Road and Transportation Research Association

Working Group Highway Design

FGSV

Directives for the Design of Urban Roads

R 1

RASt 06

Edition 2006
Translation 2012

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Working Group Highway Design
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Preliminary notes

The “Directives for the Design of Urban Roads” (RASt 06), Edition 2006, Translation 2012 were drawn up by the Forschungsgesellschaft für Straßen- und Verkehrswesen (Road and Transport Research Association; FGSV), “Urban Road” Committee (chair: Dr.-Ing. Reinhold Baier, Aachen).

Notes – The RASt cover the design and construction of access roads and of main arterial roads in built-up areas and in open country with at-grade intersections. They replace the “Recommendations for the layout of access roads” (EAE 85/95), edition 1985, as amended in 1995, and the “Recommendations for the layout of main arterial roads” (EAHV), edition 1993.

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0 Scope and structure

These directives cover the design and construction of access roads and of main arterial roads in built-up areas and in open country, with at-grade intersections. They therefore apply to category groups VS, HS, ES according to the “Directives for integrated network design” (RIN)[1] (figure 1). For those road categories, they replace the “Recommendations for the construction of access roads” (EAE)[2] and the “Recommendations for the construction of main arterial roads” (EAHV)[3].

Category group VS comprises open roads leading into and within built-up areas. The first group represents a continuation of the roads of category group LS on approaches to major built-up areas. The areas to the sides of the road are frequently characterised by loosely interspersed frontages featuring tertiary uses, so the need to access them is relatively low. Only a small portion of the frontage is accessed directly from the road. The roadsides generally feature areas for non-motorised traffic. The roads are single or two-lane. They are mainly linked to lower-order roads by at-grade intersections featuring traffic lights or roundabouts. The permissible maximum speed leading into built-up areas is preferentially 70 km/h, and within such areas mainly 50 km/h.

Category group HS comprises roads[4] within built-up areas. They form the system of local main traffic routes, and usually also provide the routes for local public transport. They may also provide link between different communities (through-roads). In terms of legal categorisation they may be federal, state, district or local roads. The roads are single-lane or two-lane. The link to roads of the same category group is generally made by means of at-grade intersections featuring traffic lights or roundabouts. Since the adjacent building uses are accessed directly from the road, the roads are characterised by areas of parking required for such usage. Cycling is preferably routed on separate cycle paths. The maximum speed limit is usually 50 km/h.

Category group ES comprises roads within built-up areas[4] providing direct access to buildings.. The roads provide access to residential, work areas and local amenities. The roads are essentially single-lane, and are connected by at-grade junctions without traffic lights.

Category group **Link function level**		Motorways	Inter-urban roads	Open main roads	Built-up main roads	Access roads
		AS	**LS**	**VS**	**HS**	**ES**
Continental	**0**	**AS 0**	░	–	–	–
Large scale	**I**	**AS I**	**LS I**	░	–	–
National	**II**	**AS II**	**LS II**	**VS II**	░	–
Regional	**III**	–	**LS III**	**VS III**	**HS III**	░
Local connectors	**IV**	–	**LS IV**	–	**HS IV**	**ES IV**
Small-scale	**V**	–	**LS V**	–	–	**ES V**

AS I Occurring, designation of category
░ problematic
– Not occurring or not justifiable

RASt

Figure 1: Scope of the RASt for the road categories of the RIN (Directives for Integrated Network Design)

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[1] “Directives for integrated network design” (RIN), edition 2008, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2008.

[2] “Recommendations for the construction of access roads” (EAE), edition 1985, as amended 1995, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1985/1995.

[3] “Recommendations for the construction of main arterial roads” (EAHV), edition 1993, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1993.

[4] Including traffic routes in areas which are capable of being built-up but are not yet built.

The link to roads of the category group HS is made by means of at-grade intersections with or without traffic lights or roundabouts. In special cases they serve as routes for local public transport. They carry most of the local cycle traffic. Not only for that reason, the permissible maximum speed on them is in many cases 30 km/h.

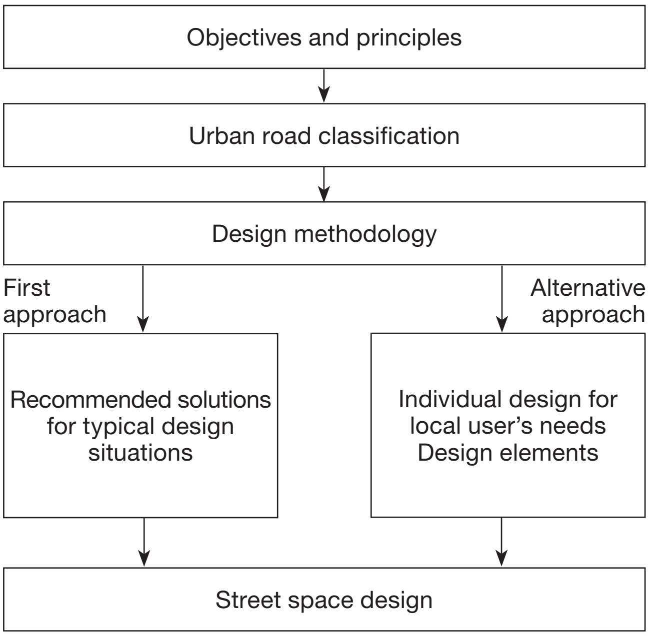

Figure 2: Structure of the RASt

In view of the many and varied demands imposed on urban roads and the special features of each individual case, no rigid rule can be followed when applying the directives. However, values and solutions at variance from those specified should only be chosen if the resulting solution demonstrably improves the specific requirements of the design task.

The structure of the RASt is shown in Figure 2.

After setting out the objectives and principles underlying local street space design (section 1), urban roads are differentiated according to infrastructural and traffic features and typical design situations are defined (section 2). Section 3 details the design methodology. The RASt further offers two routes with regard to the design process.

Users can then apply recommended solutions for typical design situations (section 5) according to their specific task at hand. Section 5 sets out profiles as well as the types of intersection and selected straight/intersection transitions. For detailing purposes, users can apply the information given in relation to usage needs (section 4) and design elements (section 6).

Individualised street space design applying the process of urban character assessment (see section 3) is based on the depiction of usage needs in section 4 and the presentation of design elements in section 6.

Technical and design procedures are then followed in both cases as set out in section 7.

1 Objectives and principles

1.1 General Considerations

Planning and design of city streets must be based on objectives derived from the liveability and viability of the towns and communities concerned, seeking a balanced consideration of all claims for use of the local street space. In this process, it will frequently be necessary – especially in urban centres – to reduce the volume, or at least the prioritisation, of individual motorised traffic in terms of speed and convenience in favour of pedestrians, cycle traffic and local public transport. This enables many problematic situations on existing urban roads to be improved and to be avoided altogether when planning new roads.

Existing and planned regional and general local **design directives** must also be considered when planning and designing urban roads,

These include:

- Land use and settlement structure
- Location, function and loading of an urban street in the networks of pedestrian, cycle and motor vehicle traffic, as well as public transport
- Preservation of historic townscape qualities
- Location within ecologically sensitive greenbelt and natural systems

1.2 Objectives and target areas

The **primary objective** in the planning and design of urban roads is to balance the needs of users both among themselves and in relation to the surrounding uses, including the improvement of road safety. This balance must usually be attained using existing areas, taking account of the urban context, design approach and ecological considerations.

The precondition for achieving such a balance is that street spaces should be recorded in their full diversity of use and should be evaluated and designed considering all relevant user needs and their respective significance.

The compatibility of motor vehicle traffic in built-up areas cannot usually be assured by design measures alone. It may therefore be necessary to establish acceptable limits on space use needs and incorporate these into overallcommunity planning.

This is especially true when

- the space available is not sufficient to satisfy all street space needs;
- the emissions from motor vehicle traffic are too high for the surrounding users; and
- individual usage needs are so demanding that they cannot be justified in competition with other user needs even when all means of compensation are utilised.

The **street space-specific objectives** can be derived from the primary objective and assigned to the following target areas (in alphabetical order, not indicating any weighting):

- Social usefulness, including elimination of barriers
- Street space layout
- compatibility with surrounding needs
- Traffic flows
- Road safety
- Cost-effectiveness

As the design of urban roads is an integral element of overall urban planning, individual objectives should not be defined either in isolation or as overriding goals.

The mutual weighting of the target areas and objectives should be problem-oriented, with a view to a specific design. It may also lead to design directives based on policy decisions.

2 Urban road classification

2.1 Basic considerations

In classifying urban roads,
– traffic characteristics and
– Urban design characteristics

different kinds and subdivisions are used (figure 3).

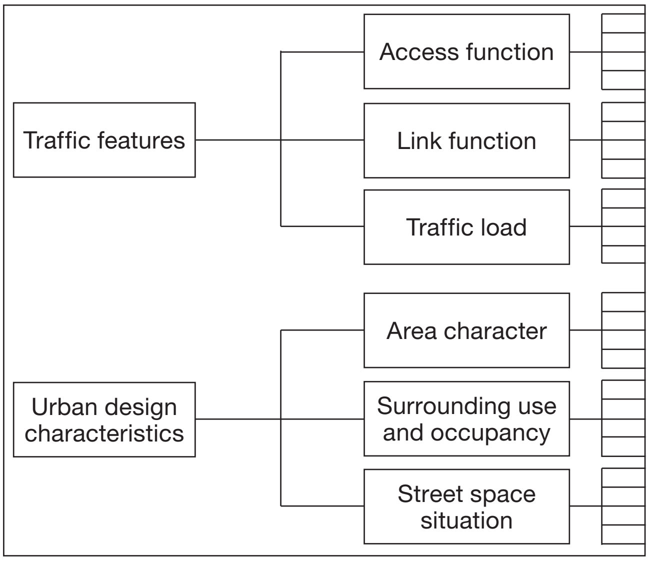

Figure 3: Distinguishing features of urban roads

The link between traffic and urban design features is particularly important for main arterial roads.

Main arterial roads are always key urban planning and traffic axes and spaces, but at the same time they are also frequently segments of wider road networks carrying regional or local public transport. They link urban areas and neighbourhoods of different size and structure and – where built-up – are primary access roads for such settlements.

Main arterial roads thus have to marry needs relating to:

- wider-area functions arising from the need to link towns, villages and suburban areas, with associated demands in terms of journey time and ride comfort;
- local functions arising from the urban context, adjacent buildings and other uses, and resulting demands in terms of environmental quality, “being in the street” and access.

2.2 Traffic features

The **access function** of urban roads is dictated by the nature and extent of the adjoining built environment and other uses, and the resulting

- Number of routes for persons using all means of transport which begin or end there
- Frequency and duration of delivery and loading operations

The access function may differ according to the means of transport, and may compete with the needs arising from the link function.

The **link function** is a key traffic feature of main arterial roads.

It is dictated by

- the importance of the locations being linked;
- the distance between those locations; and
- the intensity of traffic links.

When assessing the link function of a road, the various means of transport must be viewed in isolation; a road with a major link function for local public transport may be of lesser significance for cycle traffic, for example.

In road design, the level of the link function has effects on the needs of the respective means of transport in terms of the quality of traffic flows.

The **traffic load** in flowing traffic in all traffic modes comprises through-traffic, incoming and outgoing traffic. The resultant traffic volumes and their distribution over time can widely vary on urban roads. They are therefore a key distinguishing feature. The same applies to demand in terms of parked traffic, which depends on the surrounding uses, the available parking and the quality of access using other modes of transportion.

2.3 Urban Characteristics

The urban significance of city streets is dictated by the conception of urban space, the usage pattern in the various stages of the town‘s history, and the design quality of the surrounding built environment. On many urban roads these features have changed dramatically, or even been completely obliterated, over time.

Consequently,urban design characteristics of particular relevance to design are:

- the character of the area;
- the nature and extent of the adjoining use and function; and
- the street space situation (extent, width, alignment).

Paying attention to the urban features is particularly important because they dictate the design. Owing to the fact that there is often limited scope to vary them when designing street space, they must usually be treated as local design conditions.

The **area character** provides the starting point for the overall design of urban roads. The character of the area is primarily embodied in its historical roots. The features of a rural village, a medieval old town, a long-established residential quarter close to the town centre, or a modern housing estate on the outskirts provide a basic framework for the street space design.

Nevertheless, urban roads are generally defined to a level of accuracy necessary for the design process by the adjoining uses and their specific situation.

The **adjoining usage** and **occupancy function** – that is to say, the nature and extent of building and land usage along an urban road – plays a key role in terms of the linkage between the two sides of the road and the surrounding neighbourhoods. They must be considered as key elements in the design of the street space to a level of detail appropriate to their diversity.

Knowledge of the existing or planned adjoining usage is also important because the land use is the starting point for a wide variety of user requirements. The planned adjoining usage provides indications of potential user needs which are not observable in a site visit.

Moreover, changes relevant to the design may result from developments within an area or along a section of road which are not planned. Indicators of such changes may be for example: facade condition; building structure condition; modernisation activity; population growth; expanding businesses or conversely empty shops; increase in office space, clinics, etc.

The available **street space** is a key basis for different area allocations for users and for its design and planning. It is characterised by:

– the boundaries of the street space;

– the width of the street space; and

– the alignment of the street space.

The built context of a street is key to possibilities for re design. A densely built-up area along a road usually offers fewer opportunities to give benefit to individual user needs than an unbuilt or set-back frontage.

The width of the street space determines the extent to which perceived deficiencies may be shared among users or transferred to other street spaces, and whether changes desired by urban planners can be achieved.

The alignment of the street section also affects its design. Distinct changes to the shape of the road, such as widening or narrowing of the street, at junctions or intersections with other roads require particular attention in the design and enable the creation of public space or a sequence of spaces to attain a desired effect.

2.4 Typical design situations

Care must be taken to avoid the number of design features becoming incoherent for users.

Typical design situations can be defined from and for design practice, based on typically different street space and traffic-related circumstances in the city, medium and small town and village context (figure 4). The allocation to the road categories of the RIN is shows in table 1.

These typical design situations cover most of the design tasks occurring in practice.

Longer stretches of road, in particular, may comprise a sequence of typical design situations. This is mostly the case on main arterial roads, such as where classified roads pass through built-up areas, in which case a differentiation by segment usually becomes necessary (figure 5).

By contrast, access roads as well as short through-roads can often be allocated to a typical design situation (figure 6).

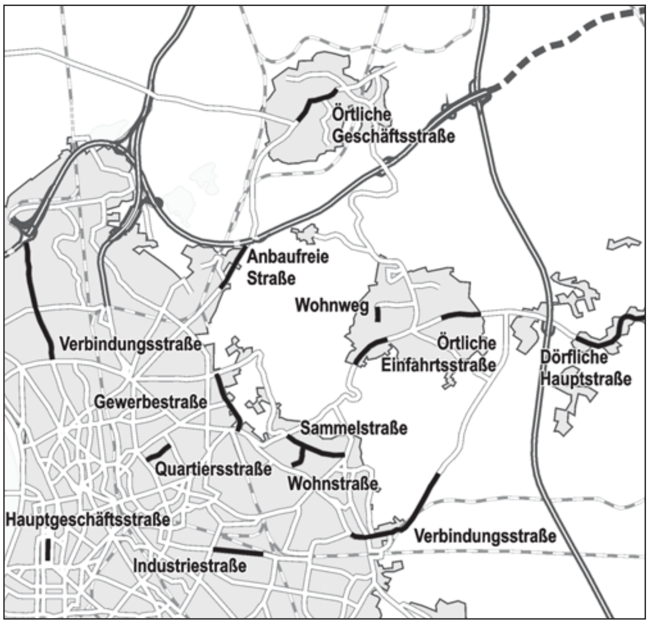

Figure 4: Typical design situations

Table 1: Allocation of typical design situations to Road categories

Typical design situations	Road categories
Residential lane	ES V
Residential street	ES V
Collector road	ES IV
City neighbourhood street	ES IV, HS IV
Village main street	HS IV, ES IV
Urban main road	HS III, HS IV
Local main street	HS IV, ES IV
Main shopping street	HS IV, ES IV
Roads in commercial areas	ES IV, ES V, (HS IV)
Industrial Estate road	ES IV, ES V, (HS IV)
Link road	HS III, HS IV
No frontage access road	VS II, VS III

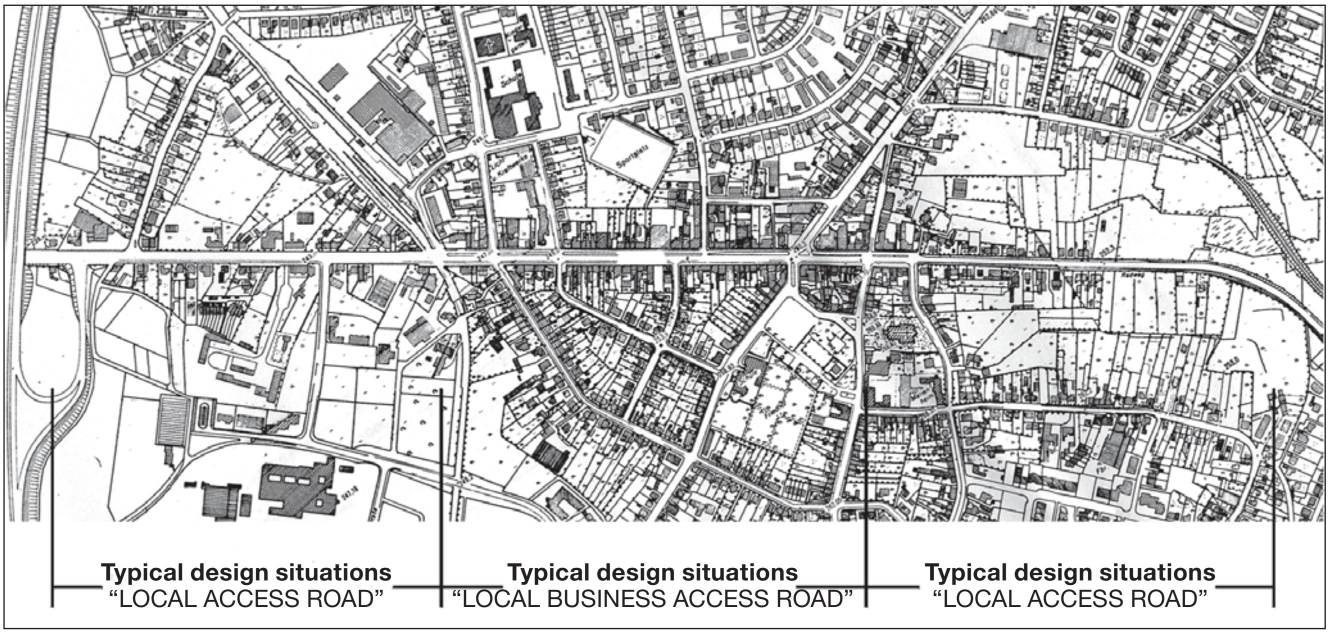

Figure 5: Example of a design task with varying typical design situations

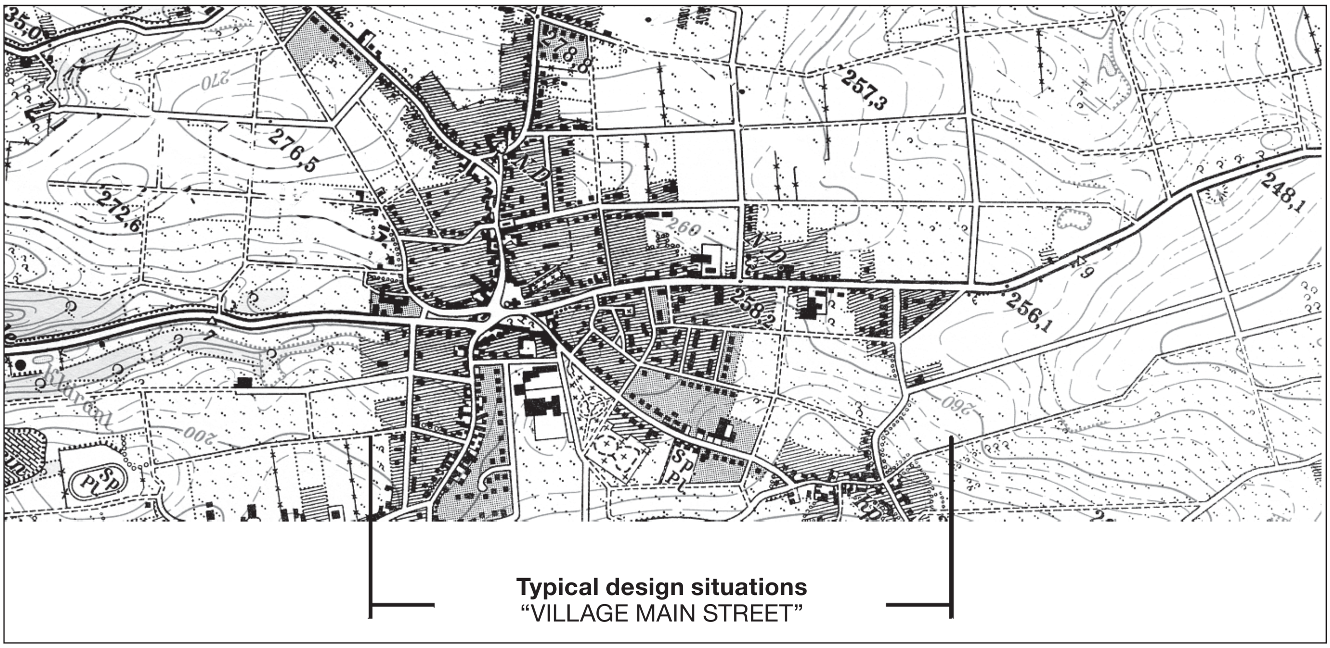

Figure 6: Example of a design task with a single 'typical design situation'

3 Design methodology

3.1 Design tasks

The tasks considered are:

- Remodelling
- New build
- Downgrading

Remodelling (including expansion) includes the redesign of a street space based on functional needs – e.g. relating to road safety or traffic flow – or design improvements to respond to adjacent use, traffic and non-traffic usage needs in the street space, and design quality while retaining existing functionality within the network.

