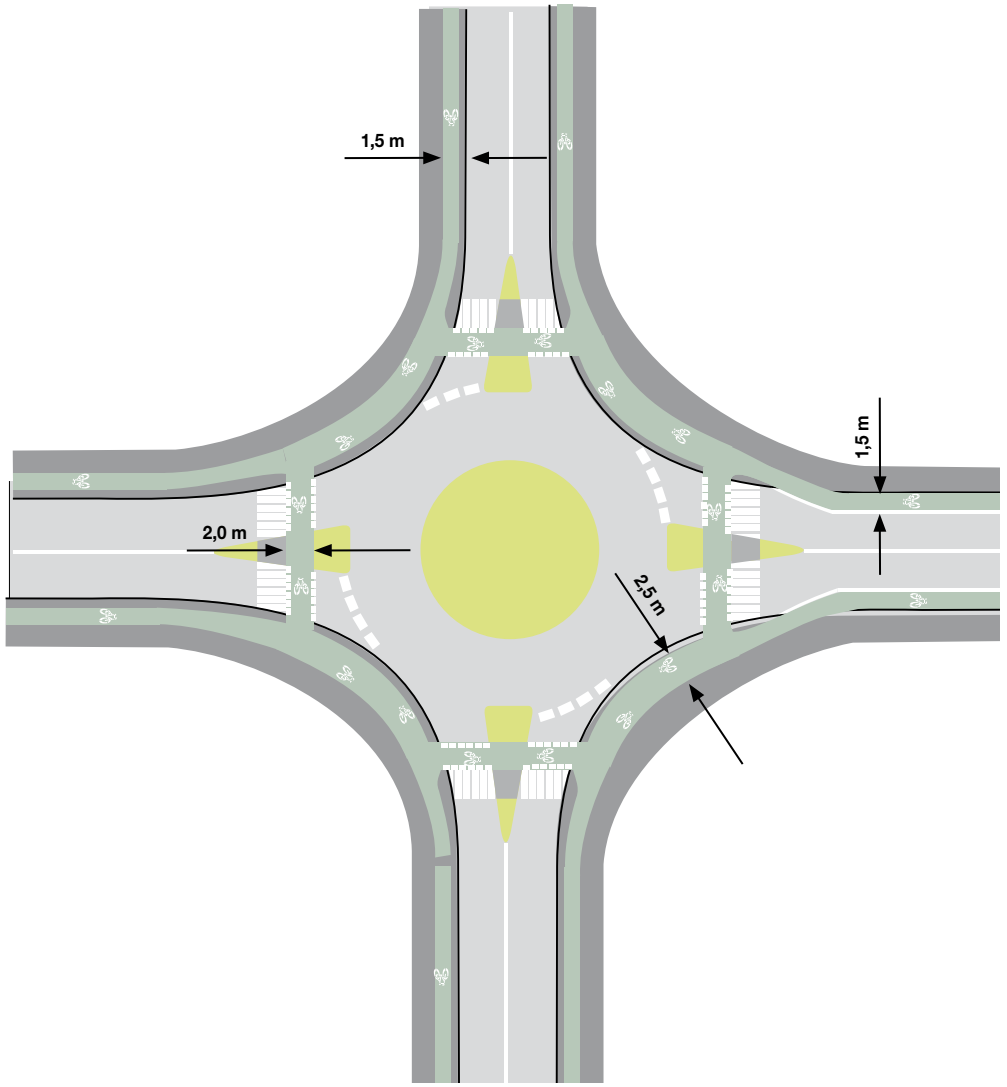


Figure 23. Roundabout

4. FACILITIES RELATED TO CYCLIST ROUTES

4.1. Service areas

Service areas are the key elements for ensuring the good quality of a bicycle road. The existence of these types of infrastructure together with adequate maintenance services and the proper location on the cyclist routes creates the perception of an improvement in the quality of the services offered and a higher opinion of the users of a bicycle road.

The service areas may have different functions, all related to the use of a bicycle:

- Rest facilities
- Eating facilities
- Parking facilities
- Bicycle renting
- Drinking facilities
- Viewpoints
- Information facilities
- Bicycle repair facilities

Photo 6. View of a rest area

So as to place the services areas in a correct location, different aspects related to the shape of the terrain must be considered:

- Proximity of a road infrastructure with proper traffic signals and a parking facilities next to the service areas for bicycles
- Possibility of finding hotels and restaurants in the vicinity
- Existence of sources of water and electricity

In setting up the service area facilities certain design conditions must be met in order to satisfy the needs of cyclists:

- To ensure good access
- Find information about the route network, services offered, etc.
- Install a water point
- A well organised parking area
- A few benches
- To be able to sit in a shade for a few minutes
- Games for children
- Outdoor eating areas – on the grass, or at a table
- Maintain the safety of the users

The fixtures and fittings of the service area will depend on the kind of services to be provided. The minimum is a bench in the shade, rubbish bins and an information board with the bicycle route network. However, the following can also be installed: tables, sources of potable water, bicycle parking facilities, games for children, bathrooms, etc.

In relation to the characteristics of a bicycle route and the surrounding area, the service areas will be adequately equipped to meet cyclists needs and in harmony with the route itself and the services to be given to its uses.

Service areas should preferably be located in those urban centres which the bicycle routes cross, or in the vicinity of other means of transport.

As a general rule there will be a service area every 8 – 10 km with a rest area and information board. The area will have a small amount of fixtures and a size appropriate for its use. This area will shall not be less than 60 m2.

Depending on the attractions at each point and the existing services near the bicycle route at every 20 – 30 km there will be a service area designed for users, who would like to take a long break, eat, sleep, etc.

If possible these areas should be located in the vicinity of public transport and also have access for private vehicles.

During the design of the service areas it should be borne in mind that cyclists are a group with special needs, e.g. they might need to rent a bicycle, to repair one, to park safely or to transport bicycles using other means of transport.

Also, especially on greenways, tourist needs should also be taken into consideration: hotel and restaurant services, tourist information, cycling itineraries and promotion of bicycle routes.

4.2. Parking facilities

Access to comfortable and safe parking facilities at the beginning and the end of the bike ride is essential for cyclists. The issues of bicycle parking and theft are aspects that require the greatest effort in the promotion and building of safe parking facilities as well as other safety and prevention measures.

Thus apart from designated parking spaces in residential buildings (parking facilities at home) an effort must be made to create parking facilities at the end part of a journey and in places where there is a change between the means of transport. These places are the following:

- Train and bus stations
- Schools

- Shopping and urban centres
- Centres for the general public
- Leisure and sport facilities
- Places of work

Faced with the difficulty to include parking facilities in the new building and development projects it is recommended to replace motor vehicles parking facilities with bicycle parking spaces. It is possible to situate approximately 20 bicycle parking spaces in each parking space, bearing in mind the space that both cars and bicycles need to park and manoeuvre

The basic criteria that must be taken into account when choosing and designing a cycle parking facility are the following:

- Security, which means prevention against theft and other acts of vandalism

- Polyvalence, which means that a cycle parking must be adequate for all different types of bicycles and make it possible to lock a bike all types of chains

- Accessibility, which means the cycle parking must be located near the cyclists' destination, as this group is more sensitive to distance than other types of commuters. The recommended maximum distance for a cycle parking for long stretches is between 50 and 75 metres, for short stretches the distance should not exceed 25 – 30 metres.

- Stability, which means that the parking spaces must guarantee that it is locked well and as such without damaging the bicycle like some cyclists do

- Comfort, which means on the one hand the comfort of cyclists, who should have the possibility to lock their bikes quickly and without damaging other bicycles and on the other hand the comfort of pedestrians passing by. The cycle parking spaces should be installed in such a way as not to become an obstacle on the pedestrian route.

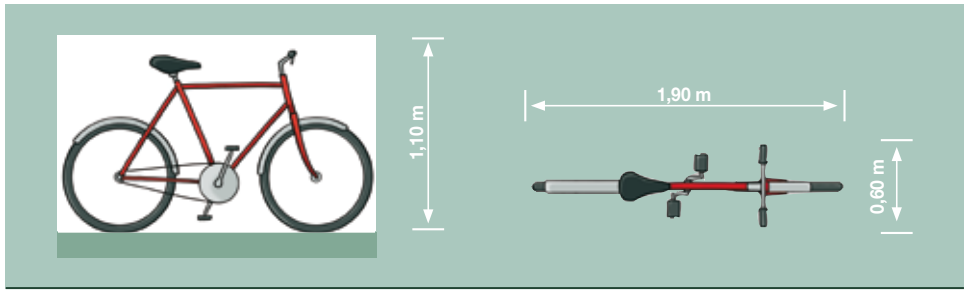


Figure 24. Basic dimensions of a bicycle. Source: Ministry of Development: ""La bicicleta en la ciudad"", 1999

- Protection from the elements protection, which means that protection against the sunshine and rain should be taken into consideration

The dimensions of bicycle parking spaces are determined by the following factors:

- The basic dimensions of a vehicle, which can vary in relation to the dimensions of the handlebars and the additional equipment. The design of a parking facility should take into consideration average dimensions, which are: width -0.60 cm, length – 1.90 cm, height between 1.00 and 1.10 m without a cyclist.

- Method of parking. There are different alternatives to for the design and position of cycle parking facilities, which imply different dimensions within a public space.

At first it is convenient to create cycle parking facilities with two heights or in an alternative order to be able to use a minimum distance between bicycles.

The most convenient forms of cycle parking are the following:

- Locked on one wheel, which means that only one wheel of a bicycle is placed in a hold and it is fastened with a bicycle chain. These types of structures need a distance of between 0.60 and 0.70 metres between bicycles. If the bicycles are place in an alternative way or if the front wheels are placed in a way the handle bars do not touch one another (these are the widest parts of a bicycle) then the sufficient distance between two bicycles will be between 0.30 and 0.35 metres.

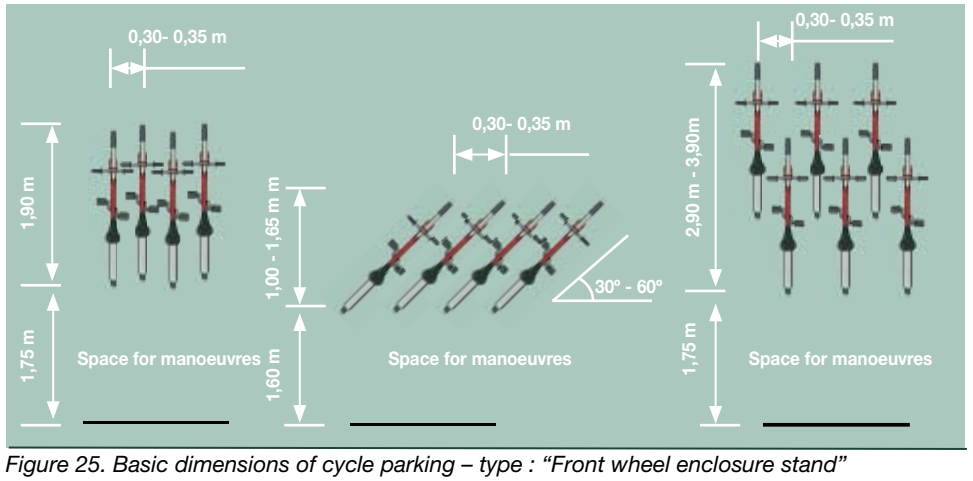


Figure 25. Basic dimensions of cycle parking – type : "Front wheel enclosure stand"

- Locked by frame. These allow the bicycle frame to be locked with bicycle chain. The dimensions of this structure are between 0.70 m and 1.20 metres long and the width is between 0.75 and 1.10 metres. The recommended distance between bicycles is of 0.80 metres.

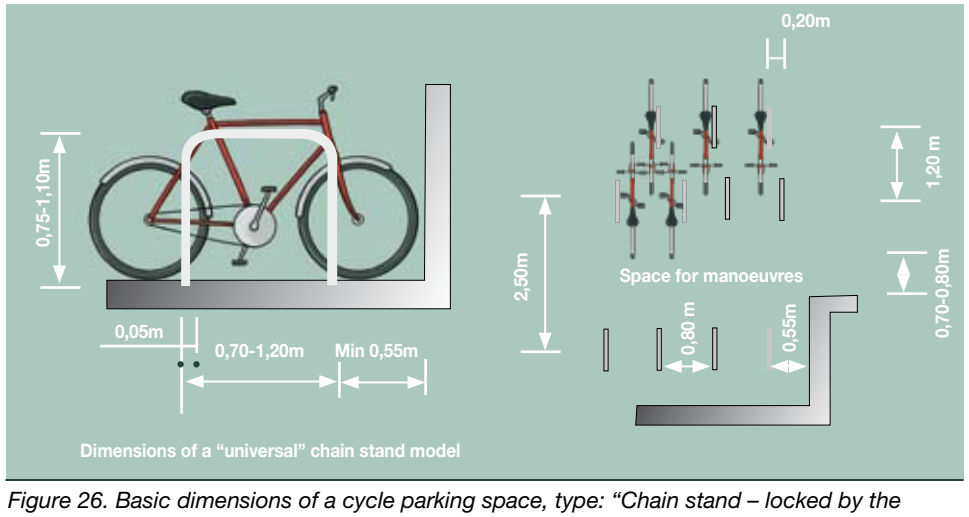


Figure 26. Basic dimensions of a cycle parking space, type: "Chain stand – locked by the frame", "Chain stand – locked by the frame and the wheels"

- Locked by the frame and the wheels. This type of stand facilitates consists of fastening a bicycle by the frame and one of the wheels. It offers stability and safety for long stay parking facilities. The space requirements are similar to the case of chain stands – type: locked by the frame, which are between 0.70 and 1.20 metres re length of a bicycle frame and between 0.75 and 1.10 metres re height, and the distance between bicycles should be 0.80 metres.

- Supports for hanging bicycles: they consist of a vertical structure 2.25 – 2.40 metres high which holds the weight of the bicycles. It offers great economy of space. However, on the other hand, this type of a stand is not very comfortable to use and are not appropriate for bicycles with additional equipment. The minimum distance between the bicycles is between 0.60 and 0.70 metres if the bicycles are hung on the same level and 0.35 metres if they are hung on different levels.

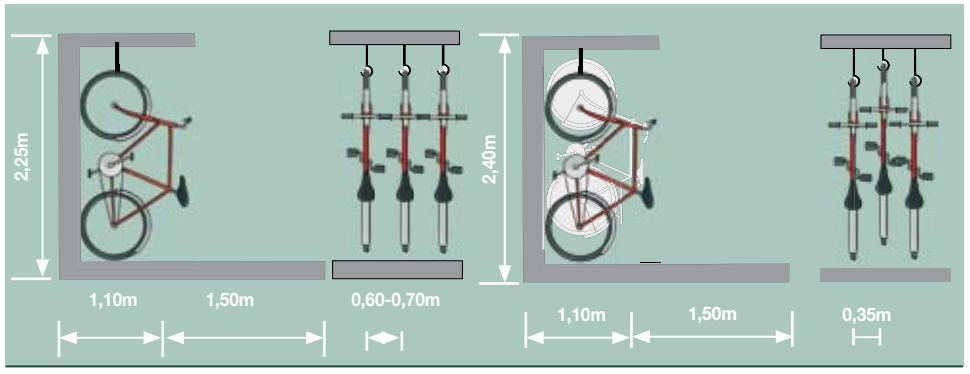


Figure 27. Basic dimensions of a cycle parking, type: "Locked by hanging"

- Individual bicycle lockers: in such a place a bicycle is protected from theft, acts of vandalism and the elements. This type of parking is appropriate for cycle parks on long journey routes, for example at railways stations. The space needed is similar to the parking spaces with holds for the frame and a wheel, but additional an width between 0.10 and 0.15 m is needed to guarantee comfortable manoeuvring.

The following table shows the minimum space required for different locking methods.

Table 12. **The space required for bicycle parking spaces in relation to the locking system**

TYPES OF CYCLE	LENGHT OF THE STRUCTURE INCLUDING BICYCLES (m)	PASSAGE FOR MANOEUVRES (m)	DISTANCE BETWEEN BICYCLES (m)
LOCKED ON ONE WHEEL			
Convencional position	1,90	1,50	0,60-0,70
Intercalated position	2,90-3,20	1,75	0,30-0,35
Diagonal position (30-60 º)	1,00-1,65	1,50	0,35-0,55
With front wheels lifted	1,90	1,75	0,30-0,35
LOCKED BY THE FRAME, LOCKED BY THE FRAME AND THE WHEELS			
Convencional position	0,70- 1,20 (structure) + 0,55 (additional space on both sides)	0,70-0,80	0,80
STRUCTURES FOR HANGING THE BIKE			
Convencional position	1,10-1,30	1,50	0,60-0,70
Position at two heights	1,10-1,30	1,50	0,35
INDIVIDUAL BICYCLE LOCKERS			
Convencional position	2,10	0,70-0,80	0,80-1,00

The criteria of safety, visibility and comfort will prevail when choosing a physical space for cycle parking. The following aspects must be taken into consideration:

- It is preferable to provide more, but smaller and well visible cycle parking spaces near to the point of destination rather than large parking spaces, which force cyclists to cover longer distances and require more expensive surveillance systems

Photo 7. Cycle parking space for a few bicycles

- In establishments with parking spaces for long periods it is better to park the bike inside the building, somewhere near the entrance.