New build demands integration of the street space into the existing or planned environment, balancing of the various needs and implementing design elements for the specific situation.

Downgrading encompasses the redesign of a street space, in accordance with the remaining usage, when the function of the road changes within the network. This usually relates to a downgrading of the link function for motor traffic.

3.2 Street space design classification and procedures

Street space design, as part of an overall urban design project, encompasses all the design and functional elements of public street spaces including the transition between public and private areas.

In developing the "recommended solutions for typical design situations", existing common urban issues, are included, for example, the space available beside the carriageway (section 5).

For individual streetscape design the process of "urban design assessment" is recommended (section 3.4).

More detailed consideration of urban design aspects is enabled by analysis of the "contribution to urban design", developed as an integral part of street-space design or as a stand-alone analysis.[5]

The street space design procedure follows the structure of planning and design processes (figure 7).

It should be noted that the design process is not linear, but rather that the objectives and goals, evaluation criteria, the design requirements of local and urban planning and traffic features are incorporated at various points into the design process.

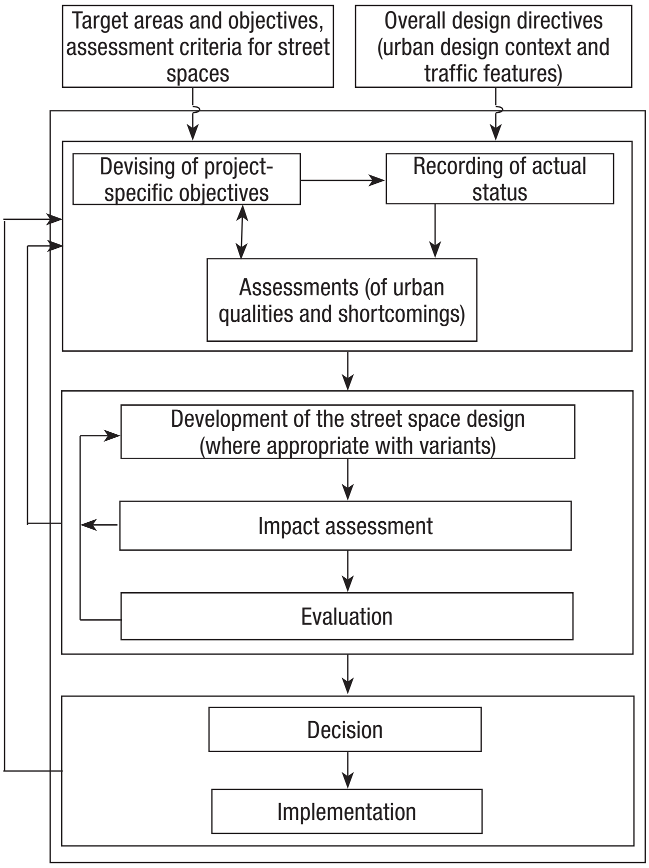

Figure 7: A street space design procedure

3.3 Determining the principles for design

A record of the current conditions and presenting the results in a comprehensible way are essential for identifying deficiencies and developing policies to address them.

The order of the streetscape design process should follow the standard structure of planning and design processes (Fig. 7).

- Regional design directives
- Municipal design directives
- Local-area design directives,

and at street level

- traffic needs
- Accident statistics
- The spatial design of the street
- Adjacent uses

The **regional**, **district** and **local-area design directives** are determined by referring to the relevant planning documents (figure 8).

A problem-oriented approach is essential in considering surrounding uses, the spatial context of the street, accident statistics and traffic needs. More or less detailed research

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[5] See "Recommendations for street space design within built-up areas" (ESG), edition 2011, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2011.

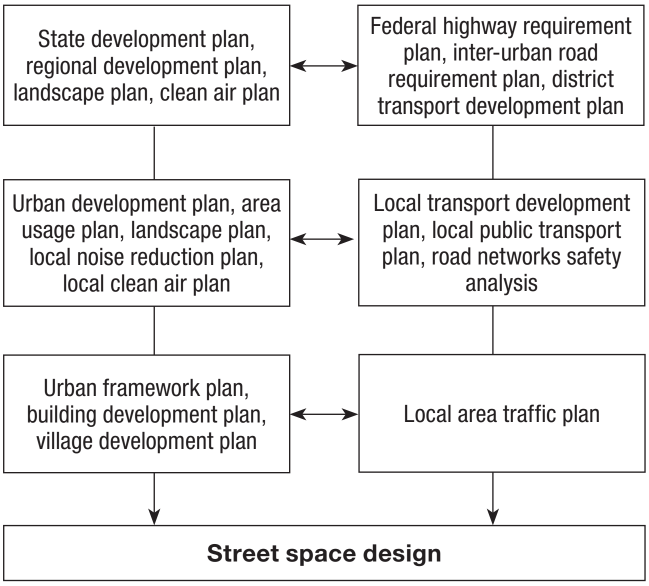

Figure 8: local bases for design directives

is required depending on the complexity of the design task and where a design rationale is required.. All cases require consideration of the locality. The use of media such as video and photos (including aerial shots) can be of assistance in this, for the designer but is no substitute for actually making site visits.

A step-by-step, problem-oriented approach avoids creating unnecessarily large volumes of data. It simplifies the development of the argument regarding design measures and action plans involving politicians and the local people concerned.

The need for extra data may increase during the design process because of specific problems (such as parking in shopping streets).

The data collection effort can be reduced by appropriate involvement of stakeholders and politicians and by evaluation of existing plans or reports.

The use of **street space** can usually only be identified by sampling over limited periods. Where there is a wide variance depending on time, data should be collected and surveys conducted at different times and locations based on the different uses and supplemented by assessment of the behaviours observed.

Any uses not identifiable during the observation period due to variations during the day or day of the week, fluctuations and particular events (such as weekly markets, particular shopping patterns, shift changes at local factories, beginning/end of the school day) should be considered individually and alongside more general trends.

Accident statistics are assessed generally by checking the safety potential on the basis of the "Recommendations for safety analysis of road networks" (ESN)6) and based on the individual locations using the accident-type charts, relating to the identification of accident clusters according to the "Fact sheet for evaluation of road traffic accidents"7).

Analysis of **accident statistics** is particularly important in planning the redesign of existing installations.

When remodelling or expanding existing stretches of road, the accident statistics of the last three years must be considered and taken into account in the design:

- Safety potential: If the safety potential ('SiPo') calculated according to the ESN is more than 50 % greater than the basic accident cost density ('gUKD') (SiPo > 0.5 gUKD), this means that prior to any remodelling there are significant safety deficits on the road. The accident statistics must be evaluated in detail and taken into account when choosing the recommended profiles and in the individual design layout of the road.
- Location-specific evaluation of accident statistics: Suitable bases for evaluation of accident statistics are the 3-year record of serious accidents (accidents involving personal injury or serious personal injury) and the 1-year chart of all accidents recorded by the police.

Characteristics of the **street space** in addition to its demarcation, width and alignment (see section 2.3) could be the –:

- Street cross sections
- Squares and square-like widening of the street
- Buildings (layout, design, corners, historical importance)
- Adjoining open spaces
- Vernacular elements (front gardens, stairs)
- Materials and surface designs typical of the location
- Distinctive green elements

can be mapped and depicted.

If the particular urban context makes the production of an "urban design analysis" useful or necessary, then this work should be guided by the maximum costs as in the ESG*).

The **surrounding uses** are determined by referring to current land registry mapping, local documentation and existing urban planning. This usually involves recording:

- the type and level of surrounding uses (such as residential buildings, number of occupants, business occupancy, number of floors, traffic-generating activities, car parking);
- the kinds of use of open space; and
- indicators of possible changes (such as facade and structural condition, modernisation activity, evidence of expanding businesses or conversely empty shops).

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6) "Recommendations for safety analysis of road networks" (ESN), edition 2003, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2003.

7) "Fact sheet for evaluation of road traffic accidents, part 1: Compilation and evaluation of accident type charts", edition 2003, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2003.

*) "Recommendations for street space design within built-up areas" (ESG), edition 2011, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2011.

The **condition assessment** essentially consists of a comparison of the design principles against the project-specific objectives and identification of deficiencies and shortcomings as the basis for developing design measures.

3.4 Design process

Although the basic structure of planning and design processes is fixed, it is neither useful nor possible to impose binding directives on such a highly creative, skills and experience-based activity. These directives provide designers with two basic routes towards solutions (figure 9):

The First approach is a "guided" design process, with allocation of the design task to one or – in the case of creating 'places' along the road – several typical design solutions; and selection of a recommended solution according to the constraints of the cross-section, the appropriate junction and the means of linking these two.

The Second approach is a "custom" design process with consideration of the individual objectives, user requirements and design directives based on appropriate selection and combination of design elements aided by an urban design assessment.

Urban design assessment (figure 10) is a process which sets reasonably justifiable dimensions for footway space against the dimensions required at street level for the carriageway, separate public transport lanes and cycle paths. Its objective is to implement street space design from the edges inwards.

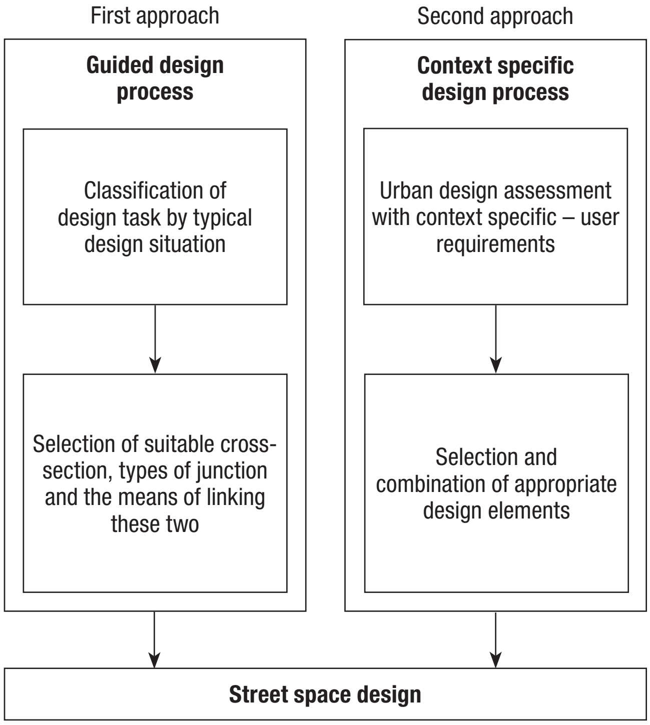


Figure 9: Structure of design processes

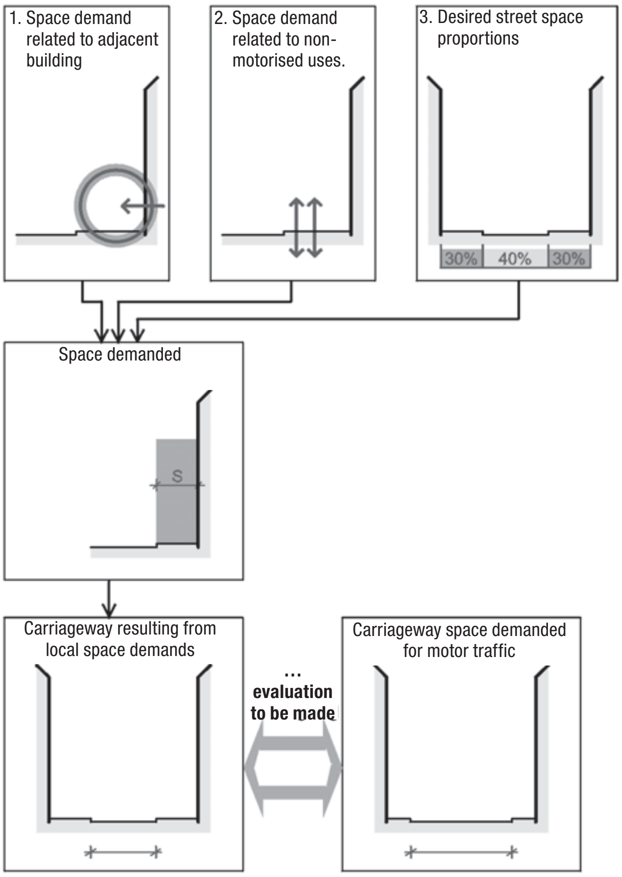


Figure 10: Urban design assessment

Urban design assessment is based on three factors:

- Between the pedestrian pathway and the facades of the street a space should be allowed where the needs of the adjoining uses can be met (amenity space, commercial areas, space for front gardens).
- Space must be provided both for pedestrian traffic and for cycle traffic where appropriate, according to the importance of the street.
- For the ease and comfort of pedestrians, the side of the street must be of a comfortable width relative to the carriageway. A ratio between side spaces and road space of 30 : 40 : 30 is perceived as agreeable.

From these three factors the **required** width can be determined. The difference between this and the overall width of the space produces the **developmentally possible** width of the carriageway. This must be balanced with the carriageway width **necessary** to handle the traffic load. These considerations must incorporate all issues relating to uniform or varying carriageway width, lane width, the addition or shared running space for specific modes and the relocation of parked traffic in the stretch of street, with the their predictable consequences (see section 3.5).

Whereas in the case of the "Recommended solutions for typical design situations" (section 5) it can be assumed that the possibilities and conditions for application of the various design elements – also with regard to their combination options and their integration into the overall design – are assured, in the case of the custom design this must be assured by the designer. An essential element in both cases during the design phase is a direct consideration of the locality and the overall space, which usually cannot be achieved solely by evaluating documentation media used to assess the initial status.

With regard to road safety, both in applying the recommended solutions as set out in section 5 and in the custom design process the following points must be considered:

- If crossing accidents (accidents involving pedestrians crossing) predominate on certain stretches of road, either profiles with central reservations should preferentially be used or – if that is not possible – adequate visual contact must be ensured by installing more frequent breaks in parking spaces and by keeping speeds appropriately low (see section 6.2).
- Where there are clusters of pedestrian accidents at certain points, crossing opportunities (such as islands, marked crossings or traffic lights) should be installed. Such areas must be kept clear of parked vehicles (no parking space allocation or loading bays). The carriageway edges must then be engineered to obstruct resting traffic (by measures such as posts or bollards).
- If accident statistics are dominated by accidents involving cyclists, or if accidents involving cyclists and pedestrians occur in roughly equal measure, it must be ensured that necessary cycle paths are located within sight of the motorised traffic – that is to say, protected lanes or cycle lanes should be preferred over cycle paths behind parked vehicles.
- If accidents generally have serious consequences (increased incidence in 3-year charts of accident categories involving personal injury ‘P’, or serious personal injury ‘SP’), this indicates inappropriately high speeds, and speed-calming measures must be deployed (see section 6.2).
- If there are accident clusters at intersections, countermeasures must be included in planning in accordance with the “Fact sheet for evaluation of road traffic accidents”.

In order to depict the possible effects of different focuses and prioritisations, it may be useful to draw up multiple design variants for specific street spaces.

3.5 Impact assessment, evaluation and balancing of interests

As the basis for the assessment, the effects of the developed design measures should be estimated. This should consider that the impact of an individual element (such as on vehicle speed) is difficult to specify without taking into account the specific overall situation, and so the overall impact cannot be derived from individual design elements.

Rather, what is required is an assessment of the impact of the planned draft measures across all target areas.

For most of the target areas to be considered suitable methods of impact assessment exist:

- Communal practicality and elimination of barriers:
  - Audit of traffic space design and crime prevention[8)]
  - User-friendly and access-friendly design of the street space[9)]
- Street space layout:
  - Urban planning measurement[10)]
- Balancing with surrounding needs:
  - Sustainability analyses[11)]
- Traffic flows:
  - Configuration of road traffic installations[12)]
- Road safety:
  - Road Safety audit [13)]
  - Road safety rating[14)]
- Cost-effectiveness:
  - Cost/benefit studies[15)].

Other useful aids may be comparative analysis of documented case examples as well as suitable cost/benefit considerations.

Balancing of the individual assessment results is based on the project-specific objectives, giving due consideration to multi-locational design precepts.

Practical experience shows that in many cases balancing the needs of flowing and resting motor vehicle traffic on the one hand and the needs of local public transport, non-motorised traffic and non-traffic road usage on the other is essential. When weighting these competing needs, taking into account the basic weightings from traffic development planning and local transport planning (such as operational impact on the individual variants) in particular the ability to relocate usage needs (such as motor vehicle parking outside of the street space) and justifiable or acceptable loads need to be assessed. This must always consider the retroactive impact on objectives and design precepts.

In view of the desired unity of construction and operation, questions of traffic control must be agreed in good time with the competent road traffic authorities, the police and – where affected – the technical supervisory bodies.

[8)] Communal safety in the street space – Guide to auditing of the public space in remodelling of existing installations, new design and planning; Recommendation of the Traffic Engineering Institute of the Federation of German insurers, No. 16, Berlin 2006.

[9)] User-friendly and access-friendly design of the street space, improving traffic in local communities; ‘direkt 54’, Federal Ministry of Transport, Construction and Housing, Bonn 2000.

[10)] “Recommendations for street space design within built-up areas” (ESG), edition 2011, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2011.

[11)] FGSV working paper no. 41: “Sustainability analyses in local traffic planning”, edition 1996, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1996.

[12)] Handbook for configuration of road traffic installations (HBS), 2001 issue, as amended in 2009, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2001/2009.

[13)] “Recommendations for safety auditing of roads” (ESAS), edition 2002, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2002.

[14)] Handbook for the assessment of road safety, FA 3 389 on behalf of Federal Ministry of Transport, Construction and Urban Development, in work.

[15)] “Recommendations for cost/benefit studies in relation to roads” (EWS) – update to RAS-W 86, draft, edition 1997, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1997.

As the result of the assessment and the balancing considerations, design measures should be produced which enable a policy decision to be made which is assured of consent from the parties concerned.

3.6 Planning stages and presentation

The visual presentation of design measures using three-dimensional drawings and traceable documentation of the objectives pursued by the street space design, the attainment of objectives and the various needs involved

- provides the affected parties with the opportunity to contribute their local knowledge and expectations to the design process;
- provides the policy decision-makers with a basis for decision-making;
- makes decisions more transparent to the affected parties;
- helps the affected parties and the decision-makers to comprehend the underlying idea and see how the design has been derived from it, and to make the necessary decisions; and
- provides designers with a means of monitoring their own work.

In addition to depicting the starting situation, setting out the concept underlying the design and describing the design elements, the explanatory report should also contain information on traffic volumes, key routes for pedestrians and cyclists, accident statistics, etc.

Design measures are initially drawn up and agreed in the **preliminary planning** stage, usually in a range of variants. However, the extensive process of recording the status required for this extends well beyond the “Identifying basics” stage of the HOAI. Views are usually presentation to 1 : 500 or 1 : 1000 scale, including details of profile division, intersection types, etc.

Following on from the basic agreement in principle, for the processing of **preliminary drafts** (according to the HOAI design planning procedure) up-to-date planning documents to 1 : 250 (1 : 200) or 1 : 500 scale are required which depict the complete planning area by location and altitude, in order to permit satisfactory integration of the design and construction process into the locality and to enable cost-effective implementation of the underlying design concept. Preliminary drafts should be developed from the preliminary plans and specify all key design elements by location and altitude as well as detailing the planned traffic installations (e.g. traffic lights), traffic control measures (e.g. guidance systems), civil engineering aspects (e.g. surface materials, design of dewatering systems) and layout features (e.g. street-lighting locations). This design phase should also present graphical verifications of tractrix curves and visibility splays.

Construction plans (according to HOAI execution planning) should ideally be to 1 : 250 (1 : 200) or 1 : 500 scale. As developments of the preliminary drafts, they contain all the dimensions and constructional measures necessary to mark out and execute the project. They form the basis for tendering.