Photo 8. Cycle parking spaces in the interior of buildings

- If a cycle parking is located outside a building it must be placed near the entrance of the building, it should be visible and it must not be located in the same parking area where motor vehicles are parked.

Photo 9. Covered cycle parking area at the entrance of a building

- Special attention must be paid to cycle parking spaces at public transport stations, so that it improves the use between different forms of transport and should not disturb other users

Photo 10. Different types of bicycle parking spaces at stations

The location of cycle parking facilities in places with little visibility is not recommended so as to avoid theft. We should also think of the possibility of covering a cycle parking space to protect the bicycles from rain and other elements.

5. SIGNPOSTING AND ROAD MARKINGS

5.1. Need for traffic signals

The signposting of a cyclepath and its surrounding should comply with the following functions:

- Provide access to the cyclepaths and their nearest surrounding, especially to important places (train and bus / coach stations, education centres, etc.)
- Act as a guide comfortably along the routes without making the cyclist stop at every intersection to look at the map
- Travel safely on the whole route fitted with specific traffic “give way” signs, especially in places where the road is shared with motor vehicles
- Be able to find the services offered along the route easily (hotels, restaurants, parking spaces, public transport, etc.)
- Be able to enjoy the landscape and places of tourist interest along a cyclepath and to be to provide complementary information about the route a cyclist is travelling on.

The places to be signposted will be those of interest to the cyclists. The following places are listed in order of importance of a place and/ or the demand of the cyclists:

- Towns (in relation to the number of inhabitants)
- Places of tourist interest
- Points of access to public transport
- Schools, sanitary, sport and leisure centres

- Shopping centres
- Parking areas
- Points with water and toilets
- Establishments with hotels and restaurants, etc.

In a cyclepath project these aspects must be defined, but not only in relation to the cyclepath itself but also to its surroundings. The following basic principles of signposting will also be applied:

- Visibility: the signs must be located in an adequate place so that they may be seen properly

- Legibility: the names of the destination places limited so that they can be read easily. The information provided must be selected and put in order of importance

- Continuity: it must be placed along the whole route from the time the place appears until arrival at that point

- Uniformity: the types of the panels and other elements must be uniform – they must have the same dimensions, colours, height, etc.

5.2. Road markings

The road markings must serve to determine the bicycle lanes, to separate two-way traffic, to identify “stop lines” and other supplementary traffic sign regulations.

The road marking for a cyclepath is represented by a symbol of a bicycle and a directional arrow. The dimensions are shown in the figure below.

In general the road markings are white. This colour corresponds to the reference B-118 of regulation UNE 48 103.

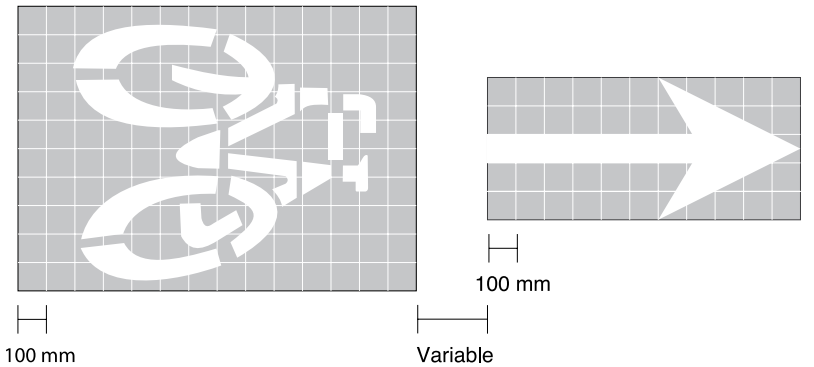


Figure 28. Cyclepath road markings

The symbol of a cyclist must be painted at the beginning of a cyclepath and along the route at regular intervals (every 250 metres). In the case of greenways and segregated lanes these intervals can be bigger as the use of the road markings in these cases is only a reminder that a person is on a cycling lane.

The rest of the road markings are subject to regulation 8.3.IC concerning road markings. These are the markings that indicate the separation of the cycle lane on a roadway from the rest of the traffic and the road markings of cyclist crossings.

5.3. Traffic signs

Signs S-33 are the elements of the vertical traffic sign system on a cyclepath. They are located at the beginning and at the end of a cyclepath and after every intersection.

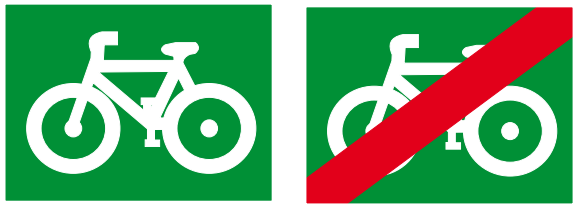


Figure 29. Traffic sign S-33 of a cyclepath

A road in a 30 km/h zone is shared between the bicycle users and the rest of the traffic. For these types of roads traffic signs S-30 and S-31 are used.

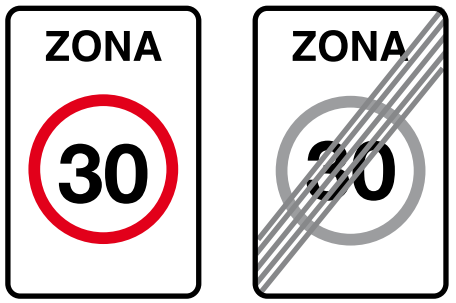


Figure 30. Traffic signs of a road in a 30 km/h zone

In the case of shared-use paths the bicycle traffic shares the path with pedestrians. For these types of paths traffic signs S-28 and S-29 are used.

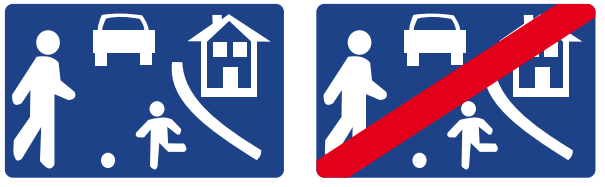


Figure 31. Traffic signs of a shared-use path

The beginning and end of compulsory bicycle circulation shall be indicated by traffic sign R-407a).

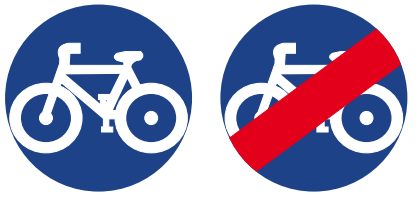


Figure 32. Traffic sign for compulsory bicycle circulation

It is recommended to limit the use of R-407a) traffic sign on the cycleways parallel to carriageways with high intensity and speed, where bicycles could cause dangerous situations.

In the big majority of situations it is more convenient to use traffic sign S-33, which allows sport cyclists to use a carriageway to cycle faster.

In the case of separated cycleways the applicable prohibition traffic signs will be used:

Figure 33. Prohibition traffic signs

If a cycleway has an intersection with a road with motor traffic or any point of conflict with conventional roads the P-22 traffic sign is used, which warns about the danger that travelling bicycles may pose to the rest of the traffic.

Figure 34. P-22 traffic sign

The regulatory traffic signs located on the cycleways separated from motor traffic are 400 mm wide. The sign is situated 220 cm from ground.

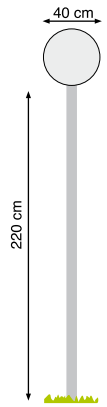


Figure 35. Dimensions of the traffic signs

5.4. Orientative road signs

The guidance traffic signs consist of a selection of information, which must be provided to the cyclists throughout the whole of the cyclepaths network and its surroundings. There are three basic principles related to these type of the traffic signs:

- Information must be provided at the appropriate time
- The messages given to users must be legible, simple and comprehensible
- The cyclist must perceive the orientative sign in a coherent and continuous manner

5.4.1. Systems for choosing destination

We will define attraction point as that place or service that must be signposted. This definition includes villages, towns, activity areas, tourist areas, specific services and other aspects, which could be of interest to a cyclist.

Destination is the literal inscription that represents a point of interest.

The points of interest are classified according to objective criteria. This classification will allow us to place the routes between the different points of interest in order of importance and will be the basis for choosing which destinations will appear on the signposting.

The final objective is to determine the destinations that must be indicated within the traffic signposting system of the intersections of the Catalan cycleway network. The analysis of this system must include the whole cyclepath network and the bicycle routes within the whole territory.

Signposting must also include the peripheral networks (those of pedestrians, public transport and motor traffic) so that neighbouring areas can adapt themselves to this study.

5.4.2. Study of attraction points

An attraction point is an element of attraction and a point to be visited, thus it needs an adequate signposting system, which will help the circulation of people.

Each attraction point must have a precise denomination, which must be known and recognisable by users. It is this name which will appear on the sign posts.

The points of references need to be structured in relation to the interest users have in them and the number of journeys taken into that direction.

The structure, which defines inventory and classification of the reference points, is the essential phase in the process of elaboration of the traffic sign system.

For road users some of the reference points, due to their outstanding importance, must be signposted much earlier on the road than other points of reference. An order of importance must be defined with the criteria that the road users intuitively posses.

In such conditions it is useful to define the characteristics which will allow the creation of a hierarchical classification and to select certain types, which will classify the points of references.

An attraction point is characterised by the functions it exercises.

Thus in first place a distinction must be made between on the one hand village centres and on the other hand other attraction points: tourist places, places of access to public transport, school centres, health centres, sport and leisure centres, shopping centres, parking spaces, water supply facilities and toilets, overnight accommodation and hotels and restaurants establishments, etc.

5.4.3. Classification of attraction points according to population

The attraction points in populated areas are classified according to the following levels:

- Primary attraction points – the capitals of the regions, the capitals of the Spanish provinces, the Principality of Andorra and the capitals of French departments
- Secondary attraction points – the capitals of municipalities with sedentary population plus the corrected floating population five times higher than the population of the referential regions and the capitals of the French cantons
- Third class attraction points: the capitals of municipalities not included in the previous category, the nuclei of villages which are not isolated >= 500 inhabitants and the French communes
- Fourth class attraction points: other nuclei of population <500 inhabitants

$$P_{fc} = \left(V_s \times 3\right) \times 0{,}4 + \left(P_c \times 2{,}5\right) \times 0{,}2 + P_h \times 0{,}6$$

P_{fc} - Corrected floating population
P_c - Camping places
2,5 Number of persons per palace
0,2 Simultaneity coefficient
V_s - Second homes
3 Number of persons per home
0,4 Simultaneity coefficient
P - Hotel places
0,6 Simultaneity coefficient

NOTES:

- In order to simplify the calculation it is assumed that the whole population of the corresponding municipalities is concentrated in the capitals
- In order to calculate the population of a municipality, the floating population is added to the fixed or sedentary corrected population, multiplied by the corresponding coefficients according to the formula provided
- The reference region population is the average of the sedentary population of integrated municipalities within each region and bordering regions, i.e. the sedentary population of each region and the bordering regions divided by the number of municipalities
- In order to calculate the level of the nuclei of the isolated villages with a population over 500 inhabitants, the number of the sedentary and floating population have been fixed and the corresponding level will be applied as if they were the capitals of a municipality with the level always limited to 2. An isolated nucleus of a village is the one over 1,000 metres from the capital of the municipality

5.4.4. Classification of other attraction points

The attraction points, which are not populated and which refer to the points of the territory with special interest for cyclists are classified according to the table below:

Table 13. **Classification of attraction points with no inhabitants**

TYPES OF ATTRACTION POINTS	CLASSIFICATION	INDICATORS (INFERIOR THRESHOLD)		
		Third	Secondary	Primary
Industrial areas	No. of salary earner	1.000	Excluded	Excluded
Schools/Universities	No. of students	3.000	Excluded	Excluded
Hospitals	No. of of hospital beds	1.000	Excluded	Excluded
Socioeconomic centres	No. of visitors / year	5.000.000	Excluded	Excluded
Tourist places	No. of visitors / year	1.000.000	Excluded	Excluded

The remainder of the attraction points which could be signposted will be considered quaternary, except for the places of access to the public transport, which depending of their territorial location may be considered in the third category.

The routes will have different levels in relation to the types of attraction points on a given route. Thus in order to establish the routes between different attraction points the following special rules must be defined:

5.4.5. Classification rule

The classification of a route is made by reducing the different types of two extreme attraction points to the lowest type. For example, a secondary attraction point on a route with a third category attraction point is considered as a third category route.

The category of a route is defined in relation to the level of the attraction point it has, and is characterised by the lowest type of the attraction point between two of its extremes.

5.4.6. Rule of maximum separation

An attraction point cannot be signposted takes a more than a certain amount of time to get to it:

15 minutes on the tertiary/ third category routes

30 minutes on secondary routes

2 hours on primary routes

The fourth category attraction points are signposted in relation to their geographic location in relation to access to the attraction point. The route is not taken into account in this case.

5.4.7. Signpost panel rule

If there are several consecutive attraction points the first one hides those following from the person looking at it. If there is a number of consecutive attraction points of the same type in a given direction (after applying the rule of levelling) the first attraction point is considered to contain sufficient indications for the users to arrive to the second attraction point, and this way consecutively to go further on.

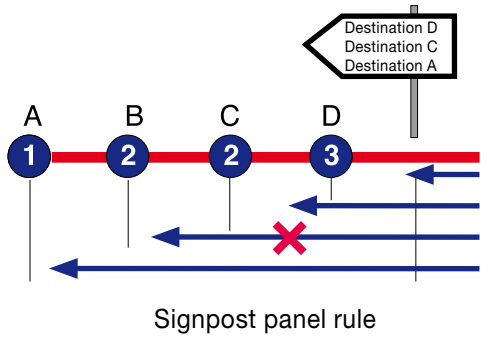


Figure 36. Example of the signpost panel rule

An attraction point of a certain level will hide other posterior attraction points, which are category or lower.

5.4.8. Rule for naming

The phenomenon of naming reflects the way the users spot an attraction point situated near another one of more importance. This phenomenon of naming will only be used for attraction points of different levels.

When a user goes towards an attraction point located near another of a superior category, they will be able to identify their destination due to the information provided about the superior category attraction point. Thus it is not necessary to mention their destination provided the former is further away than the destination of the user.

The values of the separation limit of one dominating attraction point over another are included in the following table.

Table 14. **Limit of separation of dominating attraction points**

LEVEL	DISTANCE OF DOMINATING (ACCORDING TO THE LEVEL OF THE DOMINATING ATTRACTION POINT)	VISUAL DISTANCE TO DOMINATING ATTRACTION POINTS ACCORDING TO THE LEVEL OF THE DOMINATING ATTRACTION POINT)
Primary	15 mins	16 mins
Secondary	10 mins	8 mins
Third	5 mins	5 mins

The rule of dominance also avoids the need to use the panel rule as for a user who has a dominating attraction point as their destination, this is clear and it will be easy for him to see the dominating attraction point. On the other hand the dominating attraction point will not be mentioned unless it is close and it needs to be seen, as the dominating attraction point does not sufficiently indication the destination of the user.

Moreover, users departing from a dominating attraction point might need to see the signposting of attraction points situated further away and thus there is no need for a dominating attraction point to hide the attraction point situated in the distance. In this case both points of interest – the dominating one and the one at a distance can be mentioned thereby breaking the panel rule.

The panel rule is maintained on routes between dominating points of interest.

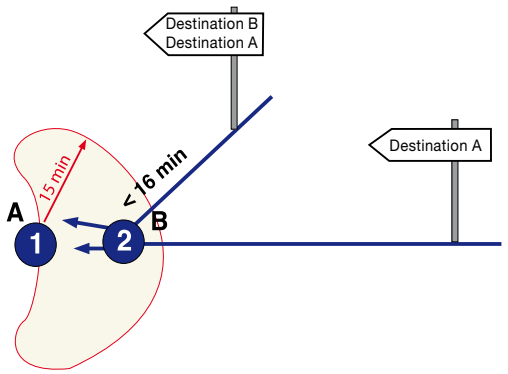


Figure 37. Rule of dominance. Entrance to the dominating attraction point

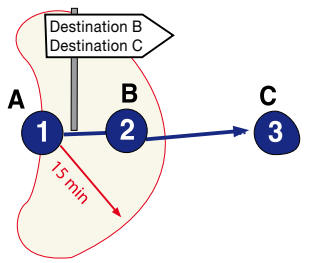


Figure 38. Rule of dominance. Exit from the dominating attraction point

5.4.9. Selection of destinations

The result of the analysis of attraction points and routes will lead to the creation of a cross-reference index card. The destinations will be defined by the existing routes on the crossroads.