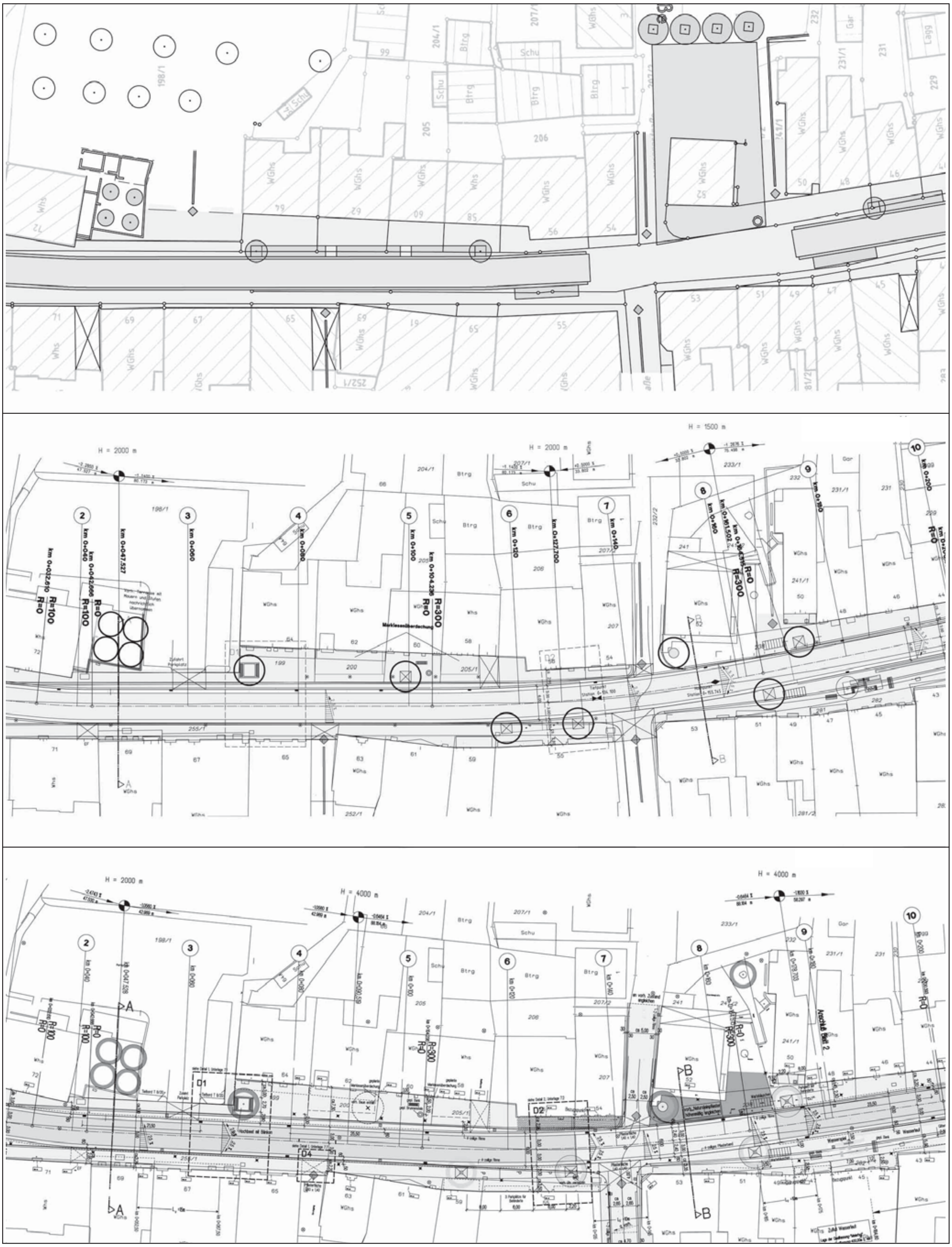


Figure 11: Example of planning stages for a street design: Preliminary draft (top), detailed development (middle) and implementation planning (bottom)

4 Street space users' needs

4.1 Basic considerations

Depending on the different infrastructural and traffic features of urban roads (see 3), user needs also vary in terms of:

– qualitative aspects;

– traffic volumes;

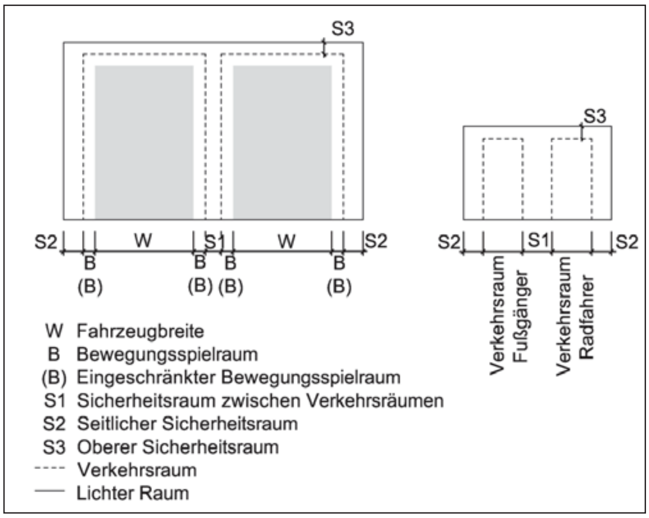
– speeds; and

– specific space requirement.

The following sets out the **specific space requirements** of the various traffic modes.

Basic dimensions of the space required for motorised traffic, including local public transport, derives from vehicle width, plus a **movement clearance** both above and to the sides, and applies for driving straight-ahead, cornering, joining a main arterial road from a side road and emerging from parking spaces.

These clearances are usually 0.25 m when meeting oncoming vehicles, driving alongside and passing cars and trucks. In exceptional cases (where there is restricted movement clearance) they may be reduced to 0.20 m in the case of buses and trucks, specific to vehicle, and 0.15 m in the case of cars (table 2).



W	Vehicle width
B	Manoeuvring tolerance
(B)	Manoeuvring tolerance in restricted situations
S1	Safety area between vehicle envelopes
S2	lateral safety space
S3	Overhead safety space
- - -	Traffic envelope
–––	Clearance (to the sides and overhead, for lighting (etc)) - Pedestrian traffic Envelope - Cyclist traffic Envelope

Figure 12: Space requirements for motor vehicles[16] (including public transport), pedestrians and cyclists

Table 2: Dimensions for manoeuvring tolerance B and for restricted situations (B)

Vehicle type	B	(B)
Car	0.25 m	0.15 m
Van	0.25 m	0.20 m
Truck	0.25 m	0.20 m
Bus	0.25 m	0.20 m
Tram	0.30 m	–

Basic clearance dimensions are derived by adding safety clearances to the 'vehicle envelopes'. The safety clearance **S1** is usually 0.25 m; between buses it is increased to 0.40 m: for cyclists it is 0.75 m. The side safety clearances **S2**, alongside moving and parked motor vehicles, are usually 0.50 m. In the context of restricted space for manoeuvre, they may be reduced to 0.25 m, or where motor vehicles approach each other (but not cyclists) they may be omitted altogether (S1 = 0.00 m). In the case of driving alongside or passing, and including the case where there is restricted movement clearance, a safety clearance S1 of 0.25 m is retained. The overhead safety clearance **S3** is always 0.30 m (figure 12).

Basic dimensions for pedestrians and cyclist traffic envelopes are 1.00 m each. Safety clearances or width allowances are added to the available **clearance** specific to context.

4.2 Public transport

Public transport provides both access and linkage functions, typically on urban streets which are of greater importance in the road network than for access purposes alone. Its passengers require punctuality and reliability. Whilst users need to be transported as close as possible to a destination; the routes also need to be covered in short running times.

Basic dimensions for the space requirements of trams[17] are derived from the relevant envelope (vehicle dimensions and movement clearances), the safety clearances, the swept path on cornering according to vehicle, and additional area for passenger interchange at stops.

The vehicle widths W (usually W = 2.40 m to W = 2.65 m) result in an approximate traffic envelope, for passing trams, of 2W + 1.00 m. Where there are pylons between the tracks, the profile must be expanded accordingly. Owing to the rail-bound nature of the mode, the traffic envelope is not dependent on speed.[18]

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[16] The width of the standard vehicles is indicated in the publication: "Standard vehicles and swept paths for verification of driveability of traffic areas", edition 2001, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2001.

[17] From here forwards in the document the word 'tram' is used as an umbrella term for tram and rail-bound rapid transit systems in general, as Germany's Passenger Transport Act (Personenbeförderungsgesetz; PBefG) defines only the tram ("Straßenbahn").

[18] When installing particular sections of rail, additional safety clearances may be required in order to comply with accident prevention regulations.

Basic measures for clearances are derived by adding side and upper safety clearances to the traffic envelope, in dimensions specified according to the BOStrab clearance directives.[19] The measures are determined in individual cases by the transport operator concerned based on the vehicles deployed and the track infrastructure (figures 13 and 14).

The **traffic envelope for buses** is derived from the vehicle widths and movement clearances of 2 x 0.25 m per vehicle when meeting oncoming traffic, passing, and driving alongside other traffic. The traffic envelope of buses in two-way operation, with a vehicle width of 2.55 m, is 6.50 m with a safety clearance of 0.40 m. Basic dimensions for the clearances are derived from the traffic envelope plus a safety clearance of 0.50 m on each side (figure 15).

In the case of scheduled bus services, the traffic envelope for buses meeting each other is usually 6.50 m wide. In other cases – with a lower frequency of bus journeys; where local public transport plays a lesser role; where buses meet less frequently en route and; where there are appropriate passing points, this measure may be reduced to 6.00 m where space is restricted and omitting the safety clearance (figure 16).

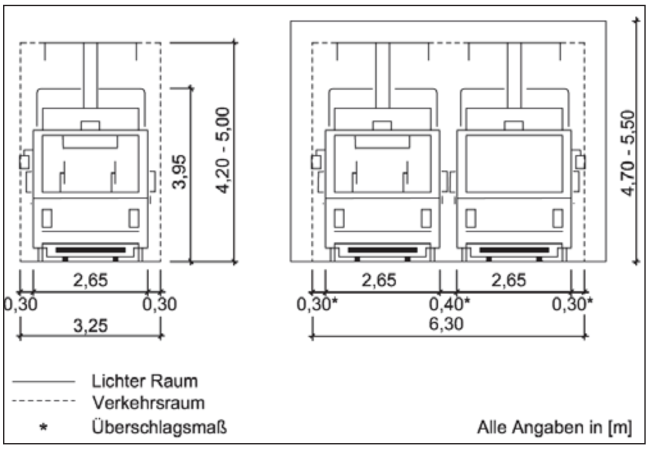

Figure 13: Basic dimensions for traffic envelopes and clearances of trams with a maximum vehicle width (W = 2.65 m)

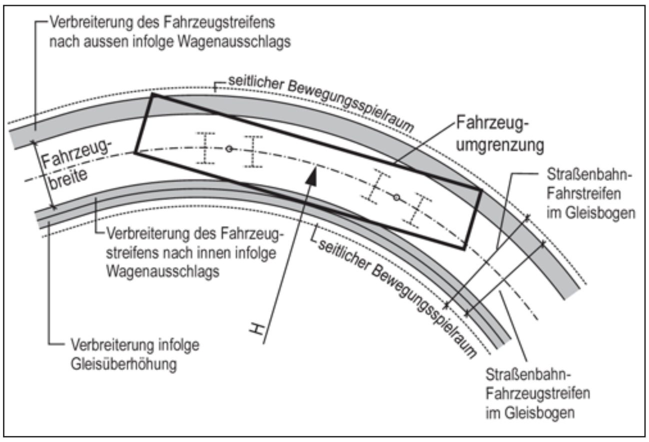

Figure 14: Example of widening of swept path for trams on bends

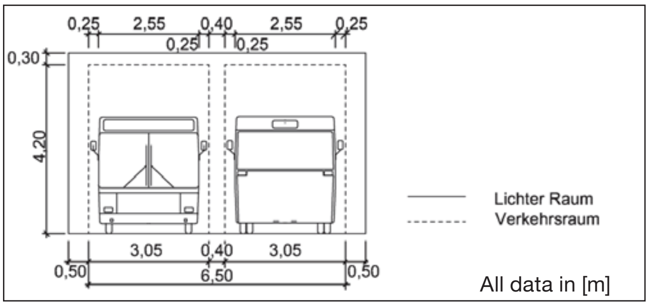

Figure 15: Basic dimensions for traffic envelopes and clearances of buses with maximum vehicle width (W = 2.55 m)

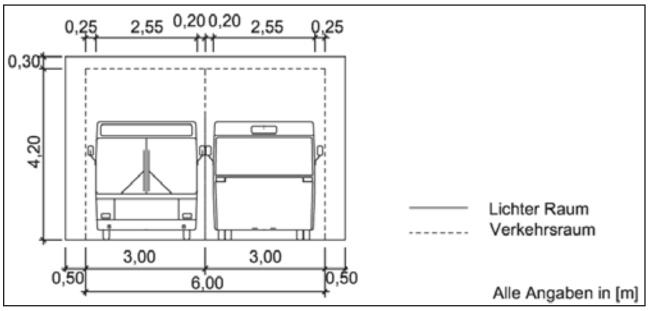

Figure 16: Minimum dimensions for traffic envelopes and clearances of buses in case of restricted movement clearances

The area required for buses when cornering and when making turns can be determined for various radii by using the ‘swept path’ templates available in the publication: “Standard vehicles types and swept path curves to ascertain roadway driveability”[20] or, from local public transport operators.

4.3 Flows of vehicular traffic

The importance of the access and linking function of urban streets sets the context for motor vehicle traffic flows. This is then used to determine the volume and composition of motor vehicle traffic which is appropriate to the street in question. If the available street space (its width, mainly) and the space requirements of other users make it necessary (see section 3.4), then ‘restricted movement clearances’ can be applied and in some cases the ‘safety clearances’ can be omitted (figure 17).

Allowance for restricted movement clearances usually requires low speeds (≤ 40 km/h) and careful driving, supported by appropriate design and traffic controls.

The examples of the space requirements in figure 17 represent a selection of possible situations. They are not intended as the means of deriving roadway widths but for reviewing the possible functional suitability of designs. They relate to two-way traffic, driving alongside and pass-

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[19] Provisional directives for measurement of the clearance of rail vehicles according to the Regulation governing the construction and operation of trams; Tram construction and operating regulations (BOStrab) (BOStrab clearance directives dated December 1996).

[20] “Standard vehicles and tractrix curves for verification of driveability of traffic areas”, edition 2001, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2001.

ing other traffic, for a range of vehicle combinations. The appropriate standard vehicles and measurement cases should be applied in each case.

4.4 Car parking

The need for parking arises from the access function of streets in built-up areas.[21]

Basic dimensions for car parking depend on

- the dimensions of the selected standard vehicle (its wheelbase, overhang, length, width, turning circle),
- whether drivers enter or leave a parking space driving forwards or reverse, and
- with or without manoeuvring and
- the space required dependent on the angle to the street (longitudinal, oblique, perpendicular) and
- on parking accuracy.

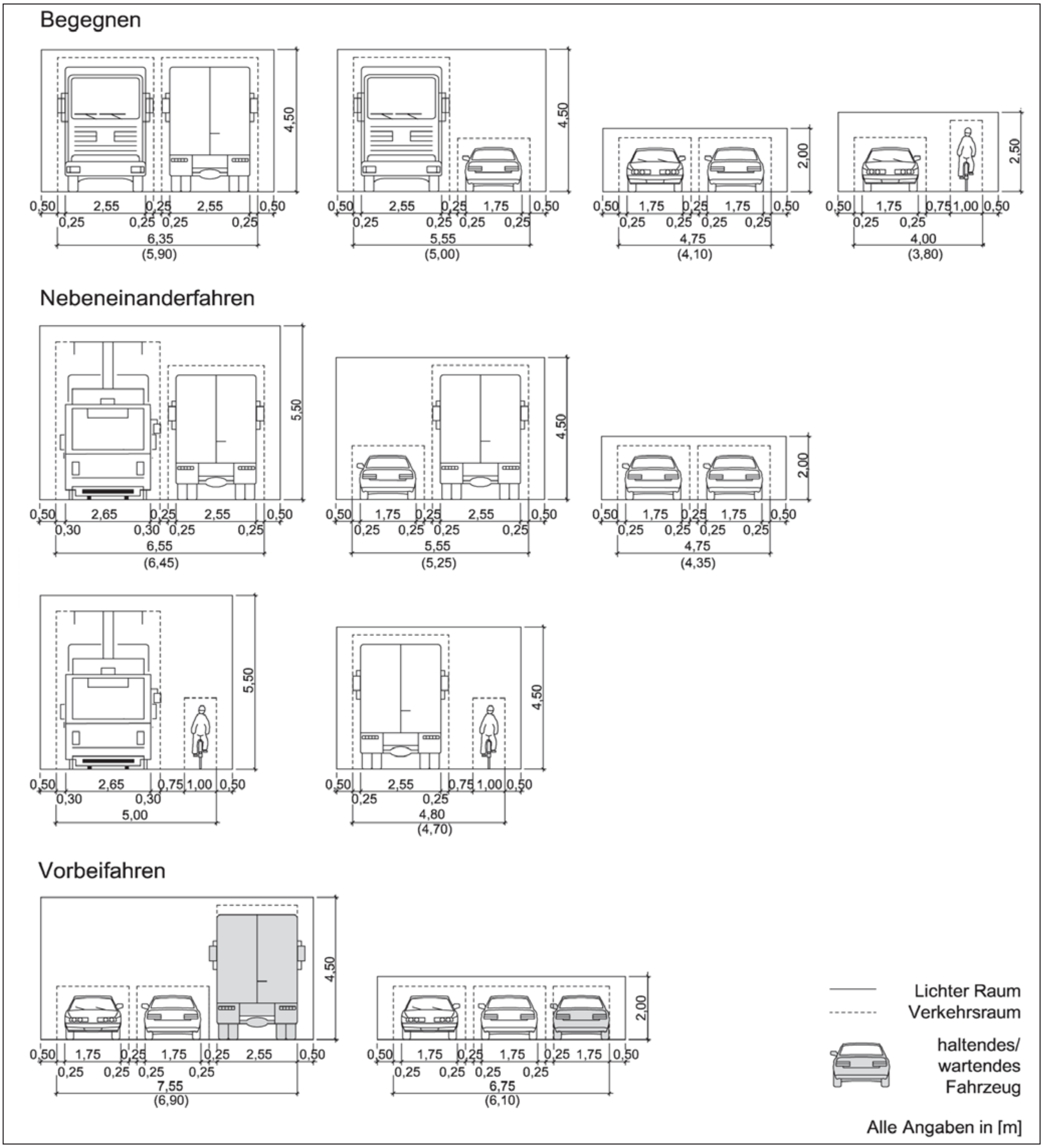

Figure 17: Examples of traffic envelopes and clearances where selected combinations of standard vehicles meet on two-way streets, drive alongside and pass each other (measures in brackets: restricted clearances apply)

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[21] For basic considerations and further detailing see "Recommendations for parking installations" (EAR), edition 2005, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2005.

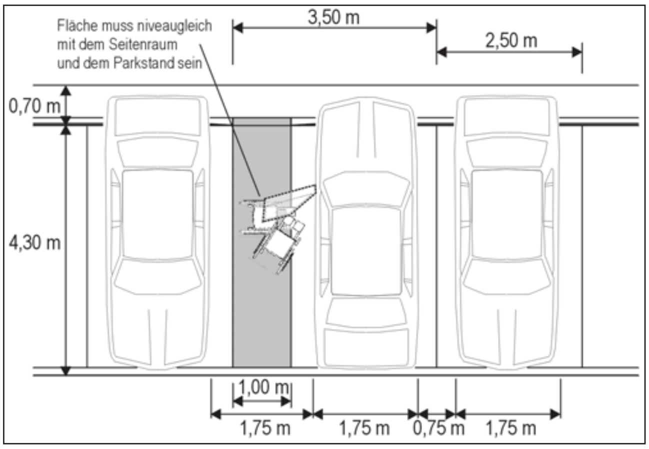

Figure 18: Basic measures for car parking

Comfortable vehicle entry and exit requires a 0.75 m side clearance between parked vehicles and solid obstacles. In the case of parking bays for wheelchair users, a clearance of 1.75 m must be allowed on one side of the vehicle. From that point there must be direct barrier-free access to the footway (figure 18).

4.5 Delivery and loading

The space requirements for delivery and loading depend on the dimensions of the vehicles used and extra clearance needed for vehicle tail-lifts as well as for unloading the goods in transit.

Additional areas for unloaded goods (approximately 3 m² to 5 m²) are desirable in the footway spaces adjacent to the cycle path and footway.

4.6 Cycle traffic

The requirements for cycling depend on the importance and location of the street within the local and inter-urban cycle network.[22)]

The cyclist's needs are primarily determined by the importance of the link function, safety aspects (especially at junctions) and the level of performance intended (e.g. fast journey times or opportunities for overtaking).

When planning for cycling, changes in the nature and extent of uses along a route may entail specific changes in the level of cycling provision in response.

Basic dimensions for the space requirements of cycle traffic are derived from the basic width and height of a cyclist and the required movement clearances (figure 19).

The safety clearances set out in table 3 should be included when configuring cycle traffic installations.

Figure 19 shows necessary widths for handling cycle traffic.

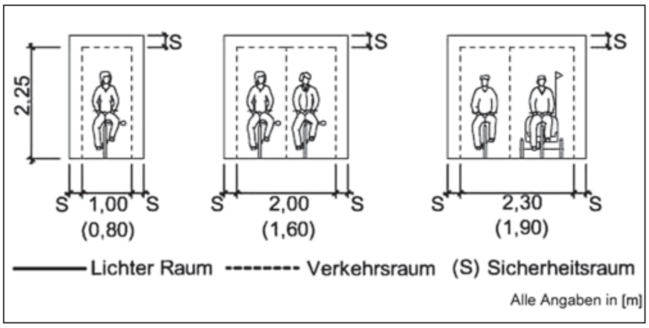

Figure 19: Basic dimensions for the space requirements and clearances of cycle traffic (figures in brackets relate to tight spaces)

Table 3: Additional safety clearances for cycle traffic installations

Distance	Safety clearance
from kerb	0.50 m
from parallel parked vehicles	0.75 m
from vehicles parked at an oblique angle or perpendicular to the kerb	0.25 m
from pedestrian traffic areas	0.25 m
from buildings, fencing, tree grates, traffic installations and other infrastructure	0.25 m

4.7 Pedestrian traffic, social use and elimination of barriers

For pedestrian traffic the need for social use (for residents, shop displays, working in the street space, play) and elimination of barriers occur along all built-up streets.[23)]

The nature of those needs varies widely depending on the adjoining uses and building types and on the location and importance of the street space within the pedestrian movement network.

Basic dimensions for pedestrian traffic are derived from the basic width and height of pedestrians and the minimum necessary manoeuvring space (figure 20).

The safety clearances for pedestrians, uses the same figures used for cyclists. The safety clearances of pedestrians and cyclists may also overlap.

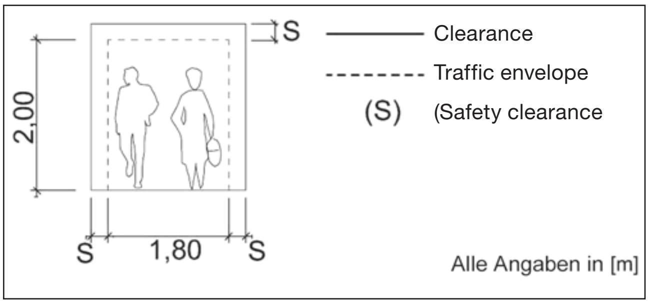

Figure 20: Basic dimensions for traffic envelope and clearance areas of pedestrian traffic

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[22)] For basic considerations and further detailing see "Recommendations for cycle traffic installations" (ERA), edition 2010, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2010.

[23)] For basic considerations and further detailing see "Recommendations for pedestrian traffic installations" (EFA), edition 2002, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2002.

Table 4: Overview of width and length requirement for persons with restricted mobility

Persons with restricted mobility	Width	Length
Blind person with white cane	1.20 m	–
Blind person with guide dog	1.20 m	–
Blind person with accompanying person	1.30 m	–
Person with stick	0.85 m	–
Person with crutches	1.00 m	–
Person with wheelchair	1.10 m	–
Person with pram	1.00 m	2.00 m
Wheelchair with an accompanying person	1.00 m	2.50 m

Basic dimensions for persons with restricted mobility[24] include the space requirements of persons using a stick or crutches, blind persons using a stick or accompanied by a guide dog or other person, or derived from the dimensions of wheelchairs and their manoeuvring space (figure 21).

In the German Disability Rights Act (Behindertengleichstellungsgesetz), the characteristic of being free of barriers is defined as follows: "Barrier-free in relation to building structures and other installations, means of transport, technical equipment, information processing systems, acoustic and visual information sources and communications systems and other elements of the built environment, means that they are accessible to and usable by disabled persons in the general customary way, without particular difficulty and essentially unassisted."[25]

Many disabilities are likely to impair mobility. People may also be restricted in their mobility because of old age, or people of any age may be temporarily handicapped because of illness or injury. The proportion of such persons among the general population will increase in view of projected future demographic trends.

Freedom from barriers also relates to people pushing babies or small children in prams or pushchairs. Their mobility may be impaired if they have difficulty in entering or exiting public transport, or when pavements are blocked by parked vehicles. Achieving barrier-free use of public transport means that the floor-height of the vehicle and the kerb at stops must be level.

A city street can be described as being barrier-free if it can be used accordingly in all its parts.[26]

Basic dimensions for recreational areas cannot be specified due to the diversity, in terms of both time and space, of different overlapping uses (such as children playing). The basic dimensions of typical elements can be used as guidance (table 25).

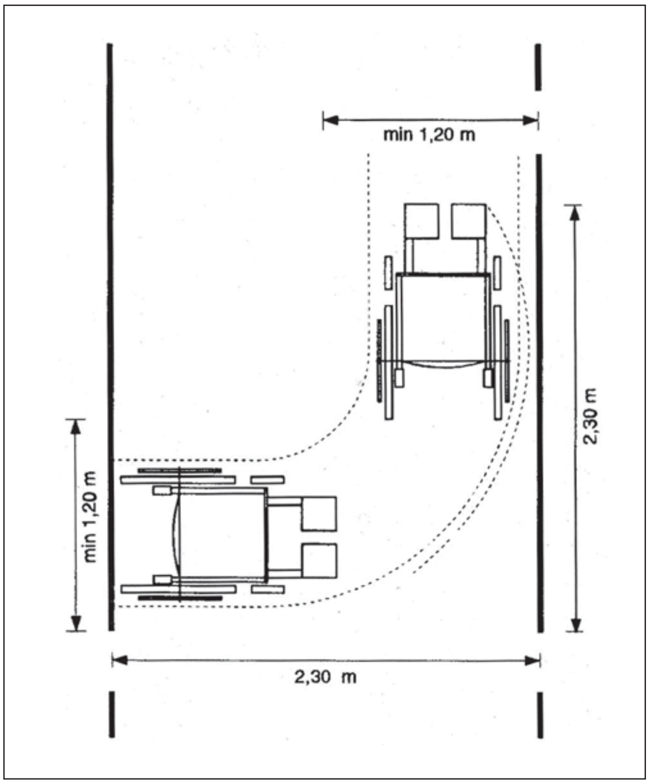

Figure 21: Area requirements for a wheelchair on bends

4.8 Greening[27]

For the greening of street spaces, requirements grow out of ecological and aesthetic objectives. In this, a distinction must be made between large scale objectives (separation or interlinking of ecologically important systems in terms of urban design, and the highlighting of such systems by the design) and small-scale requirements (layout, conservation of planted areas and trees, reducing areas of paving, highlighting areas of different function).

Basic dimensions of the space requirements for vegetation are derived from the above-ground and underground space required for the cultivation of trees and shrubbery according to their type and function. Of all plantings, trees make the greatest demands on space, because – alongside their above-ground mass – they also require a large root base, to provide stability and to enable sufficient water and nutrients to be absorbed.

In order to estimate the anticipated volume of the crown, individual trees are classified as:

- Class I trees (large trees growing to a height of > 20 m)
- Class II trees (medium-sized trees growing to a height of 15 to 20 m)
- Class III trees (small trees growing to a height of 7 to 15 m)

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[24] User-friendly and access-friendly design of streetspace, improving traffic in local communities; 'direkt 54', Federal Ministry of Transport, Construction and Housing, Bonn 2000.

[25] § 4 BGG (Disability Rights Act)

[26] "Instructions for the design of barrier-free traffic installations", in progress; Forschungsgesellschaft für Straßen- und Verkehrswesen.

[27] "Instructions for roadside planting in built-up areas", edition 2006, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2006.

Taking into account the growth of different species, the above-ground space requirements for full-grown trees are:

- for large trees up to 4,000 m³ or more;
- for medium-sized trees up to 1,500 m³ or more;
- for small trees up to 1,000 m³ or more.

If the expected space requirement above-ground is not available within the street, a tree from a smaller category should be used, or no tree planting should be undertaken. In tight spaces, smaller trees or trees with a particular growth form (such as with a tapering, pyramid-shaped or spherical crown) should be considered.[28)]

When planting trees, it is useful to adhere to the clearances set out in table 5.

Table 5: Clearances between trees and trafficked areas, buildings and technical installations

Traffic areas, buildings, technical installations	Distance
Cycle traffic area	≥ 0.75 m
Motor vehicle traffic area	≥ 1.00 m
Rail traffic area	≥ 2.00 m
Buildings, narrow-crowned trees and large-crowned trees	≥ 3.00 m ≥ 7.00 m
Walk-in cable tunnels	≥ 1.50 m
Underground pipes/cables	≥ 2.00 m
Lights	≥ 3.00 m

Attention must be paid to the differing root diameters. On existing roads, these minimum clearances can frequently not be maintained due to the fixed locations of underground pipes or cables and the available street space width. In such cases the distance to underground pipes/cables can be reduced to 1.00 m provided appropriate protective measures are taken.

Alongside urban roads, only method 2 according to the “Recommendations for tree planting” should be used to create the planting pit (figure 22).

The planting pit should be constructed in such a manner that the tree grate is as large as possible. The distance from the trunk must always be at least 50 cm. A tree grate should be provided which is at least 4 m² (better still: 9 m²) and permanently permeable to water and air. This requirement cannot always be achieved on existing urban roads and therefore adequate living conditions for trees must be created by suitable site improvement measures.

To achieve the required underground growth space, measures to expand the ground through which roots can grow are required. Depending on the local site factors and underground conditions, this may require aeration in the form of:

- horizontal aeration;
- trench aeration; and/or
- deep-level aeration.

Further instructions are contained in the “Recommendations for tree planting”[29)].

4.9 Utilities

The Utilities’ requirements for street space relate to the underground location of pipes and cables, meeting the needs of utility and emergency services vehicles (refuse disposal, street cleaning, snow clearing, the fire service) and the positioning of refuse bin containers.

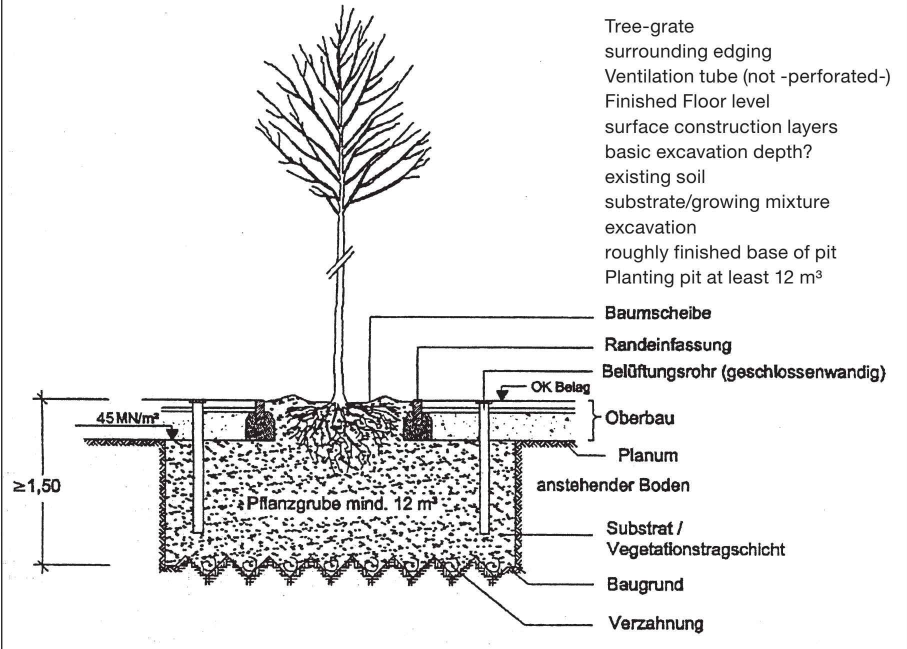

Figure 22: Planting pit construction method 2 (pit partially or fully built over)

[28)] Basic dimensions for the space requirements of trees are derived from the “Recommendations for tree planting, part 2: Preparing locations for new planting, ditches and root chamber extensions, construction methods and substrates”, edition 2004, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (Landscape development and construction research society), Bonn 2004.

[29)] “Recommendations for tree planting, part 2: Preparing locations for new planting, ditches and root chamber extensions, construction methods and substrates”, edition 2004, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (Landscape development and construction research society), Bonn 2004.

Basic dimensions for underground utility pipes and cables and their appropriate location in the street are shown in figure 23.

Telecoms and power cables should be at least 0.60 m deep and in the case of gas and water pipes, at least 1.00 m, unless any required crossovers for house connections require other depths.

It is preferable that sewers and gas pipelines are laid under the carriageway, whereas utility lines are laid beneath footways and any separating areas on both sides of the road, so that they can be maintained and repaired easily and reusable materials can be employed to retain the unity of design and the look of the place. Pipes and cables in the carriageway or gutter area should be laid close to the edges, so that installation, repair and cleaning work does not excessively impede the traffic flow. However, sewer and drain covers should not be located in the wheel tracks of motor vehicles or in gutters. The layout of electricity, gas and water supply pipes and telecoms cables can be adapted to the locations of trees.

District heating pipes are approximately 1.00 m (to 2.00 m) wide and 0.60 m high, with a coverage of 1.20 m. Expansion joints (with access pits) require an area of approximately 4.00 x 2.00 m.

If, when planting trees, a minimum clearance of 2.50 m between the outer skin of the trunk and of the utility installation is not observed, then in each case a review needs to be undertaken to define protective measures to prevent penetration by roots.

Requirements for above-ground utilities arise from the demands of the fire service, street cleaning and refuse disposal services. Dimensions are derived from the respective vehicles used.

Distribution boxes for telecommunications systems require an area of approximately 0.50 x 1.00 m. A local network substation requires 3.00 x 6.00 m, and a compact substation approximately 1.00 x 2.00 m. Public telephones require an area of 1.00 x 1.50 m.

Fire service vehicles do not exceed the dimensions allowable by German road traffic licensing regulations (StVZO). The width of access areas and the provision of adequate ladder and set-up space must be balanced in each case with the technical capabilities of the local fire service.

Regardless of that provision, according to DIN 14090[31] in the case of buildings with windows over 8.00 m, a working space with a minimum width of 3.50 m and of sufficient length must be provided, at least in sections, at a maximum 9.00 m and minimum 3.00 m distance from the building front.

Street cleaning and refuse disposal vehicles do not reach all the maximum permissible dimensions set by StVZO, but are frequently 2.55 m wide. In confined spaces, the service may use smaller vehicles, in consultation with the public utilities concerned.

Vehicles for street cleaning and clearing winter snow and ice on footpaths, even if they conform to the provisions of § 35 para. 6 clauses 1 and 2 StVO, require reinforced pavements capable of withstanding such forms of cleaning

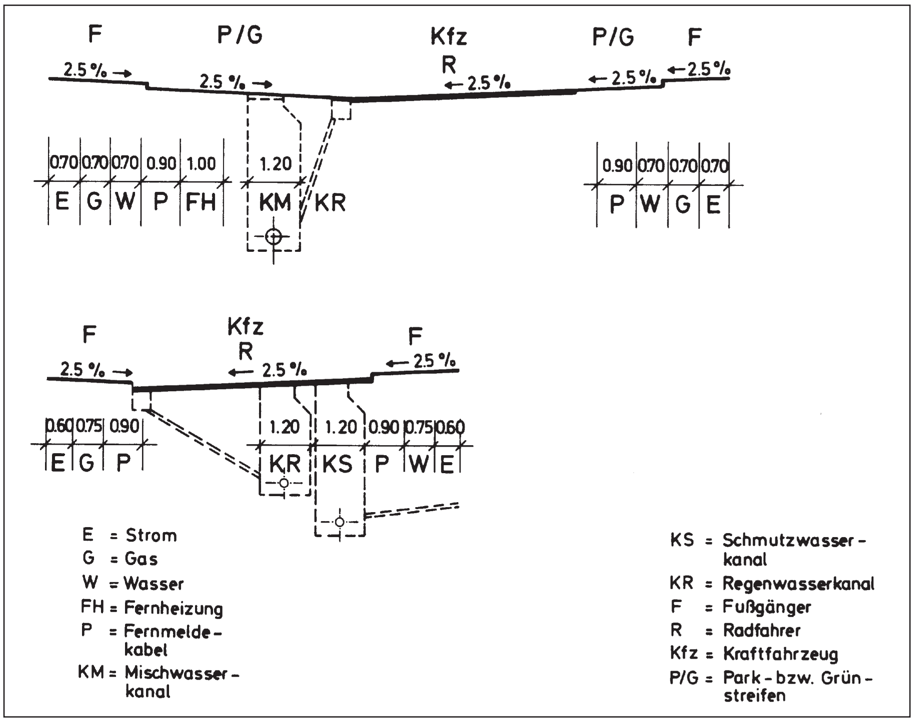

Figure 23: Basic widths of utility pipes and cables and their recommended layout in the street (DIN 1998)[30]

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[30] DIN 1998: Location of pipes and cables and installations in public areas; directives for planning; edition 1978-05; German Standardisation Institute, Berlin 1978.

[31] DIN 14090: Areas for the fire service on properties, edition 2003-05, German Standardisation Institute, Berlin 2003.

without damage. Any installations in the footpaths must be separated by at least 1.50 m to enable cleaning vehicles to travel along uninterrupted.

4.10 Special usage requirements

Special requirements arise for some main arterial roads where the use of vehicles with dimensions, axle loads or gross vehicle weight ratings exceed the limits generally permitted by law (StVZO). They include large agricultural and forestry vehicles, special-purpose vehicles operated by civil defence and the military, as well as other large-capacity and heavy-duty transports.

Basic dimensions for the traffic areas needed by special vehicles derive from the dimensions of the vehicles concerned (width, height, length, wheelbase, overhang, turning circle) plus their upper and side movement clearances, though they must be kept tight.

According to regulations (StVZO), special agricultural and forestry vehicles, such as combined harvesters, may be 3.00 m wide.

Heavy military vehicles can be up to 4.00 m wide, and according to the "Directives for the layout and construction of roads for heavy-duty military vehicles" (RABS)32) width increases of up to 1.50 m must be incorporated to take account of different speeds.

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32) "Directives for the layout and construction of roads for heavy-duty military vehicles" (RABS), edition 1996, Federal Ministry of Transport, Bonn 1996.

5 Recommended solutions for typical design situations

5.1 Introduction

The following section sets out 12 **typical design situations**. The recommended solutions are illustrated as cross-section profiles; they refer to a range of use constraints, of pedestrians, cycle traffic and parked traffic, the importance of the street in the local public transport network, the motor vehicle traffic volume and street width (section 5.2). It can be assumed that these typical design situations cover most of the design problems encountered in practice (70 % to 80 %). Then, dependent on the network function and traffic volume – as expressed by the number of lanes – suitable junction types are recommended for the link roads, the motor traffic volume, the infrastructure context and the available street space (section 5.3). Finally, for a few selected street cross-sections, suitable transitions at junctions are presented (section 5.4).

5.1.1 Determining a recommended cross-section

The recommended cross-section is derived from the 'typical design contexts', which are described, illustrated with a photograph and with example layouts, according to the:

- character of the area;
- typical constraints and requirements;
- any special points of note.

The recommended cross-section is identified by using the following steps (figure 24):

Step 1. The key design demands relate to:

- pedestrian traffic and dwellings;
- cycling;
- parking provision

These are usually already defined in one of the cross-sections of the 'typical design situations'. If a requirement differs significantly from one of these, in the design context, then variations should be investigated carefully and incorporated into the design.

Step 2. Defining the different demands of local public transport:

A distinction is made between

- no public transport (kein ÖPNV) – i.e. no, or infrequent bus traffic;
- bus service (Linienbusverkehr);
- tram (Straßenbahn).

Cross sections recommended for bus traffic can also be used if there is no bus traffic.

Step 3. Defining the volumes of motorised traffic, grouped into five partly overlapping peak-hour ranges, which may refer to current or forecast levels, depending on the design task, referred to the cross-section:

- < 400 vehicles per hour
- 400 – 1,000 vehicles per hour
- 800 – 1,800 vehicles per hour
- 1,600 – 2,600 vehicles per hour
- > 2,600 vehicles per hour.

A recommended cross-section for a specific volume of traffic is usually also suitable for lower volumes of motor vehicle traffic from a traffic engineering point of view.

Step 4. This depends on the street space width available or planned – usually the width between buildings.

The specified widths indicate the minimum in each case in order to apply the cross-section shown.

If more space is available, up to the next "step-change level" for example, in respect of either cycle provisions, or parking bays or dedicated bus lanes, and which result in a changed cross-section layout, then any such space should be assigned primarily to pedestrian traffic and residential needs, and where appropriate also to cycle traffic.

If less space is available, the suitability of a smaller cross-section or the omission of a profile element, such as parking lanes, may be investigated. Reducing the dimensions of any element within the recommended cross-sections should be avoided.

Traffic volumes especially in the range from 400 to 1,000 vehicles per hour – result in differences related to the ease of crossing a road, which need to be considered when selecting a profile. At the upper end of this range, with corresponding difficulty in crossing, are cross-sections

- without parking lanes, or
- without advisory or on-street cycle lanes,
- without central islands or central reservations.

Federal inter-urban through roads (Bundesstraßen) and serving traffic from a wide-area, have a high link functionality. Due to their heavy traffic volumes, they are usually treated as roads carrying scheduled bus services.

On narrow through-roads, with a low pedestrian traffic demand, the footways on both sides can be laid out to a width of 1.50 m.

If no suitable profile can be found under these conditions, then a custom design process (see section 3.4) must be undertaken.

If significant safety problems have been identified in planning the remodelling or expansion of existing roads, the special points in section 3.4 must be noted.

5.1.2 Principles underlying the design and balance of interests in the recommended cross-sections

The cross-sections and their respective combinations of elements, depict the recommended solution considering all users' needs in the given conditions.

The cross-sections use the design elements in section 6, coordinating and balancing them, considering their advantages, disadvantages and their respective interactions, for example to avoid combining minimal dimensions.

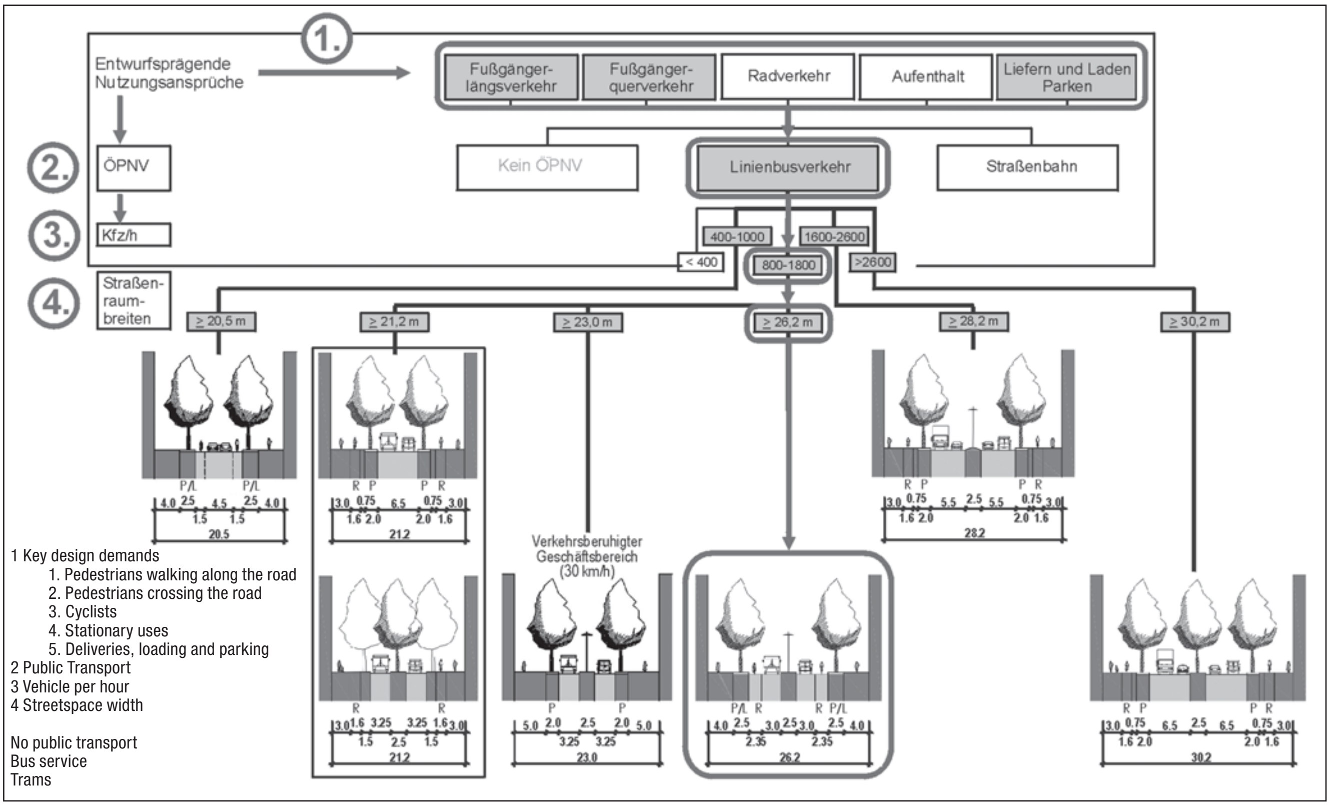


Figure 24: Step-by-step selection of a recommended cross-section

The cross-sections presented are restricted to essentially symmetrical solutions, as they predominate in normal practice. Asymmetric solutions can be developed from appropriate analyses.