For every destination a route of the maximum level will be selected and the result will be put in the corresponding box.

In order to facilitate the analysis of the cross-reference index cards a system of numbering and classification of every crossroads will be established. It will allow the relation of, with no error, the different index cards of each itinerary. Each index card will have map of the crossroads with the different possible movements.

Thus in order to choose the destinations signposted on a panel, the following criteria will be taken into consideration:

- The highest level routes
- Among the highest level routes those corresponding to the highest level attraction points
- The routes which need less junctions to get to an attraction point
- The routes leading to an attraction point through the closest junction
- The routes corresponding to the nearest attraction point

The principle of readability requires that the name of the destination to be effectively signposted be as small as possible. Thus it might be necessary to reduce the names of the initial destinations on the cross-reference index cards. The following limitations are established for the destinations that will be included on the traffic sign panels:

- On one panel a maximum of three destinations can be indicated and a maximum of two destinations of the same level
- Only one attraction point will be indicated on a panel and if possible, in accordance with the other criteria of this chapter, and will follow that outlined until the destination is reached

The work will be summed up in the summarised index cards, where different destinations will be described in detail.

5.4.10. Group of informative traffic signs

The informative signs is a group of traffic signs located along a cyclepath with sequential information necessary for a cyclist to take decision about which the route to follow when approaching crossroads or just after crossing it.

1. Early signposting: a traffic sign with diverse or one module with the corresponding arrows, sometimes it may be a map-type or a written text

2. Final destination: a traffic sign with one or more modules with corresponding indications, which shows the final destination point where the cyclepath should be abandoned, the arrow is inclined 45º down

3. Route confirmation sign: a traffic sign used to confirm the direction to go in order to get to the route where the sign is located

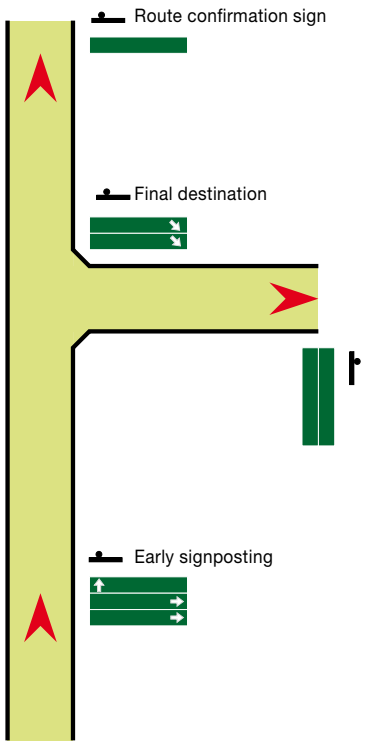


Figure 39. Group

5.4.11. Traffic sign panels

The informative signs for the cyclepaths correspond to the types of signs presented in the figure 39 in relation to their location on the route:

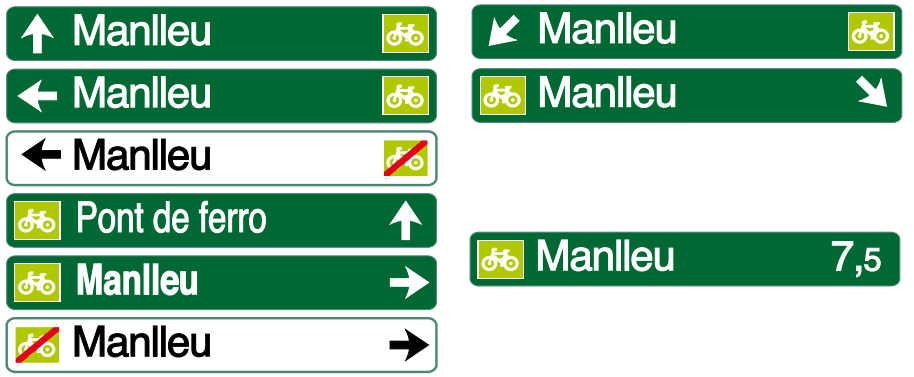


Figure 40. Early signposting, final route direction signs, route confirmation signs.

Ordinary roads also have signs indicating nearby cyclepaths (see figure 40).

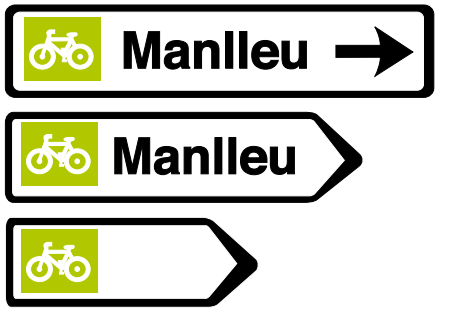


Figure 41. Traffic signs on ordinary roads

The range of colours used for these traffic signs is the following:

Figure 42. RAL colours used for traffic signs

The location of the traffic signs must be appropriate so that cyclists and pedestrians can read the indications, decide what interests them and take the proper course of action.

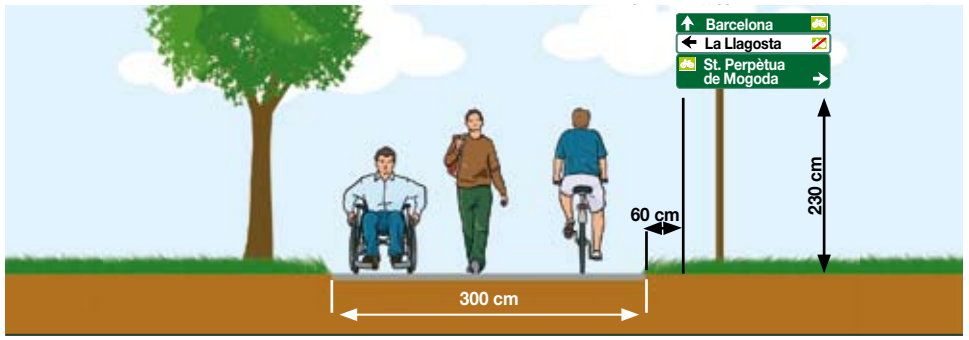


Figure 43. Location of direction traffic signs

The following signs for service areas are used:

The symbols used correspond to the service provided. The following signs are among the most common ones:

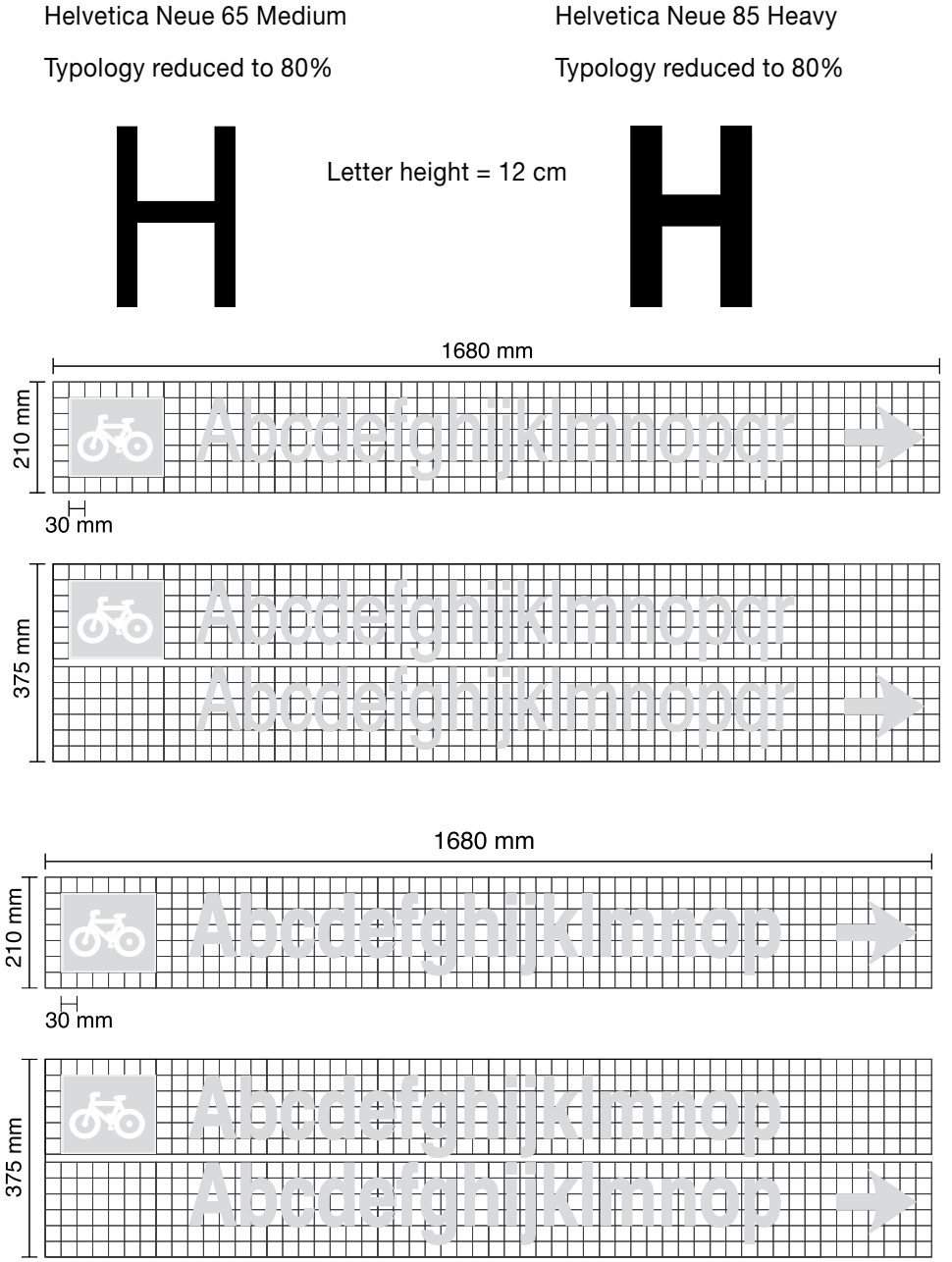


Figure 44. Dimensions of the letter type on the direction traffic signs. H = 12 cm

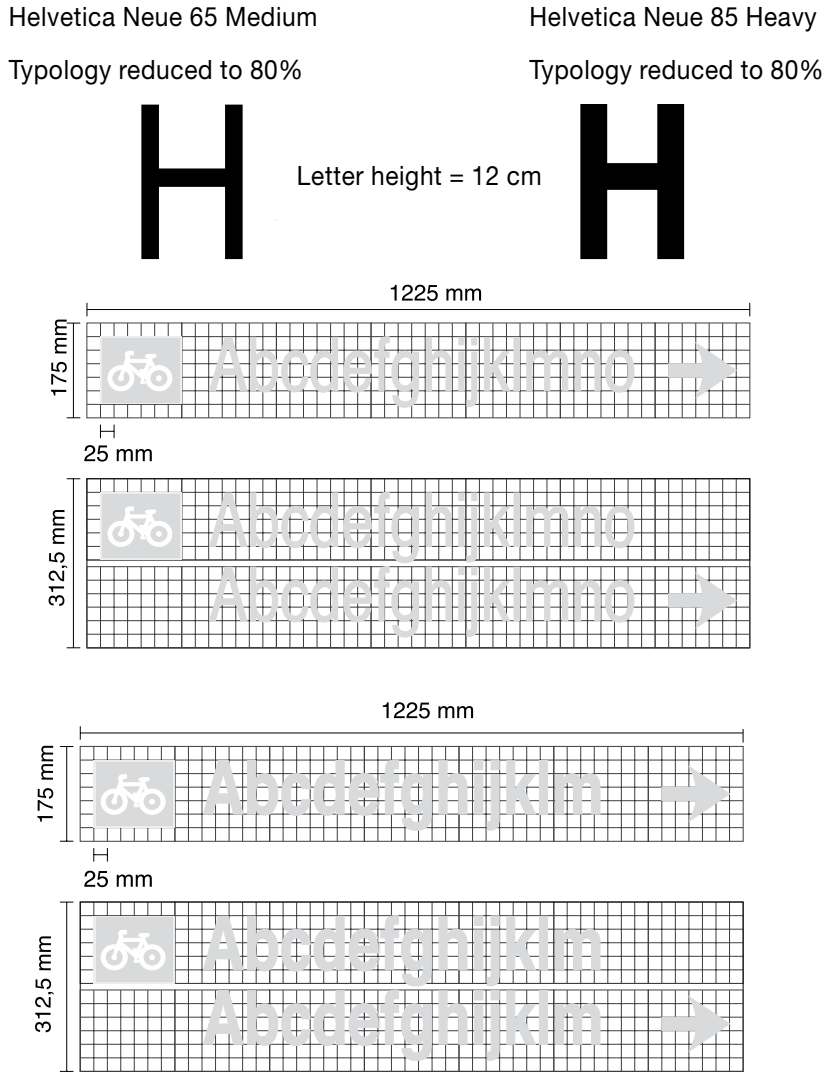


Figure 45. Dimensions of the letter type on the direction traffic signs. H = 10 cm

5.6. Traffic signs for route information

In the rest areas and other points of interest on the cyclepaths signs

providing information about the cycle routes, services, places of interest, and so on are located. In this way cyclists are informed about the routes for pedestrians and cyclists and different activities in the surrounding area with graphic information.

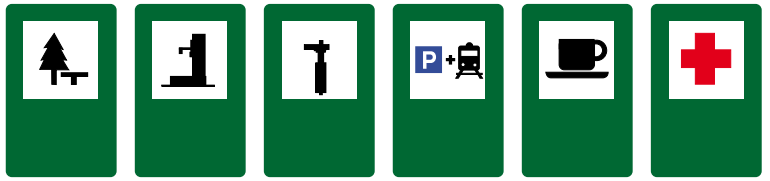


Figure 46. Traffic signs for services

These signs are placed on wooden structures and are protected against rain and the sunshine so that they last longer.

The figure indicates the dimensions of route information signs. The information provided corresponds to the each area.

5.7. Supports and materials of traffic signs

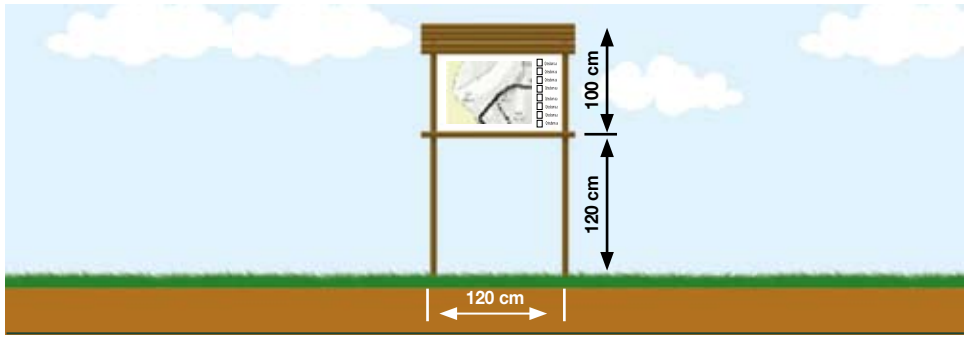


Figure 47. Location of orientative traffic signs.

The following dimensions for traffic sign supports are used: the resistant section of the pole and its fundaments that deal with the physical conditions, with a thickness and diameter of the walls that is appropriate for its positioning, the amount and dimensions of the sign panels and the total height of the sign.

- On greenways and bicycle lanes the material used will be treated wood so as to integrate the cyclepath with the surrounding landscape
- On cycle lanes and in the urban areas modular aluminium systems are used

If the pole is put into the ground using an iron sheet with a clamp, it is possible (in the case of an accident, or for other reasons) to dismantle the traffic sign, including the support pole and to reuse the anchorage.

It is very important that the introduction of the traffic signs should be carried out with the proper replacement of the materials of the existing paved surface.

The telescopic pole system allows the amount of information to be changed without the need to change the pole.

In the case of traffic signs that consist of more than one panel, these must have as little separation between them as possible. A separation of no more than 2.5 cm is recommended.

The traffic sign panels are made from aluminium and they are two types:

1. Perimeter reinforcement thanks to double brackets. The maximum diametre of the panels vary in relation to the presses of each manufacturer. The dimensions are limited. The pole is connected thanks to the rails fixed on the back of the panel and via a bridle to the tube. It is the most simple and economic system.

2. Rigidity is obtained due to protruding profile which is attached to the whole sign with special fixed protruding guide attached to the panel on the back, which are used to attach them to the vertical tube using bridles. This is the most common system.