The most important design principles applied in the recommended cross-sections relate to:

- The design of carriageways with special consideration for public transport;
- The management of cycle traffic;
- The allocation of uses in the footway areas, including parking;
- Issues of safe crossing; and
- The basic design concept of street space in the form of the street space proportions.

When designing carriageways, the following design principles are followed:

- Carriageways based on the shared-use principle, or without separating kerbs, for traffic volumes below 400 vehicles per hour and where the maximum speed is 30 km/h or less.
- On roads where scheduled bus services run, two-lane carriageways are 6.50 m wide, or 7.50 m where advisory cycle lanes are marked out on both sides.
- Each direction is usually physically separated. A single-lane layout has a width of 3.25 m – a marked-out advisory cycle lane is 3.75 m, and alongside a mandatory cycle lane is 3.00 m. Dual carriageways can be installed with a width of 5.00 m. Each side of a dual carriageway is usually 6.50 m wide.

Particular attention is paid to the selection and layout of bicycle facilities as follows:

- On roads with traffic volumes below 400 vehicles per hour, cycle traffic is routed on the carriageway.
- For traffic volumes of 400 to 1,000 vehicles per hour, advisory cycle lanes are usually recommended.
- For traffic volumes over 1,000 vehicles per hour, cycle lanes or cycle paths are used.

Regarding the shared use of pavements by cyclists, the following distinctions are made and shown in the cross-sections:

- If no cycle facilities are planned for roads with traffic volumes between 400 to 1,000 vehicles per hour, and if the maximum speed is above 30 km/h, the footway is available for use by cyclists.
- If advisory cycle lanes are planned for roads with traffic volumes between 400 to 1,000 vehicles per hour, the footway is not released for use by cyclists.
- If advisory cycle lanes are planned for roads with traffic volumes between 800 to 1,800 vehicles per hour, the footway may also be made available for use by cyclists.

This use is allowed, where appropriate, provided pedestrians are given priority.

When combining parking lanes and cycle lanes, the following basic measures will be assumed:

- Advisory cycle lanes, next to parking lanes of 2.00 m width, are 1.50 m wide
- [Mandatory] cycle lanes 1.60 m wide adjacent to a parking lane (2.00 m), are positioned with an additional 0.50 m safety separation, this does not have to be separately marked.
- Off-carriageway cycle paths of 1.60 m are given an additional 0.75 m safety separation when adjacent to a parking lane (2.00 m in width).

Pavement widths specified in the cross-sections are a minimum of 2.50 m, based on the requirement for two pedestrians to be able to pass each other. This width also takes into account the obligation/permission for child cyclists up to the age of 8 years/10 years respectively (§ 2 StVO) and for safety clearances from buildings and from the carriageway. Only for narrow village main streets do cross-sections differ, with a footway width of 1.50 m, because of the low pedestrian numbers.

Local shopping street pavement widths are configured at 4.00 m, and with an adjoining cycle path 3.00 m. On main shopping streets they are configured at 5.00 m, and with an adjoining cycle path 4.00 m.

In addition, parking lanes are usually located at the near-side and combined with trees.

For pedestrians the ease of crossing carriageways is particularly importance in terms of road safety. For this reason the cross-sections include continuous central reservations to facilitate crossing. They are for use in design situations with primarily linear crossing requirements, in both local and main shopping streets.

As well as the speed of vehicular traffic, visual contact between pedestrians and drivers is a key factor in ensuring safe crossing, sections with parking lanes on both sides were used with central reservations as crossing facilities. Where advisory cycle lanes are used they enable the necessary visual contact prior to stepping onto the core carriageway, in the cases illustrated no special crossing facilities are required.

For most of the typical design situations the cross-sections assume vegetation to be desirable throughout the streetscape. As shrubbery and the like may be problematic in terms of both traffic and personal safety (visual contact, monitoring of concealed areas), only trees are shown. Considering all users across an existing or proposed street space, a combination of tree planting with parking lanes appears to be the best solution. With the intention of achieving street space proportions of 30 : 40 : 30 for footway space/carriageway/footway space, and considering the relevant advantages and disadvantages with regard to traffic safety, cross-sections featuring cycle facilities with a roughly equal width of either cycle paths or advisory cycle lanes close to the carriageway are shown. Note also the examples of the straight-intersection transitions set out in section 5.4 in this respect.

When using the recommended cross-sections, it should generally be the case that they should not be applied as ‘standard cross-sections’ along an entire length of street but rather, near intersections and beyond them, at specific points or along specific sections as:

- an alternation between two recommended cross-sections; or
- a specific response to a change in the space based on land-use needs (section 3) and the individual elements (section 6).

5.2 Cross-sections

5.2.1 Residential lane (Cul de sac)

Characteristics

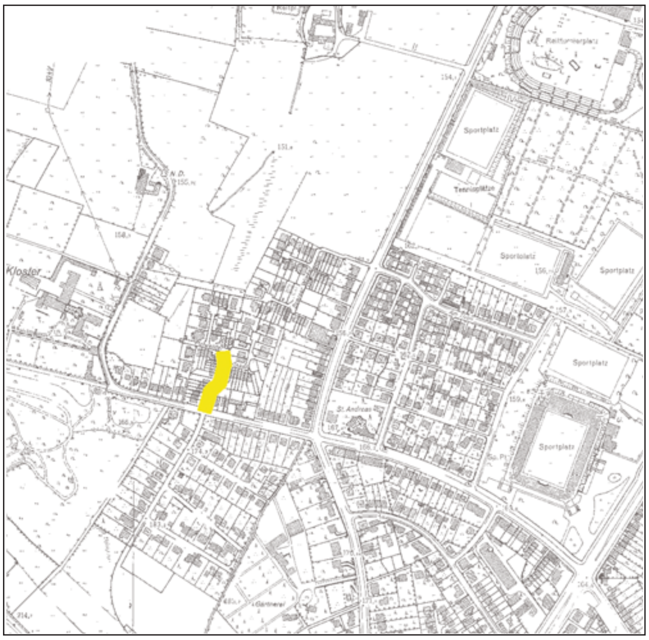
- Access road (ES V)
- Predominantly built-up with terraced and detached houses
- Residential only
- Short length (up to approx. 100 m)
- Traffic volume below 150 veh/h
- Usage: residential.

Typical constraints and requirements

- Residential function should be reinforced by the shared-use principle.
- Path widths should enable cycles/cars to pass each other.
- House entrance areas must be protected from vehicles coming too close, and visual contact must be assured.

Special points of note

- In cul-de-sacs, depending on the local situation, a turning space styled as a free area must be provided for refuse collection vehicles.
- Cul-de-sacs should be designed for pedestrians and cyclists to pass through.



Residential lane with a small offset square

Residential lane with greened area for residents' cars, general residential use or children's play

Residential lane with narrow vehicular access and house entrance areas protected by plants and trees

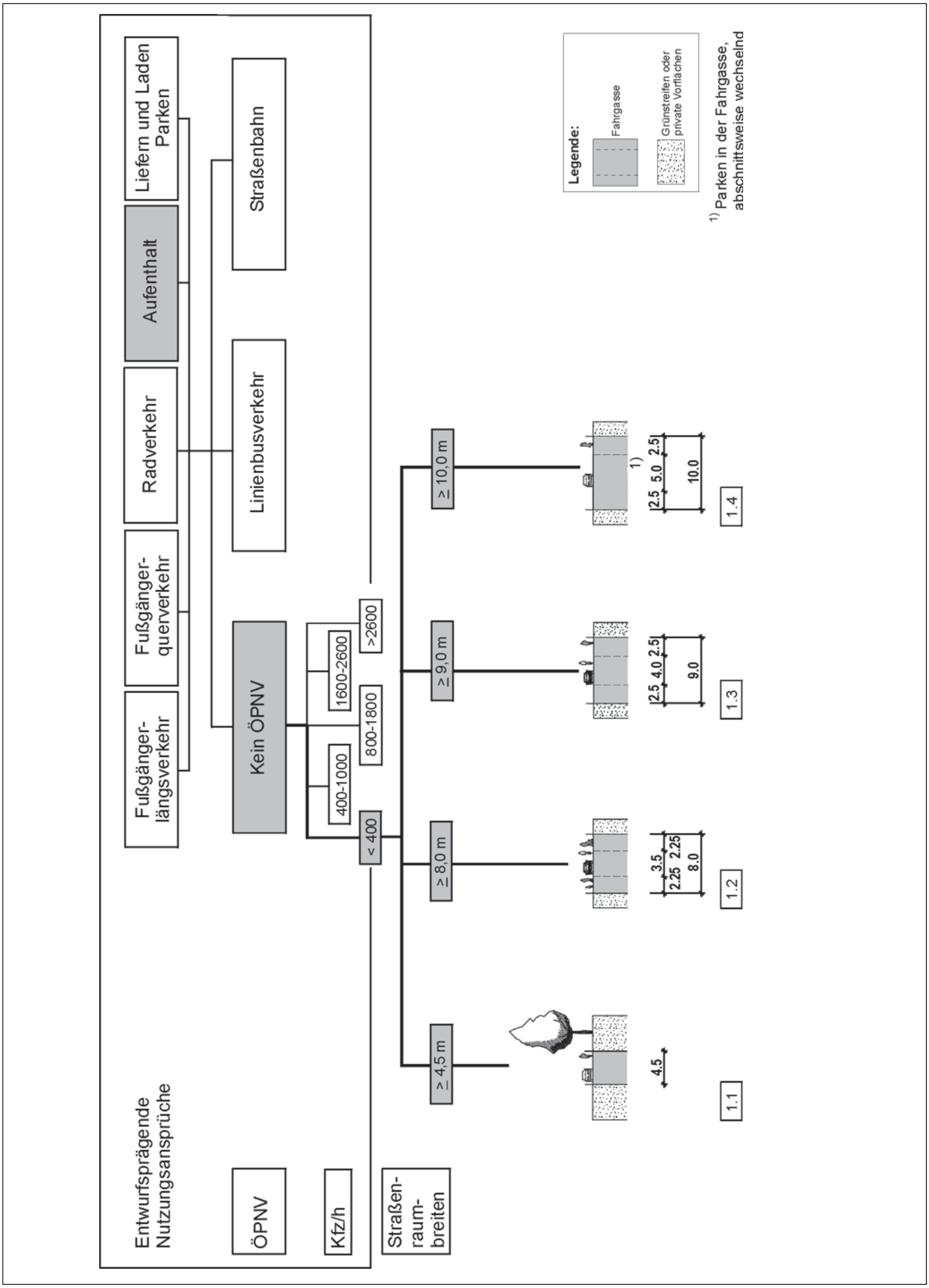


Figure 25: Recommended “residential lane (cul de sac)” cross-sections

5.2.2 Residential street

Characteristics

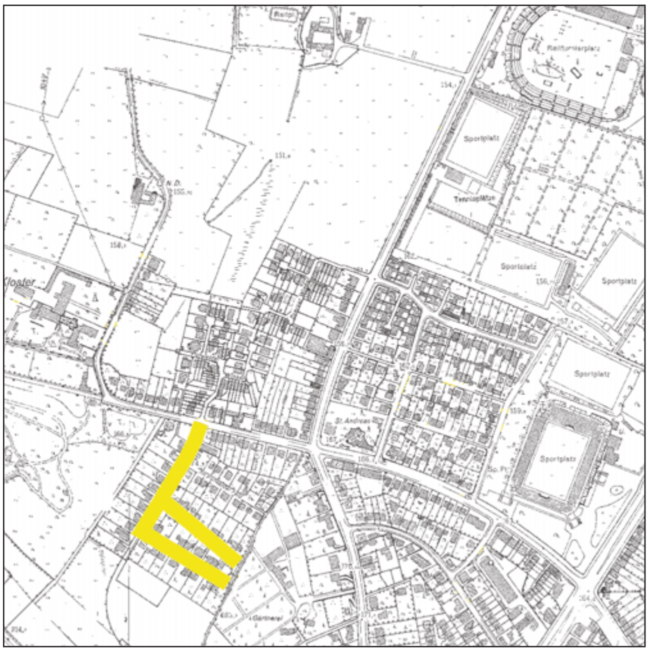
- Access road (ES V)
- Different forms of building: rows, terraced and detached houses
- Residential only
- Short length: up to approx. 300 m
- Access function only
- Traffic volume below 400 veh/h
- Usage: Residential, parking.

Typical constraints and requirements

- Carriageway widths should allow oncoming cars to pass.
- Passing points should be laid out as necessary for cars and refuse collection vehicles to pass.
- Bicycle facilities are not required.
- No special requirements are imposed with regard to pavement widths.

Special points of note

- In most cases residential streets are located in 30 kph zones.
- In special cases, depending on their location within the road network, residential streets may also be part of a cycle route. If so, the following points should be taken into consideration:
  - Cycle routes form part of local cycle networks; they serve existing or expected cycle traffic, providing key links away from main arterial roads.
  - To ensure efficient cycle journeys, right of way over other access roads may be provided, with appropriate engineering, such as speed humps and be clearly marked.
  - In some isolated cases, bus services may be routed along cycle routes.



Residential street in an urban neighbourhood with environmental traffic calming elements

Village-style residential street with ‘soft separation’ and offset parking bays

Cycle route with bus lane

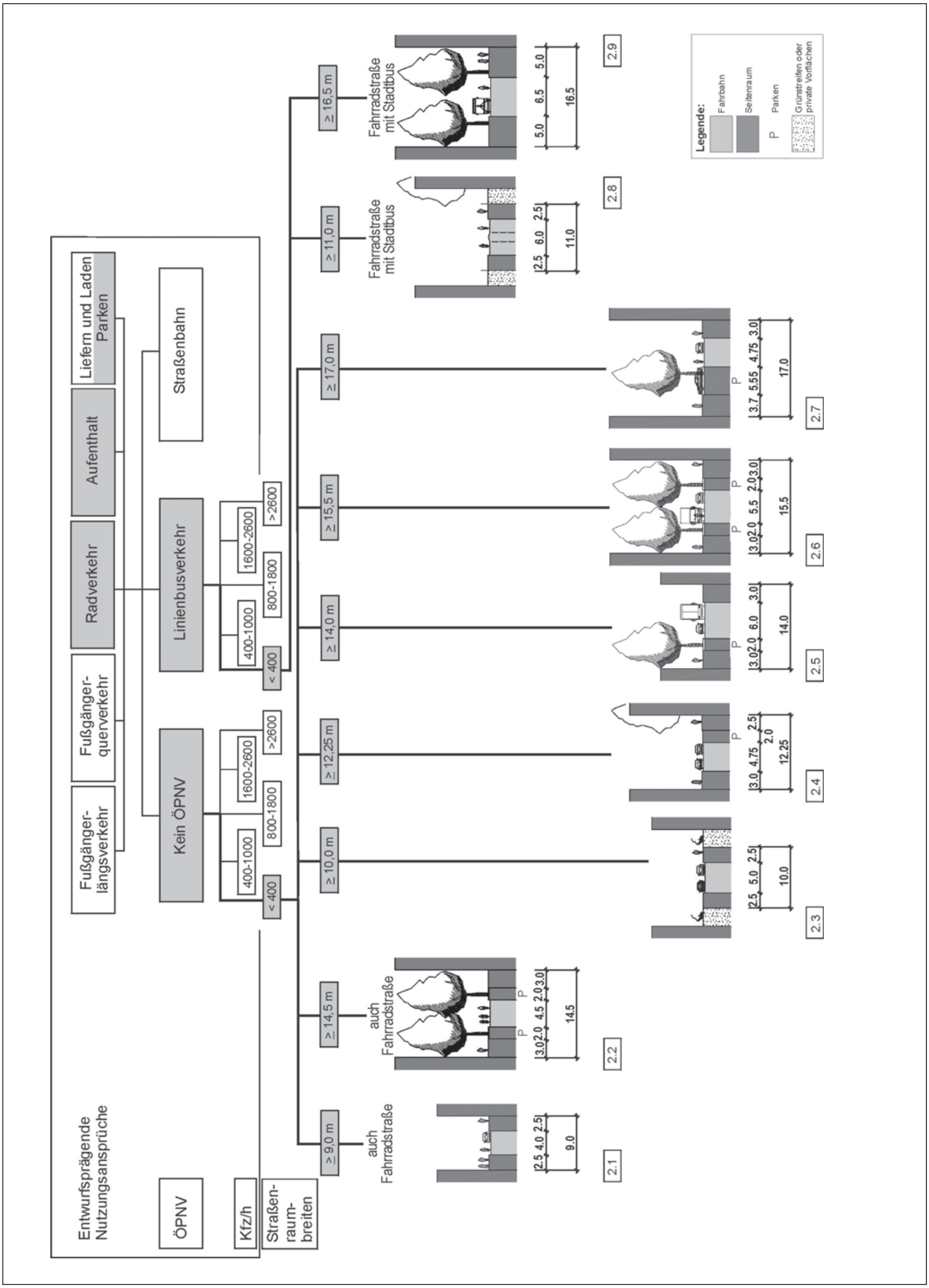


Figure 26: Recommended “Residential street” cross-sections

5.2.3 Collector road

Characteristics

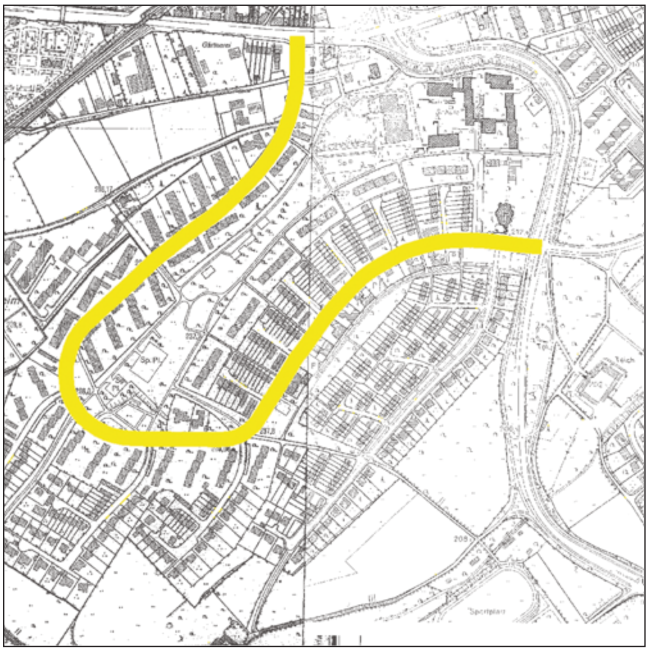
- Access road (ES IV)
- Different forms of building, often linear development, point blocks
- Primary use is residential, with individual shops and community facilities
- Street spaces tend to be undefined rather than narrow
- Length depending on the size of settlement 300 to 1,000 m
- Traffic volume 400 to 800 veh/h
- Special user requirements: pedestrians walking along, crossing requirement at specific points, mostly scheduled bus service traffic.

Typical constraints and requirements

- Speeds are usually too high.
  This is underpinned by the half-open frontage, with buildings facing away from the street.
- There is mostly sufficient parking for residents in the private area.
- A concerted effort is required to break-up the long open street into shorter section.
- Crossing facilities should be used to reinforce the segmentation of the street and speed restraining measures applied.
- Cyclists should be protected by cycle facilities or by effective speed restraint.

Special points of note

- Potential use conflicts, such as with an intersecting school route, should be highlighted and ameliorated by appropriate design.
- The street space should be visually framed as a unit and subdivided as appropriate.