Photo 11. Perimeter reinforcement with a double bracket

The panels must not have sharp corners and the radius must not exceeded 4 cm. The perimeter profiles of the panels must not be higher than 1.5 cm (horizontally and vertically). A minimum of two brackets are necessary to fix the panel to the post.

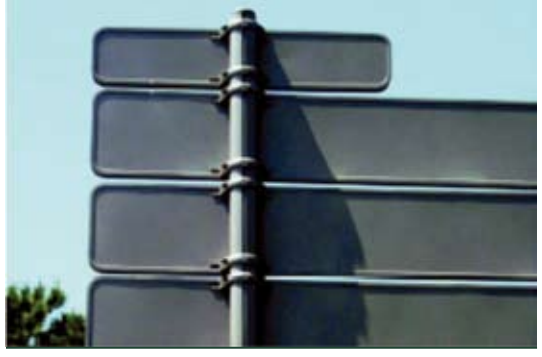


Photo 12. Protruded profile around a sign panel

5.8. Marking elements

5.8.1. Systems for restriction of access to cyclist routes

In order to prevent the intrusion of motor vehicles onto the cyclepaths special elements which prevent the access of unauthorised vehicles on the cyclepaths must be placed near the proper traffic signs.

These elements must however have special characteristics. They must

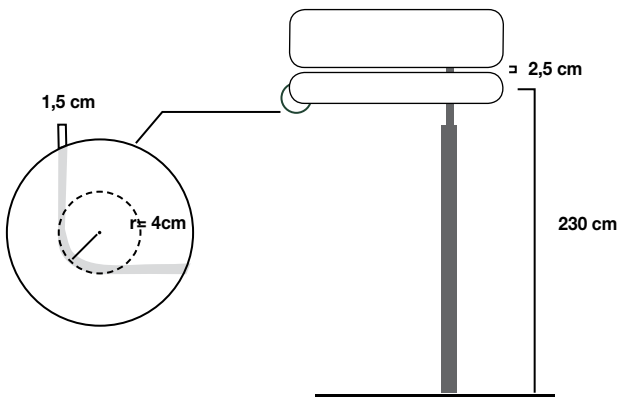


Figure 48. Detail of the angle of the panel

be flexible enough to allow access to determined vehicles (maintenance vehicles, ambulances, etc.) in certain situations.

Thus very strict and rigid prohibition of access is not advisable. The use of mechanisms with mobile elements in order to facilitate the access of the aforementioned vehicles is recommended.

- Separating barriers: two separated bars which pivot on their axis thereby allowing access to maintenance vehicles. The barriers must allow access to wheelchair users, bicycles with trailers or tandems
- Barrier: swinging or pivoting mechanism, which occupies the whole road with the lateral lane reserved for cyclists. It must be fitted with a system to lift the barrier to allow access to authorised vehicles
- Central bollard: with an automatic or manual system to allow authorised vehicles to pass

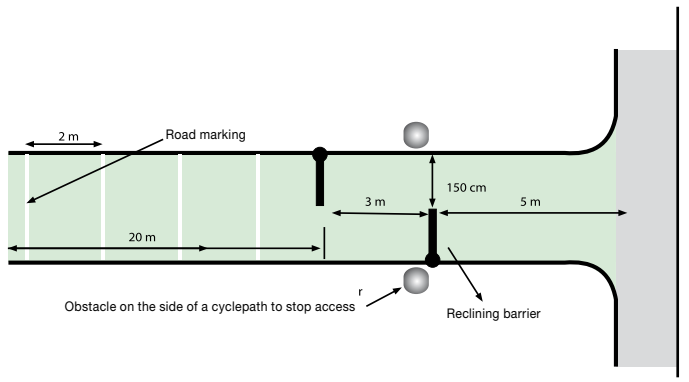


Figure 49. Separating barriers to restrict access to a cyclepath

Photo 13. Separating barriers at the entrance to a cyclepath

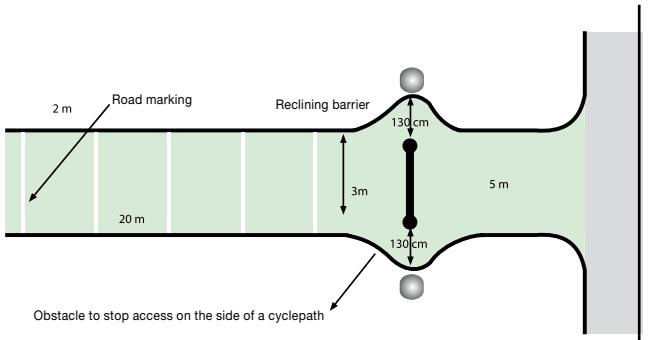


Figure 50. Restriction of access with a reclining barrier

Photo 14. Reclining barrier

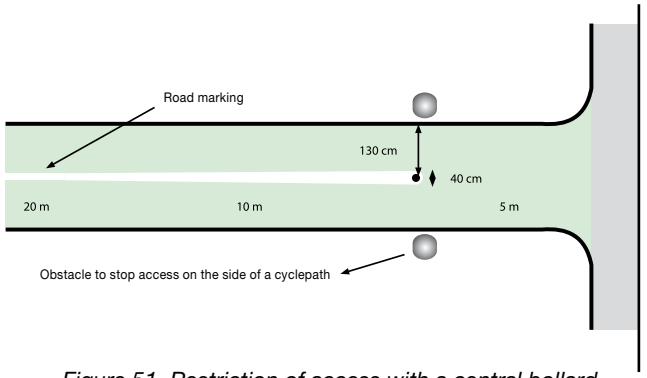


Figure 51. Restriction of access with a central bollard

Photo 15. Central bollard

5.8.2. Systems of containment

Security barriers are not the only elements of a protection system for the surrounding of a cyclepath, but also include devices which protect the cyclists from falling.

Thus the use of the barriers should be limited. They should be used in places where falling off a bicycle could lead to a serious injury (hills, canals, etc.) or to restrict access to cultural or areas of natural beauty that should be protected.

In order to achieve a better integration into the surrounding environment the barriers on the greenways and cycle lanes will be made of treated wood.

Photo 16. Wooden containment barriers on cyclepaths

Conventional systems will be used on a cyclepath in an urban area. Special attention must be made not to use elements with sharp edges which could cause serious injuries when a cyclist falls off their bicycle.

The height of a barrier should vary due to the different centres of gravity of a cyclists and pedestrians. Thus is should be 140 cm for cyclists and 110 cm for pedestrians.

6. BLENDING IN WITH THE LANDSCAPE

6.1. Visual image

An image a cyclepath has is, to a large extent, related to different physical and spatial elements, which all together must be structured in a way that as a whole they transmit to the observer a legible, harmonious and significant perspective.

If the natural landscape has been used for the design of a cyclepath the route is more enjoyable.

Fundamental to the stimulation of the use of a cyclepath network is the urban or the rural environment along a given cyclepath; whether a recreational cyclepath or those used daily. Cyclepaths, apart from their well known functions, also define space and create a global image of forming a part of a citizen's life.

Photo 17. An image of a cyclepath, which respects the surrounding

An immediate consequence of this sense is the respect users have for one another and the harmony with other methods of transport.

In order to define the design of a landscape along a cyclepath the following aspects must be taken into consideration:

- Axis of visual interest – consider the visual points of focus created by the axis of the cyclepath in order to place elements in the appropriate places
- Close views – the spatial character, defined by its function and the components, must give a representative image which is clear to the users of a cyclepath
- Medium distance views – these are peripheral images and ones that the components of the landscape offer. They serve as elements of orientation for the users of a cyclepath
- Distant views –mountain ranges or the sea as the horizon, and the buildings seen on the horizon must be considered as visual milestones
- Definition of use and parametres – trees, furnishing and any other structural elements and equipment must serve as a reference and give a cyclepath a certain character
- Spatial definition and of the image as a whole: eliminating the residuals terrain and implementing a cyclepath in accordance with the immediate area of influence with the objective of integrating the route with the environmental system

Figure 52. Integration of a cyclepath into landscape

The following fundamental elements must be taken into consideration when designing the landscape of a cyclepath:

- A methodological process must be carried out, which starts with an inventory of the elements that make up the landscape, the vegetation, the functional and aesthetic elements
- Climatic functional requirements must also be considered. This information will allow the creation of the criteria for the design; visual effects, appropriate species of vegetation, adequate mobility, proper finishing elements, etc.
- Elements necessary for the optimum functionality within a public space must be established. It implies an adequate design of the spatial whole, which will harmonise with the surrounding elements already existing
- The cycle parking areas and the complementary spaces must be located strategically to be in harmony in relation to space and in dimensions with the whole area
- Very special attention must be paid to preserve and reinforce the natural ecosystems by preserving ecologically fragile areas and by protecting places susceptible to erosion
- The most important natural elements of a given landscape must be given importance in order to make them compatible with the artificial elements of the landscape (new buildings), harmonious visual relationships must be found and important natural elements should be emphasised: mountains, rivers, lakes, forests, etc.