Roundabout on a collector road on a large residential development

Crossing point for pedestrians and cyclists on a collector road on a large residential development

Collector road with footways behind tree-lined green border strips

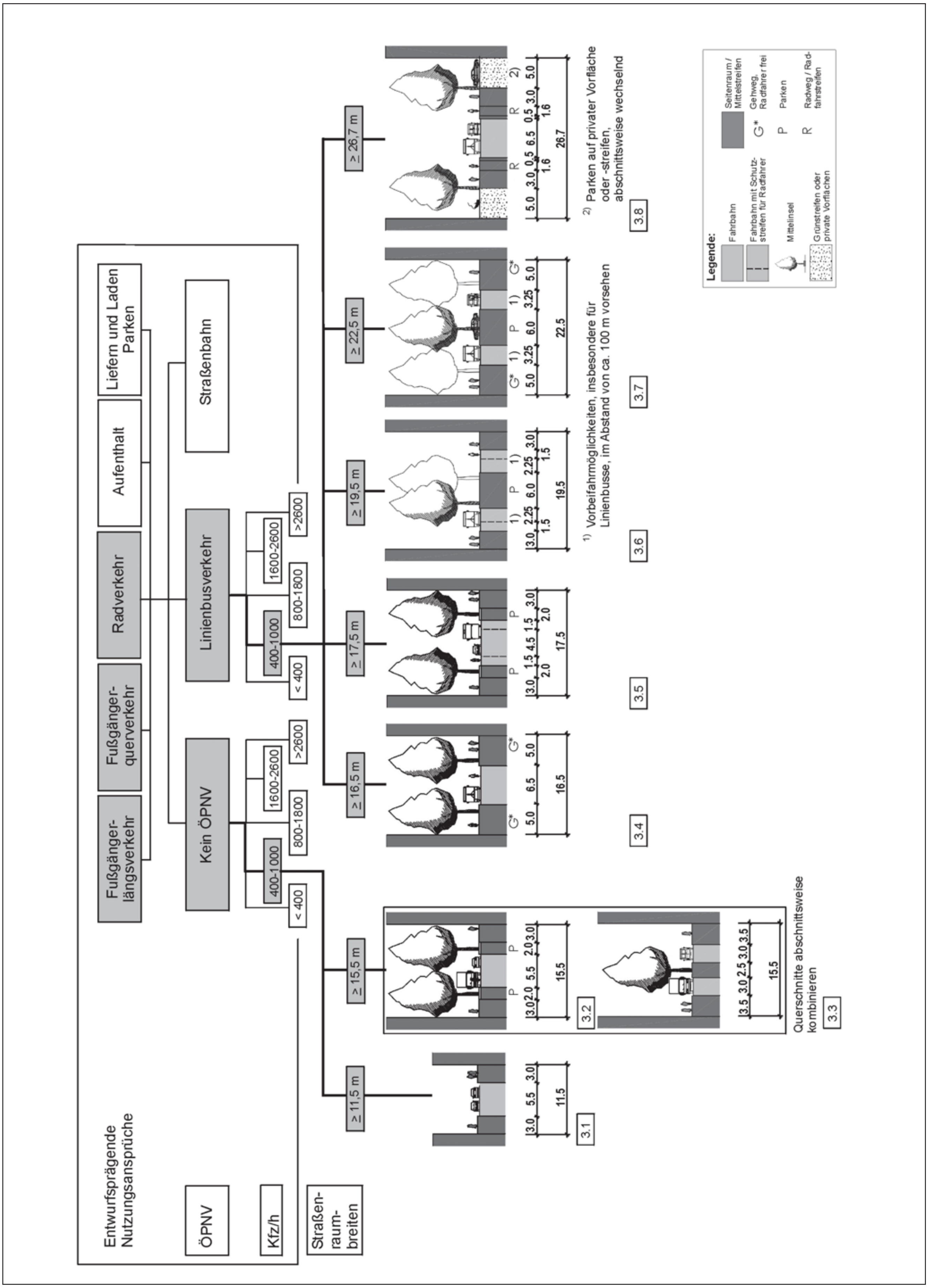


Figure 27: Recommended "collector road" cross-sections

5.2.4 City neighbourhood street

Characteristics

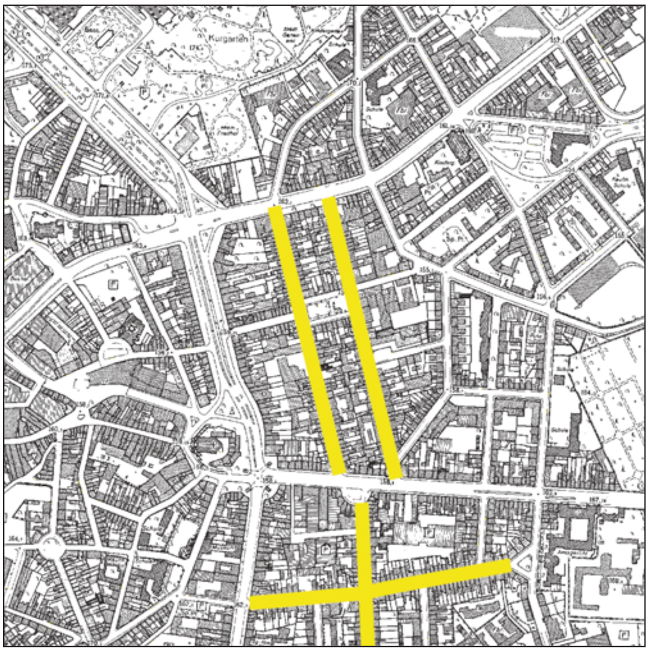
- Access road/main arterial road (ES IV, HS IV)
- Continuous, dense building frontage, mostly long-established
- Mixed use residential, commercial and service sector
- Section lengths between 100 and 300 m
- Front to front widths from 12 m
- Traffic volume 400 to 1,000 veh/h
- Usage requirements: pedestrians walking along, parking
- Scheduled bus service traffic possible, according to use mix also heavy traffic.

Typical constraints and requirements

- The high density of use results in high demand for parking in the street.
- Street space design must help improve the quality of open space.
- Crossings can be concentrated at the intersections, which should be kept free of parked vehicles.
- For lengths over 200 m, street sections should be implemented by interrupting the parking rows in combination with measures such as plateau humps.

Special points of note

- The design of street space should respond to the symmetry of the urban design.
- It is important to ensure that illegal parking is prevented.



City neighbourhood street in a long-established residential area with parking bays separated by tree planting

City neighbourhood street in an old area with speed cushions ("Berliner Kissen") at road narrowings

City neighbourhood street as main arterial road in a long-established city area

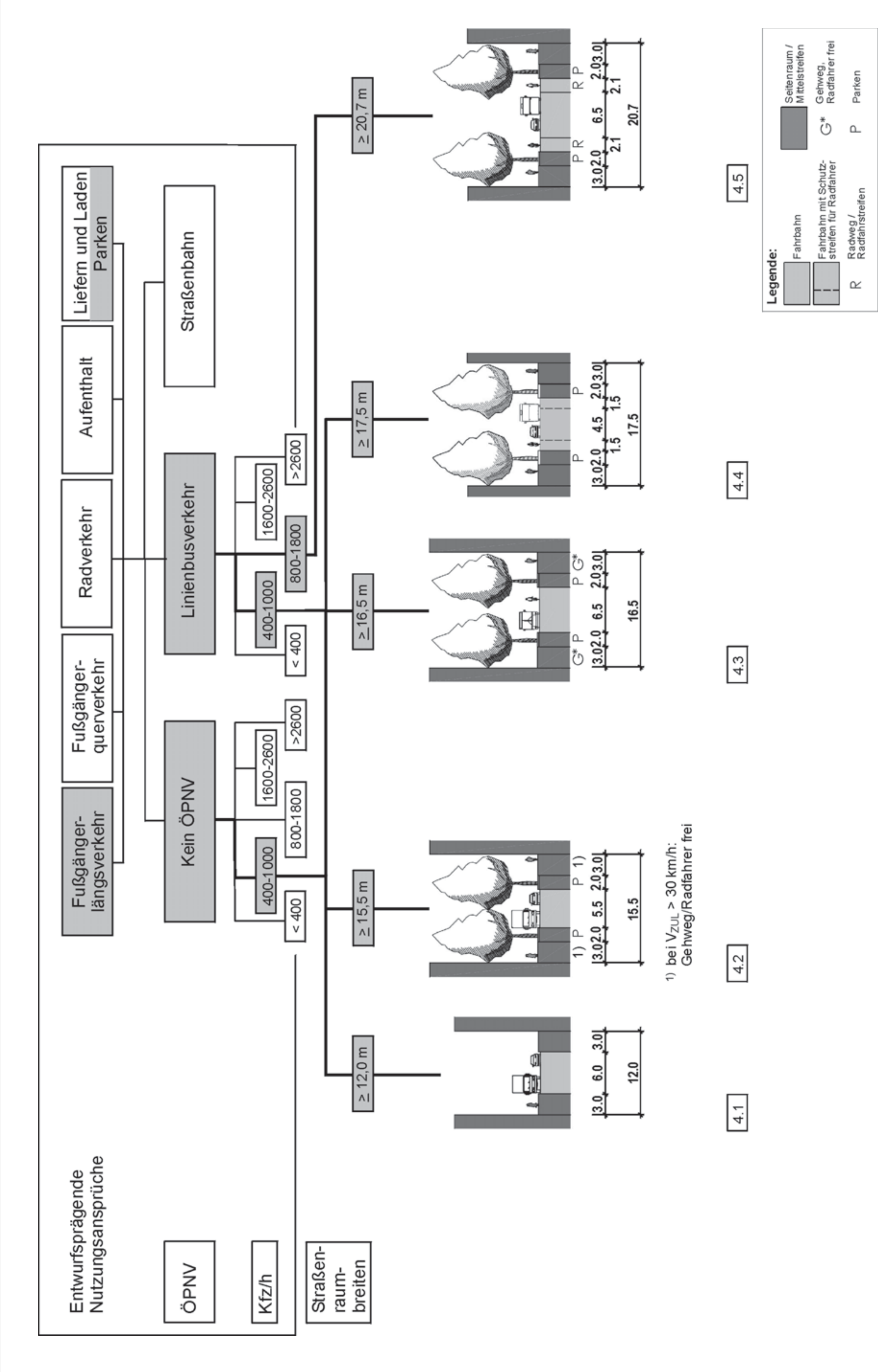


Figure 28: Recommended “City neighbourhood street” cross-sections

5.2.5 Village main street

Characteristics

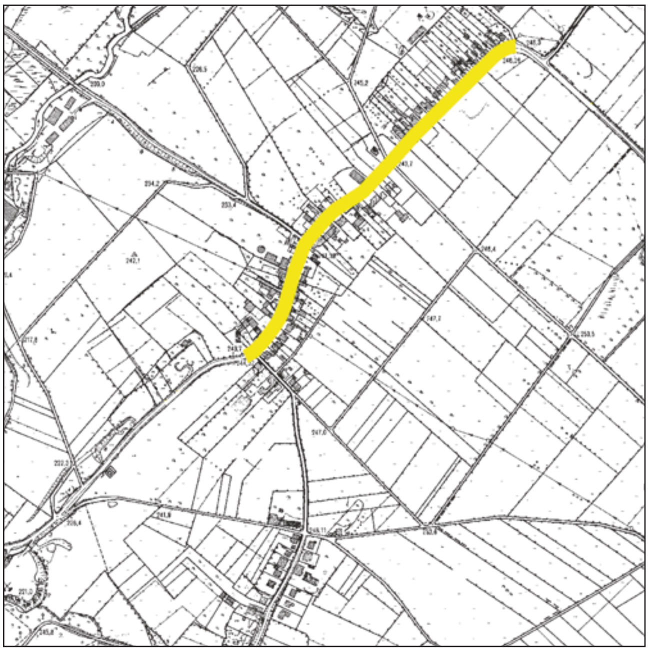
- Access road/main arterial road (ES IV, HS IV)
- Rural building and settlement structure
- Broad spectrum of types, depending on region: Narrow to very wide street spaces, 100 m up to several kilometres long
- Traffic volume between 200 and 1,000 veh/h
- Also scheduled service bus traffic
- No predominant use requirements.

Typical boundary conditions and requirements

- Even low-frequency pedestrian and cycle traffic demands safe, adequately dimensioned areas and/or imposition of appropriate motor vehicle traffic speeds as well as safe crossing of junctions and property driveways.
- Traffic speeds in the zones entering the built-up area should be effectively calmed.
- Depending on length, the street should be designed in sections, responding to the existing urban development, to assist in speed reduction.
- The locations and layout of crossing facilities should respond to local needs.
- Where frontages are close to the road, it should be explored whether, for example, narrower carriageways, a partial carriageway narrowing (see section 6.1.1.9) or a shared-space section, are acceptable.

Special points of note

- For traffic calming, appropriate central islands and medians should be installed, and at the entrance to the built-up area – where there are crossing streets – mini roundabouts.
- In many cases, extra-urban two-way cycle paths end at the entrance to the built-up area. They must be split into cycle traffic installations on both sides of the road, with safe crossing aids such as central islands, or be continued into the locality. On very short through-roads it may also be advisable to continue the two-way cycle path all the way through.
- In the case of low traffic volumes, a ‘soft separation’ without upstand kerbs can be used, with a distinctive transition to the normal separation principle, and subject to a 30 km/h speed limit.
- If ‘soft separation’ is chosen, attention should be paid to the characteristics and composition of the motor vehicle traffic.
- From a design viewpoint, the creation of multi-use footway spaces, for example signed “Pedestrian footpath – open to cyclists”, which do not have to be uniformly surfaced, is desirable. Illegal parking should be prevented.
- In tight situations, the pedestrian area must be protected against vehicular access.



Traffic calming at the entrance to a locality using a central island with a clear offset from the carriageway

Traffic calming at the entrance to locality using a roundabout

‘Soft separation’ between carriageway and side space

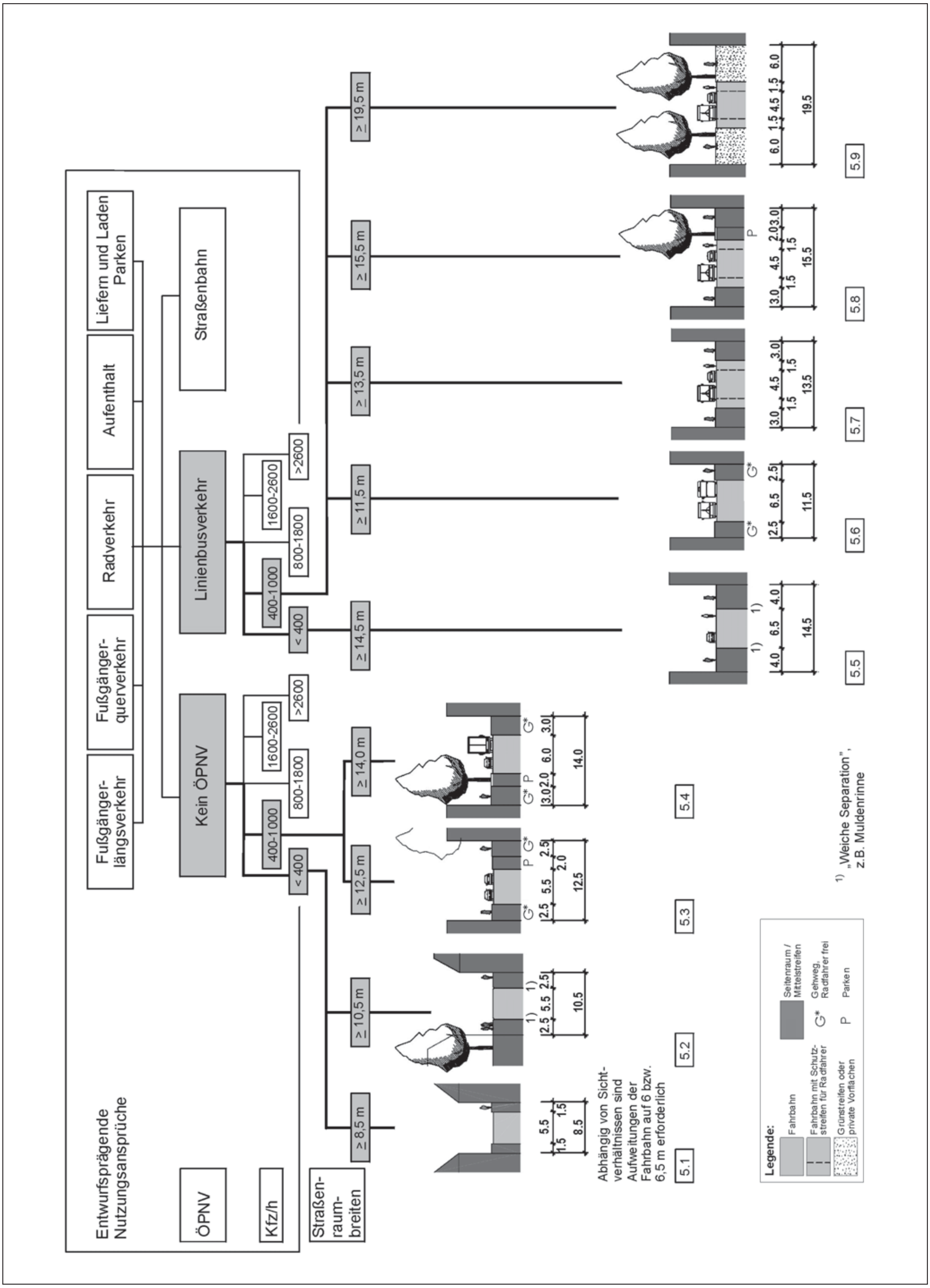


Figure 29: Recommended "village main street" cross-sections

5.2.6 Urban main road

Characteristics

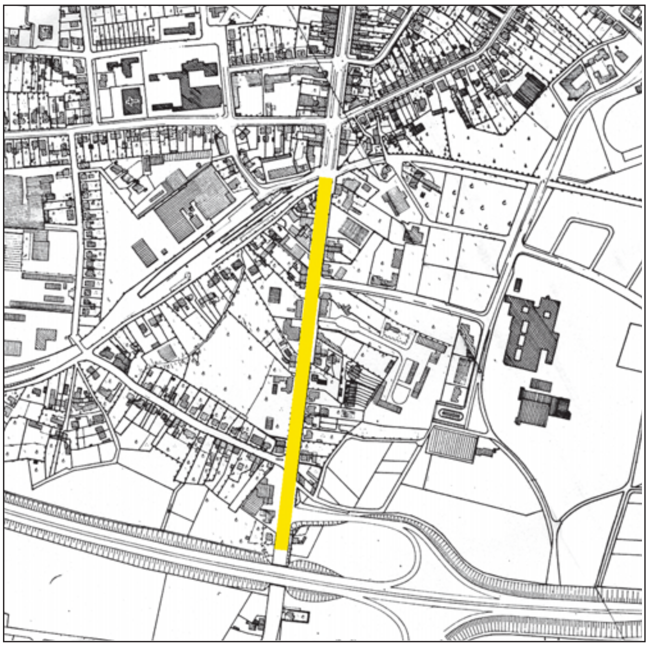
- Main arterial road (HS IV, HS III)
- Continuous or semi-open frontage
- Mixed use, commercial, residential, little business use.
- Wide range of street space widths
- Section lengths from 200 to 800 m
- Traffic volume 400 to 1,800 veh/h
- Usually scheduled service bus traffic.

Typical boundary conditions and requirements

- In most case sufficient area is provided for footway spaces.
- Problems arise from high speeds due to frequent straight running and low density of footway use.
- Depending on length, the street should be designed in sections, to assist in speed reduction and provision of crossing facilities.
- Parking requirements should be considered at specific points dependent on adjoining use.

Special points of note

- Appropriately engineered central islands and mini roundabouts are suitable for traffic calming.
- The separation principle between carriageway and footway should be underscored by design.



Urban main road with advisory lane for cycle traffic

Urban main roadwith traversable central reservation and advisory lane for cycle traffic

Urban main road with wide paved gutter and adapted footway space design

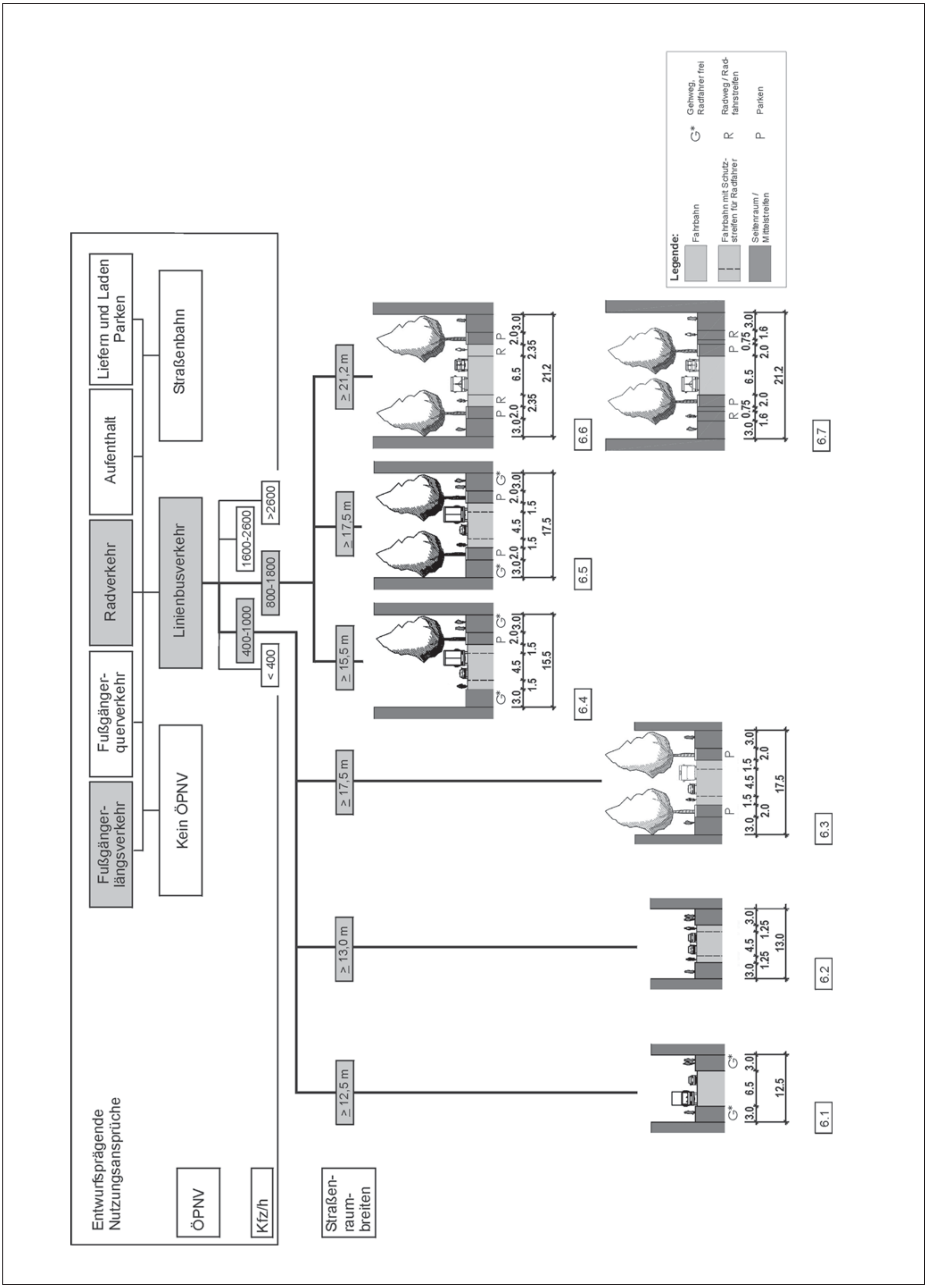


Figure 30: Recommended “Urban main road” cross-sections

5.2.7 Local main street

Characteristics

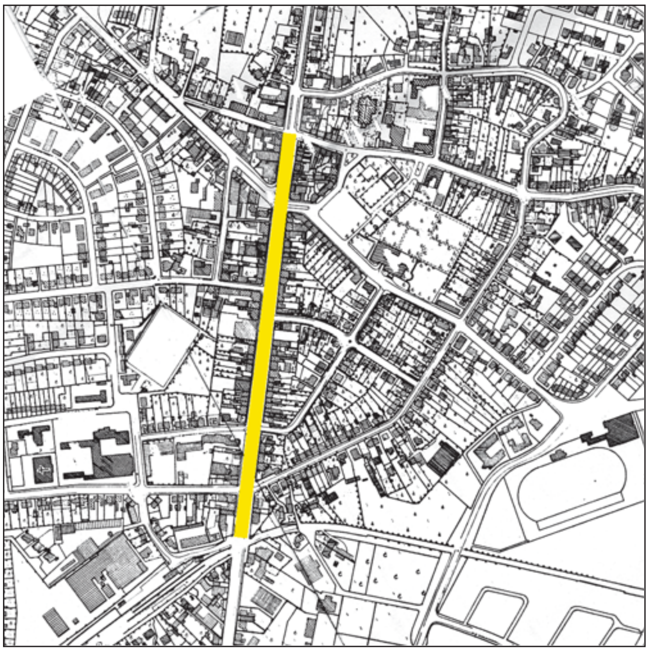
- Access road/main arterial road (ES IV, HS IV)
- Local main streets are located in the heart of city districts or in the centres of small and medium-sized towns
- Continuous frontage predominates, with business uses all along
- Very varied street space widths may occur
- Length between 300 and 600 m
- Traffic volume between 400 and over 2,600 veh/h
- Special use needs: Pedestrians walking along and across, parking, delivery and loading, local public transport in the form of bus and/or tram.

Typical boundary conditions and requirements

- An important factor is the provision of adequate footway area and an enabling direct ‘crossability’.
- Owing to the direct crossing need, low/appropriate speeds and visual contact between pedestrians and vehicles should be ensured.

Special points of note

- Footway space design adapted to business use is necessary; tree planting is desirable.
- In the case of cross-sections with parking bays on both sides, the street should be designed in segments with an adequate density of central islands as crossing aids.
- In cross-sections with trams, special areas for overhead cable masts should be planned, as appropriate.



Local main street with traversable central reservation as crossing aid

Local main street with paved side strip

Local main street with one-way traffic

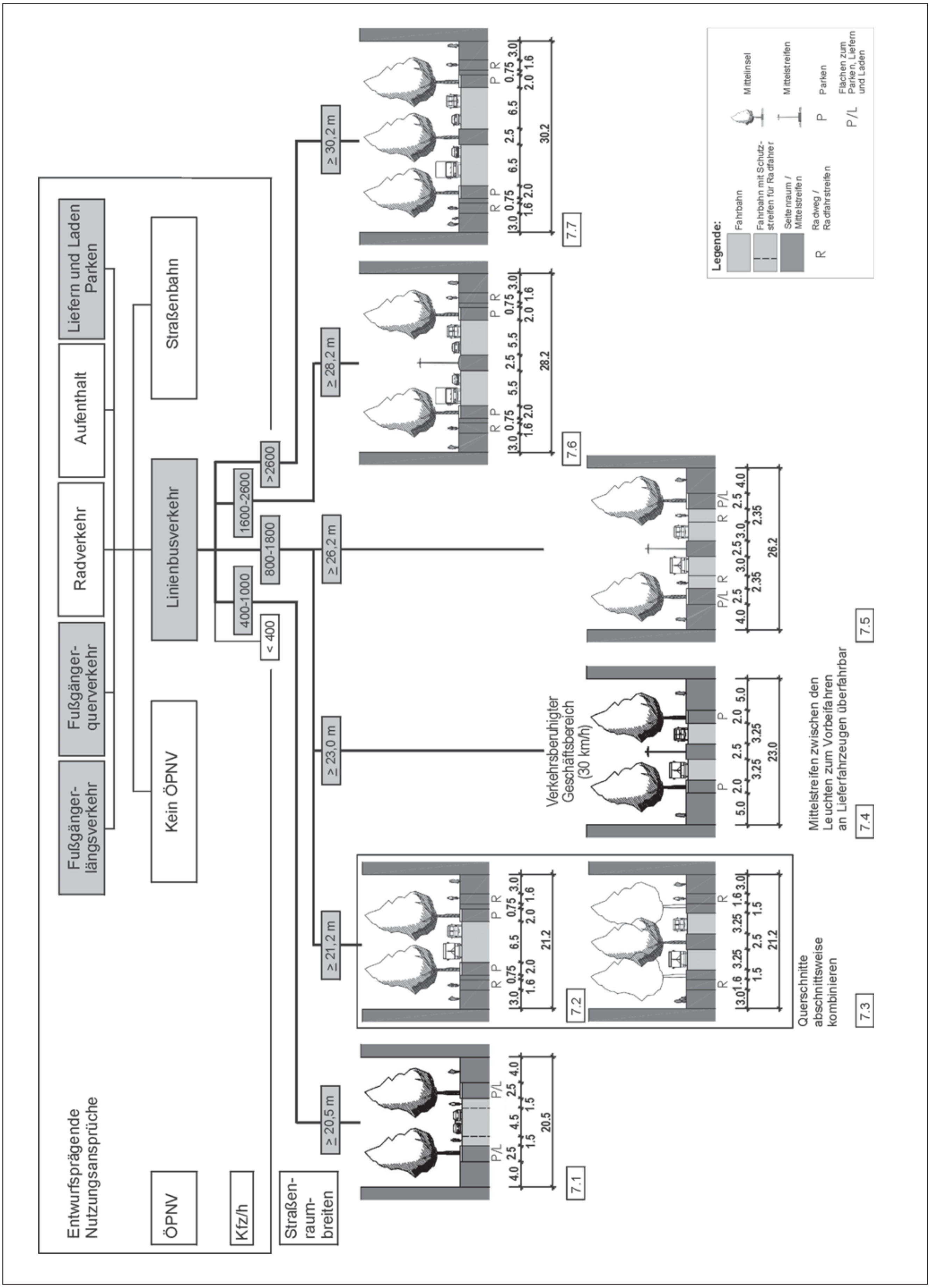


Figure 31: Recommended “local main street” cross-sections (first part)

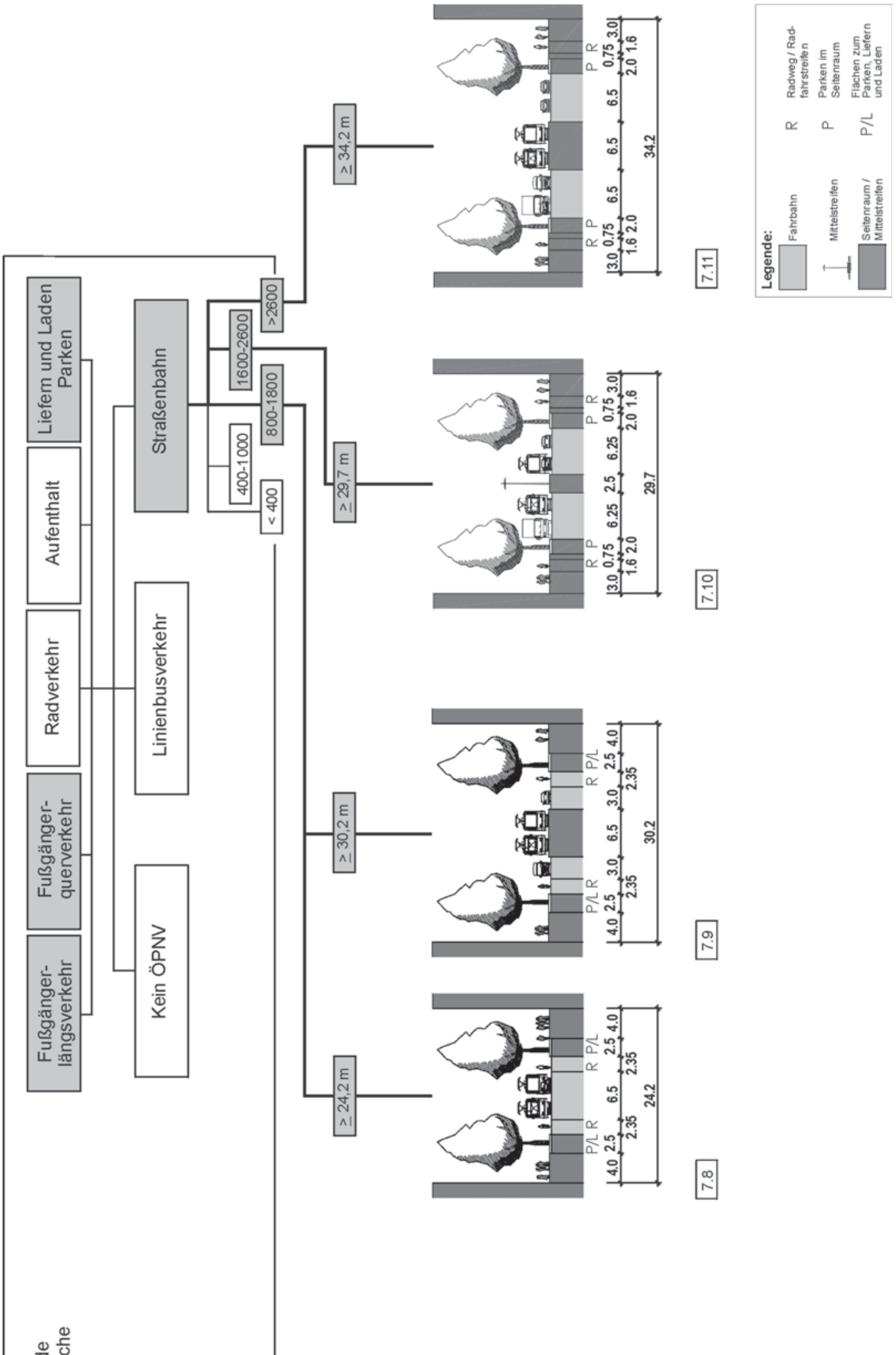


Figure 32: Recommended "local main street" cross-sections (second part)

5.2.8 Main shopping street

Characteristics

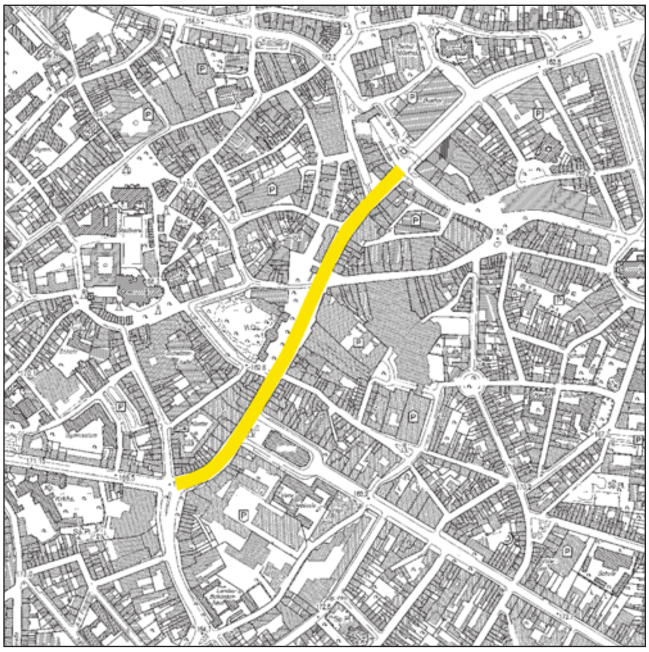
- Access road/main arterial road (ES IV, HS IV)
- Main shopping streets are located in the centres of large cities and medium-sized towns
- Dense business use, with continuous building frontage, residential only in exceptional cases
- Depending on town size 300 to 1,000 m long
- Traffic volume from 800 to 2,600 veh/h
- Special use requirements: Pedestrians walking along and across, parking, delivery and loading, local public transport and general presence of people.

Typical boundary conditions and requirements

- It is important to provide sufficient footway space and crossability.
- Because of the crossing need, low/appropriate vehicle speeds are necessary and making sure there is good visual contact between pedestrians and vehicles.

Special points of note

- Footway space adapted for business use is required; tree planting is desirable.
- In the case of cross-sections with parking bays on both sides, the street should be designed in segments with an adequate number of central islands as crossing aids.
- Solutions for facilitating cycle traffic are to be implemented according to motor vehicle traffic volume.
- To improve the quality of user experience and reduce the separation effect, main shopping streets in city and large town centres, motor vehciles access can also be restricted to public transport (also allowing taxis, short-time delivery/loading and cycle traffic).
- In cross-sections featuring trams, special areas should be planned as necessary for overhead cable masts.
- Along a tram route, tree crowns must not extend into, or overgrow, the vehicle clearance zone.



Main shopping street with cycle path and adequately dimensioned areas for pedestrians and for shop displays

City/large town main shopping street as public transport route

Main shopping street with comfortably styled areas for pedestrians passing through and staying

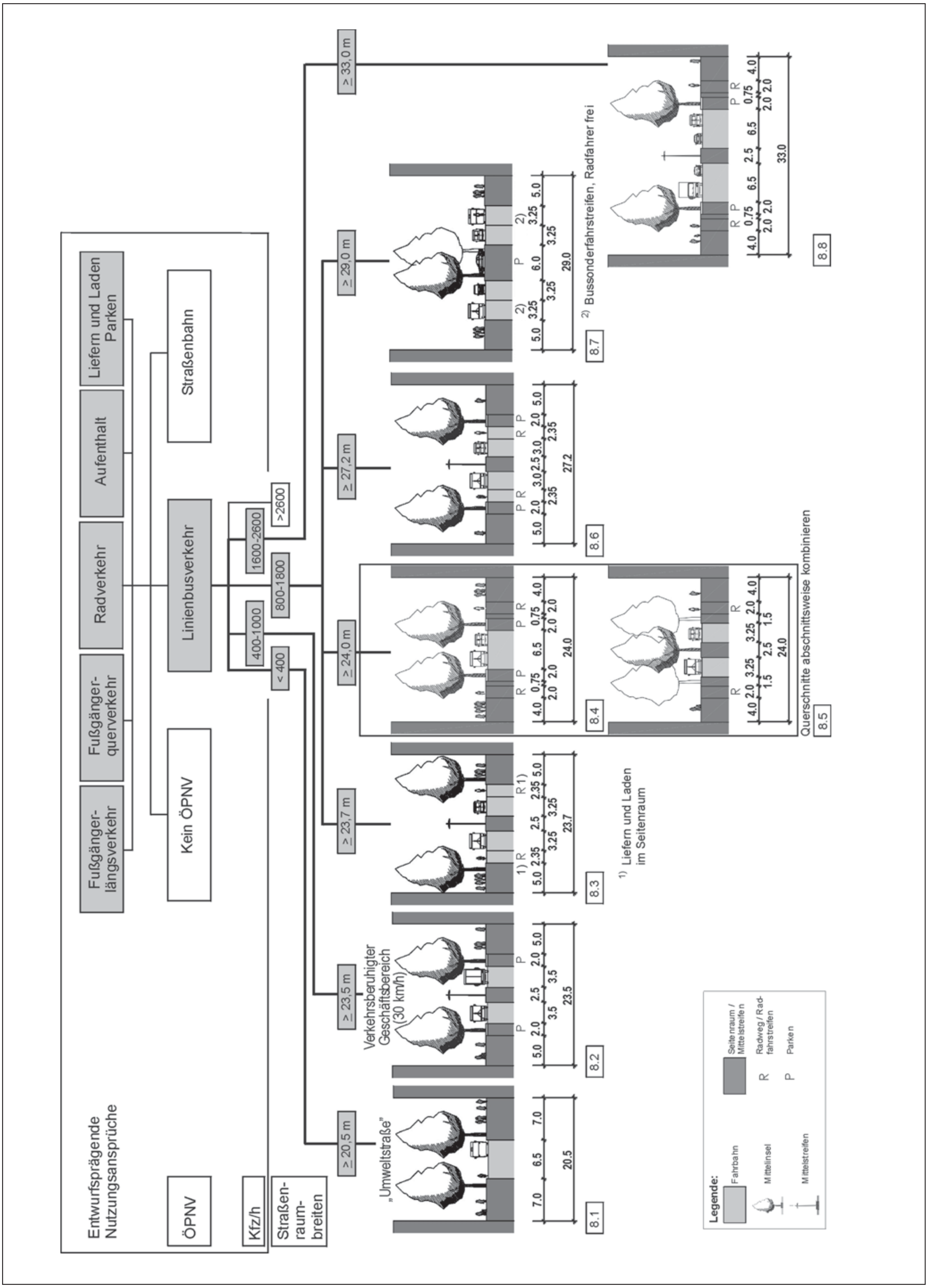


Figure 33: Recommended "main shopping street" cross-sections (first part)

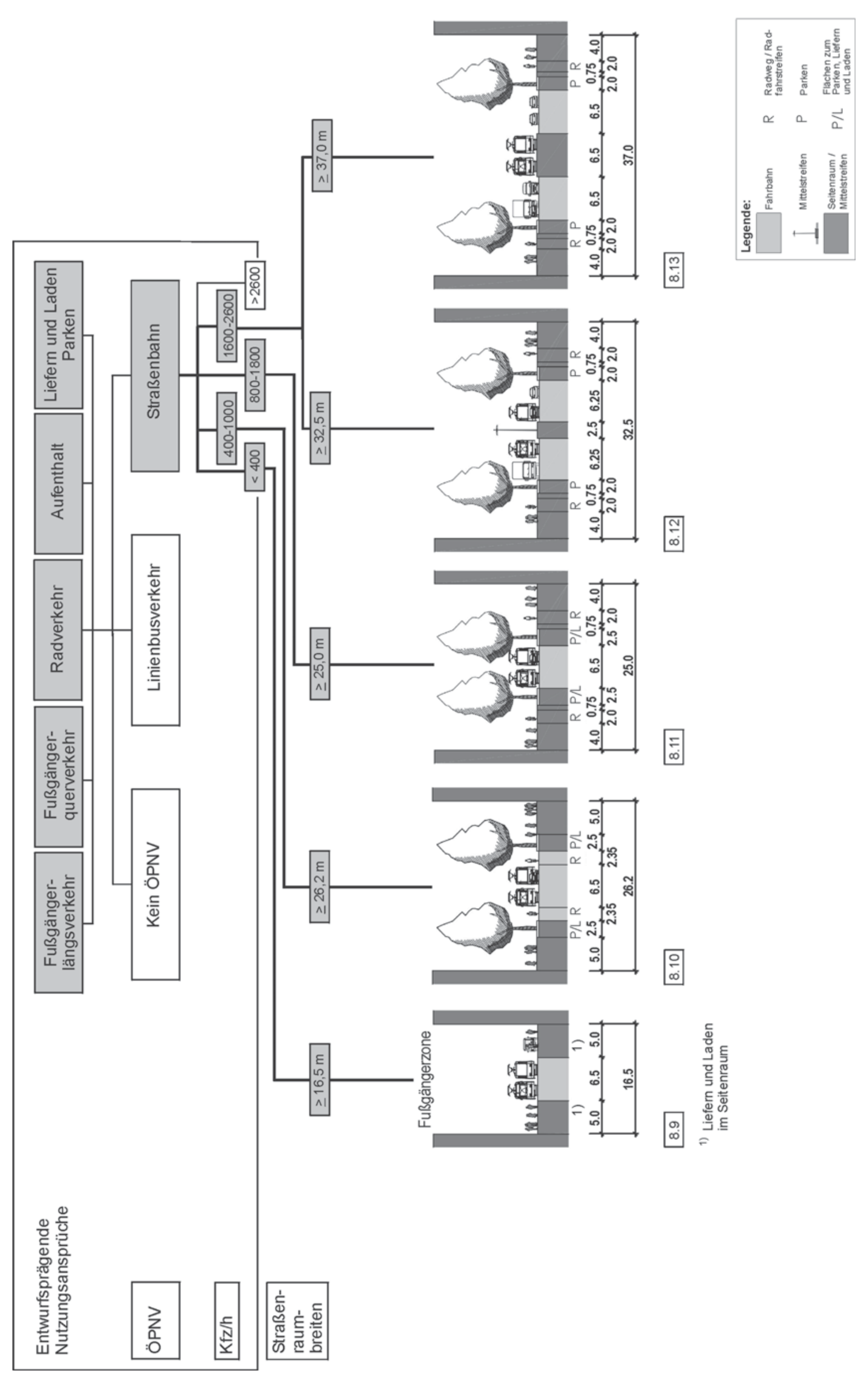


Figure 34: Recommended "main shopping street" cross-sections (second part)

5.2.9 Roads in commercial areas

Characteristics

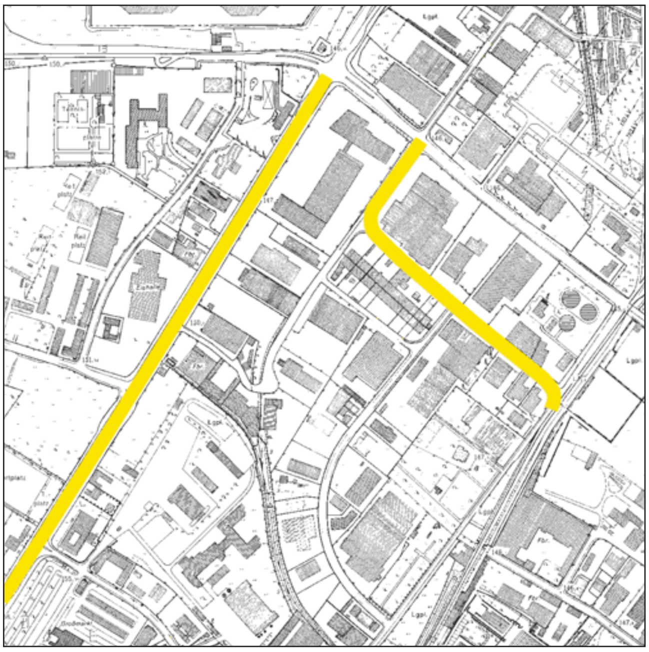
- Access road/main arterial road (ES IV, ES V, HS IV)
- Mostly large plots of land with single buildings and associated parking areas
- Commercial usage: Retail, office, leisure
- Section length 200 to 1,000 m
- Frequent, often heavy-loads accessing properties
- Traffic volumes from 400 to over 1,800 veh/h
- Special use requirements: Delivery and loading, visitors' parking.