6.2. Vegetation design

In the design of vegetation along a cyclepath the following general aspects must be taken into consideration:

- Uniformity – the vegetal material must present homogenous characteristics, preferably only species from among the habitual vegetation from the area
- The distance between trees should be kept the same. The recommended minimum distance between tree trunks is 10 metres and between shrubs 5 metres
- Tree must be planted on a minimum of two metres of road
- Trees must have only one trunk, oleanders must never be used as they might cause dangerous situations
- Pruning must allow a minimum visibility of 2.50 metres measured from surface level

When planting vegetation the following technical specifications must be taken into consideration:

- Preparation, adaptation and cleaning up a given territory. To avoid damaging the infrastructure special protection barriers will be erected above ground level up to 1.2 metres high
- Replanting of the route, sowing templates (distance and geometric distribution)
- Planting will be done with a minimum diameter of one metre every 70 centimetres deep, leaving enough space for substrates
- The ground around the planted plant must be compact, the soil must not cover the level of the surrounding terrain
- Protective structures must be put up around trees with a minimum width of 1 metre, they must not coincide with architectonic barriers

Figure 53. Diagram showing planting of a tree

The criteria concerning form, texture and the corresponding planting template must fulfil the necessities of a given space, the bicycle traffic and the maintenance system of the cyclepaths. The careful selection of vegetation is recommended, bearing in mind the following criteria:

- Resistance to environmental and climatic conditions and type of soil
- Height, growth and structure of branches and their maintenance
- Availability on the market, low cost and consolidation of the existing species
- In urban areas – resistance to pollution

The use of adequate vegetation may delimit areas, focus cyclist visually, protect from noise, the wind, the sunshine, etc.

When cyclepaths are parallel to conventional roads the plants growing between the carriageways and the cyclepath form a natural protective barrier against noise and the exhaust fumes emitted by motor vehicles. If this option is chosen oleander should be planted and there should be constant maintenance, especially pruning.

In order not to limit the cyclist's vision the oleander must be no higher than one metre and they should not become an architectonic barrier for pedestrians or for people with reduced mobility. The minimum width of such a separation with oleander is 1.50 metres. If it is impossible to implement this width another solution must be found.

6.3. Protection against the elements

Apart from its virtues as part of the landscape, vegetation plays a very important role in protection against unfavourable climatic conditions for cyclists – rain, wind, strong sunshine.

The putting up of strategic special shelters for cyclists is recommended – somewhere which will allow the cyclist and their bicycles and other uses of the route, such as pedestrians, people with reduced mobility, skaters, to shelter during showers and protect themselves from the rain.

When building a shelter the following aspects must be taken into consideration:

- It should preferably be located in strategic locations, it should be well signposted so that users will be able to find it even in unfavourable weather conditions
- It should have capacity to receive all types of bicycles and wheelchairs.

A balance should also be established between the cost of building a shelter, its durability and the requirements for maintenance.

Apart from its aesthetic and environmental qualities vegetation also serves to mitigate unfavourable weather conditions:

- Shade against extreme conditions of possible sunstroke
- It softens the force of the rain
- If provides better consolidation of the soil
- It minimises strong winds

The aforementioned characteristics should also be included in the analysis of costs of establishing and conservation of vegetation along a cyclepath. Thus in order to be able to obtain these benefits, it is not only necessary to plant trees, but also bushes, smaller plants and (grass, dry plants, etc.) which will act as a protective layer and will also be part of the aesthetics of the route itself.

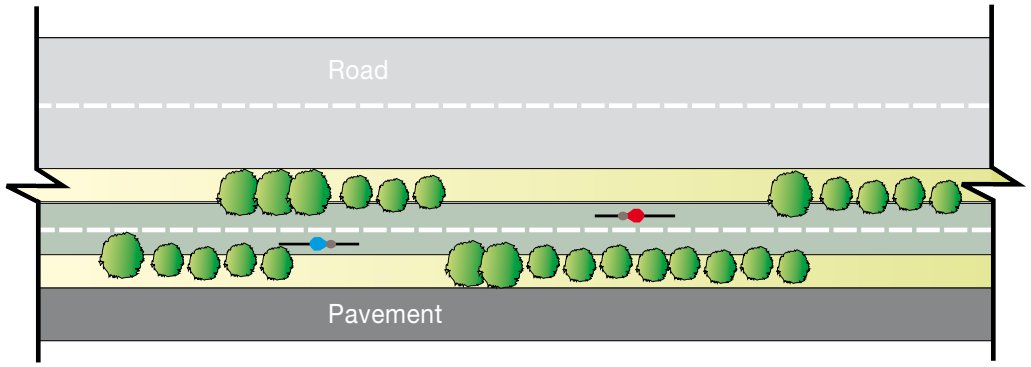


Figure 54. Shade on a cyclepath

In urban areas an accurate study should be undertaken to find out the aspects of the vegetation in relation to them protecting against the elements and the aesthetic component, always having in mind the fact that vegetation will have to be compatible with the road users (public transport, pedestrians, parking vehicles, etc.).

To reduce the cost of planting and maintenance it is recommended to plant trees in lines of ten alternatively on each side of a cyclepath. This pattern of planting will allow a cyclist to have intervals of shade along the route at different times of the day.

6.4. Lighting

In urban areas the cyclepaths will have the same level of lighting as the roads. Lamp-posts should be located as far as possible from the cyclepaths to avoid cyclists colliding with them.

In the interurban areas the necessity of providing the lighting system along a route has to be studied individually for every cyclepath according to the characteristics of the cyclepath itself.

Visibility on intersections is extremely important. It is recommended that a cyclist crossing an intersection should still be seen by the drivers of motor vehicles beyond the crossing thanks to the continued lighting.

It is also recommended that a cyclepath be illuminated proximately 50 metres before a crossing to enable a driver to see that the cyclist wants to cross the intersection.

Figure 55. Lighting of intersections

7. MAINTEINANCE AND EVALUATION

7.1. Maintenance and cleaning services

Maintenance and cleaning services are extremely important for the good functioning of a cyclepath. Bad quality maintenance will result in the route being used less and an increase in the insecurity in cyclists.

Misconceptions about the design of a cyclepath lead to a high number of maintenance and cleaning works result from, for example mistakes in the drainage system, wrong design of shoulders or access roads, or inadequate planted vegetation, or vegetation overgrowing the sides of a cyclepath. This is why it is extremely important to have these aspects in mind when designing a cyclepath, as they will condition/ determine the effort put in maintenance of the whole period of use of this infrastructure.

Works that must be carried out routinely:

- Grass cutting – at least twice a year, a metre wide stretch on either side of the cyclepath
- Pruning – at least once a year and ensuring that cut branches are not left abandoned as they may cause falls
- Sweeping – once a month, necessary to do again after rainfall and more often in autumn because of falling leaves. Cyclepaths should always be ready for use without posing danger to the cyclists
- Rubbish collection – once every two months and after special activities that took place on the cyclepath
- Maintenance of the road markings –it is necessary to check them once a year and repaint the road markings on a cyclepath
- Maintenance of borders and access to roads– to maintain the adequate level of the borders and access in relation to the cyclepath platform
- Cleaning off snow – during periods of snowfall it is necessary to keep the cyclepath in good condition so that bicycles can circulate

The checking and replacement of the surface of a cyclepath will made when necessary.

- Limpieza de la nieve: en episodios de nevadas, será necesario mantener la vía en buen estado para la circulación de las bicicletas
- Cuando haga falta, se hará una revisión y reposición del firme.

7.2. Follow up and evaluation

Once a cyclepath has started to be used a follow up and evaluation by the users of a cyclepath is be necessary. Collection of data shall be carried out using surveys addressed to the users of the cyclepaths, capacity surveys (manual or automatic) and surveys aimed at employees (bicycle rent, repair services, tourist offices, etc.).

The development of the use of a given cyclepath will be evaluated, based on the information obtained, and measures of promotion and communication will be taken using leaflets and bicycle guidebooks, information about the economic impact a cyclepath has for a given region, etc.

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Departament de Política territorial i Obres Públiques