Typical boundary conditions and requirements

- Predominantly vehicle-friendly structures with few 'crossings' over the road.
- Despite the private parking on offer, public parking remains necessary/useful in relation to some cross-sections.
- Parking bays can be combined with tree planting, which is often necessary to 'frame' the street space.

Special points of note

- Depending on the frequency and sequencing of private property accesses,
  - check the feasibility of locating cycling facilities in the footway
  - the safety of entrance and exit routes to the properties' should be examined.



Road in a commercial area with a divided longitudinal parking lane, cycle traffic sharing the footway space, bus stop

Road with turning lane to access large commercial properties

Road in a commercial area with roundabout and two-way shared footway space

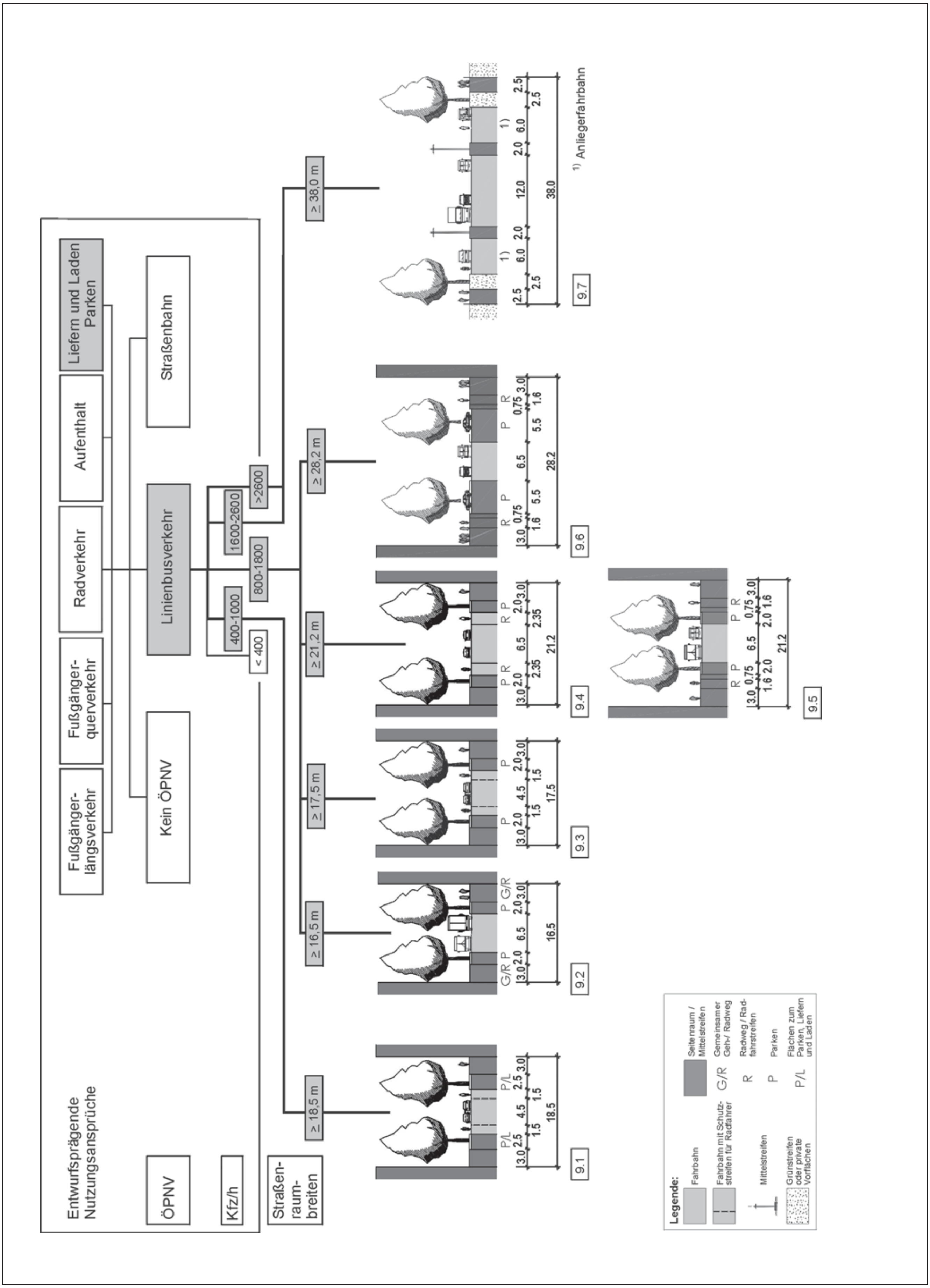


Figure 35: Recommended “Roads in commercial areas” cross-sections

5.2.10 Industrial Estate road

Characteristics

- Access/main road (ES IV, ES V, HS IV)
- Building on large plots of land
- Manufacturing, industry
- Length 500 to 1,000 m
- Traffic volumes from 800 to 2,600 veh/h, with major heavy traffic
- Minimal other use requirements
- Usually with a scheduled bus service.

Typical boundary conditions and requirements

- Wide carriageways are required with, or adjacent to, parking for trucks/semi-trailers.
- Pedestrian and cycle traffic volumes are low, and there is no significant crossing requirement.

Special points of note

- Bus Stops must be of sufficient size and clear of other traffic.
- The width of the parking lane (between 2.50 and 3.00 m) depends on the frequency at which trucks are parked.

Industrial Estate road (main road) with greened central reservation and longitudinal parking lanes, also cycle paths in the footway space

Industrial Estate road (access road) with greened central reservation and parking on the carriageway

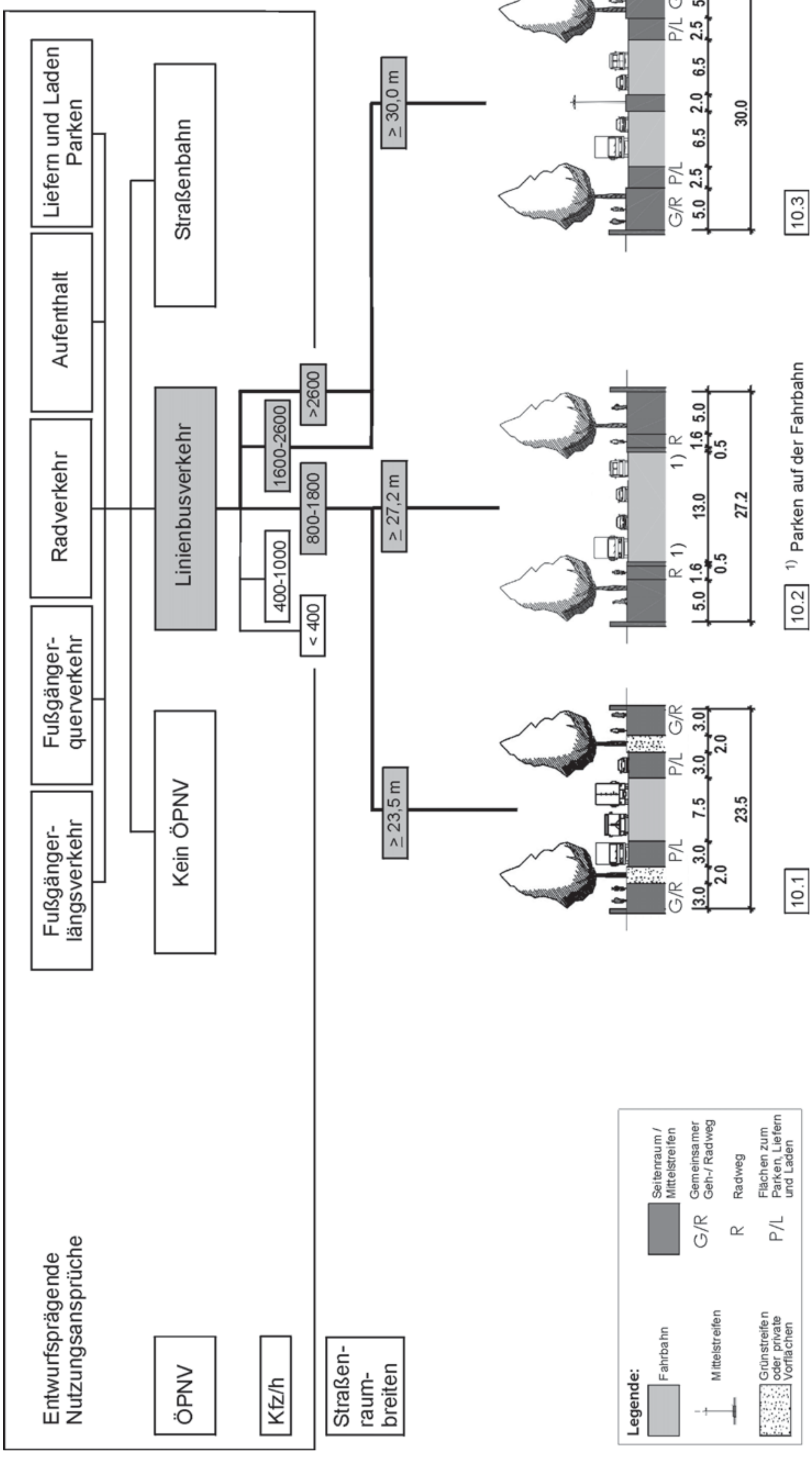


Figure 36: Recommended cross-sections for "Industrial Estate road"

5.2.11 Link road

Characteristics

- Main arterial road (HS III, HS IV)
- Mixed forms of development, with medium to low density
- Residential and commercial uses
- From the outskirts of a locality inwards, varying sections with different urban characters
- Length 500 to over 1,000 m
- Traffic volume 800 to over 2,600 veh/h, with predominantly through movement
- Special use requirements: Cycle traffic, public transport.

Typical boundary conditions and requirements

- Parking is mostly on private land.
- The mostly open street space and low density of use tend to encourage excessive speeds.
- Pedestrian crossing facilities are required and should be focused on a few crossings.
- Cycle traffic should be routed on segregated facilities.
- Long straight roads should be divided into discrete sections in order to keep vehicles within the speed limit.

Special points of note

- Bus stops must be of adequate dimension and kept clear.
- In cross-sections with trams, special areas should be provided for overhead cable pylons.
- Along a tram route, tree crowns must be kept clear of wires.

Link road with parking and green border on one side

Link road with flush tram rails and 'hybrid' cycle paths

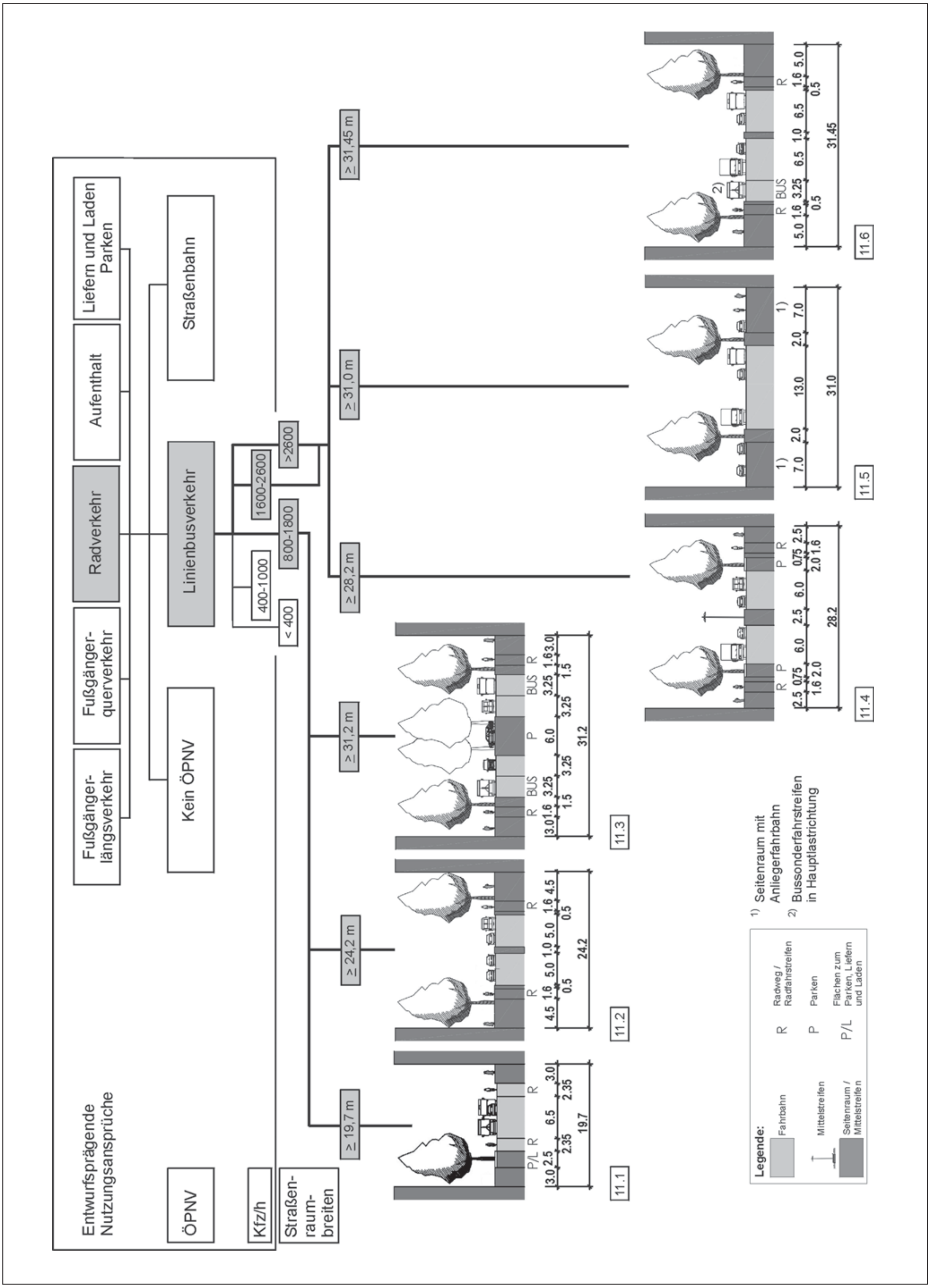


Figure 37: Recommended "link road" cross-sections (first page)

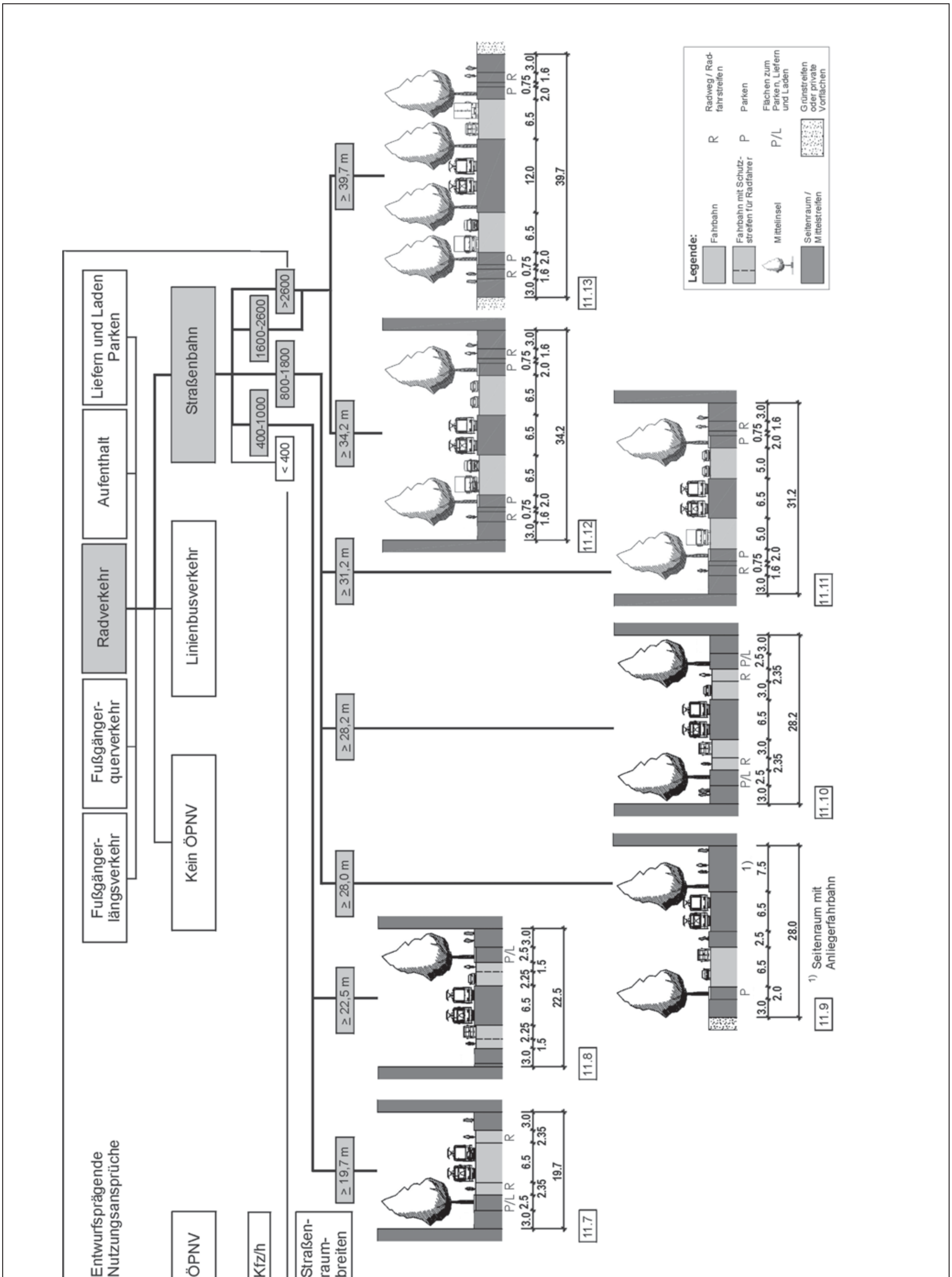


Figure 38: Recommended "link road" cross-sections (second page)

5.2.12 No frontage access road

Characteristics

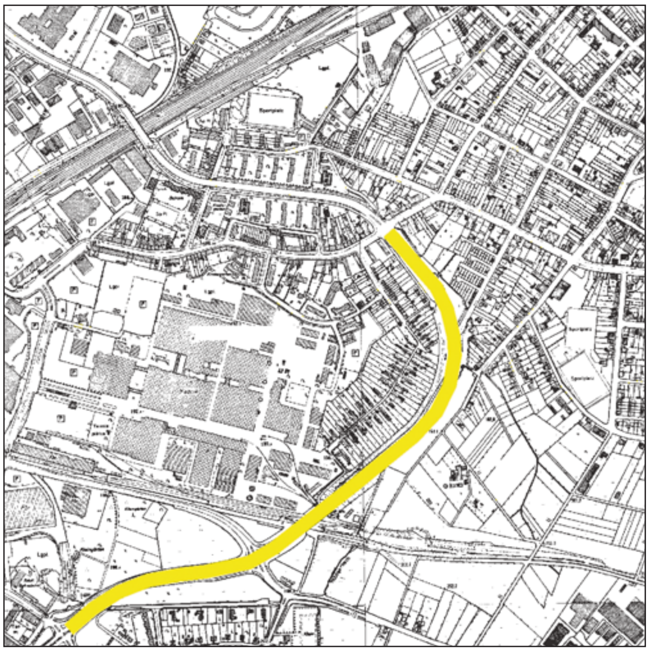
- Main arterial road (VS II, VS III)
- with building frontages facing away from the street, or undeveloped areas, approaching or within a built-up area
- Traffic volumes from 800 veh/h to 2,600 veh/h with occasional high volumes of heavy traffic
- Minimal other use requirements
- Usually with a bus service.

Typical boundary conditions and requirements

- The carriageways are mostly built with central reservations.
- Pedestrians and cyclists are routed on separate, shared pathway/cycle routes.
- Pedestrian and cycle traffic volumes are usually low and there is no significant crossing requirement.

Special points of note

- Bus stops must be adequately dimensioned according to actual or expected speeds and kept free for use.
- Cycle traffic may play a key role, depending on the location within the network. In this case separate pedestrian and cycle paths must be laid out.
- Where important pedestrian and cyclist crossings meet, such as where leisure traffic route crosses, suitable crossing facilities must be provided, such as central islands and, where appropriate, speed restrictions.
- In cross-sections with trams, locations should be reserved as necessary for overhead cable pylons.
- On a tram route, tree crowns must not extend into or overgrow the clearance zone.
- Where maximum speeds are above 50 km/h, the need to install passive safety systems should be investigated. The larger area resulting from such a requirement is shown in figure 39 for $V_{limit} = 70$ km/h.



No frontage access road in built-up area with a tram lines

No frontage access road with pedestrian/cycle paths on both sides, approaching built-up areas

No frontage access road, central reservation with planting, also pedestrian and cycle paths on both sides within built-up areas

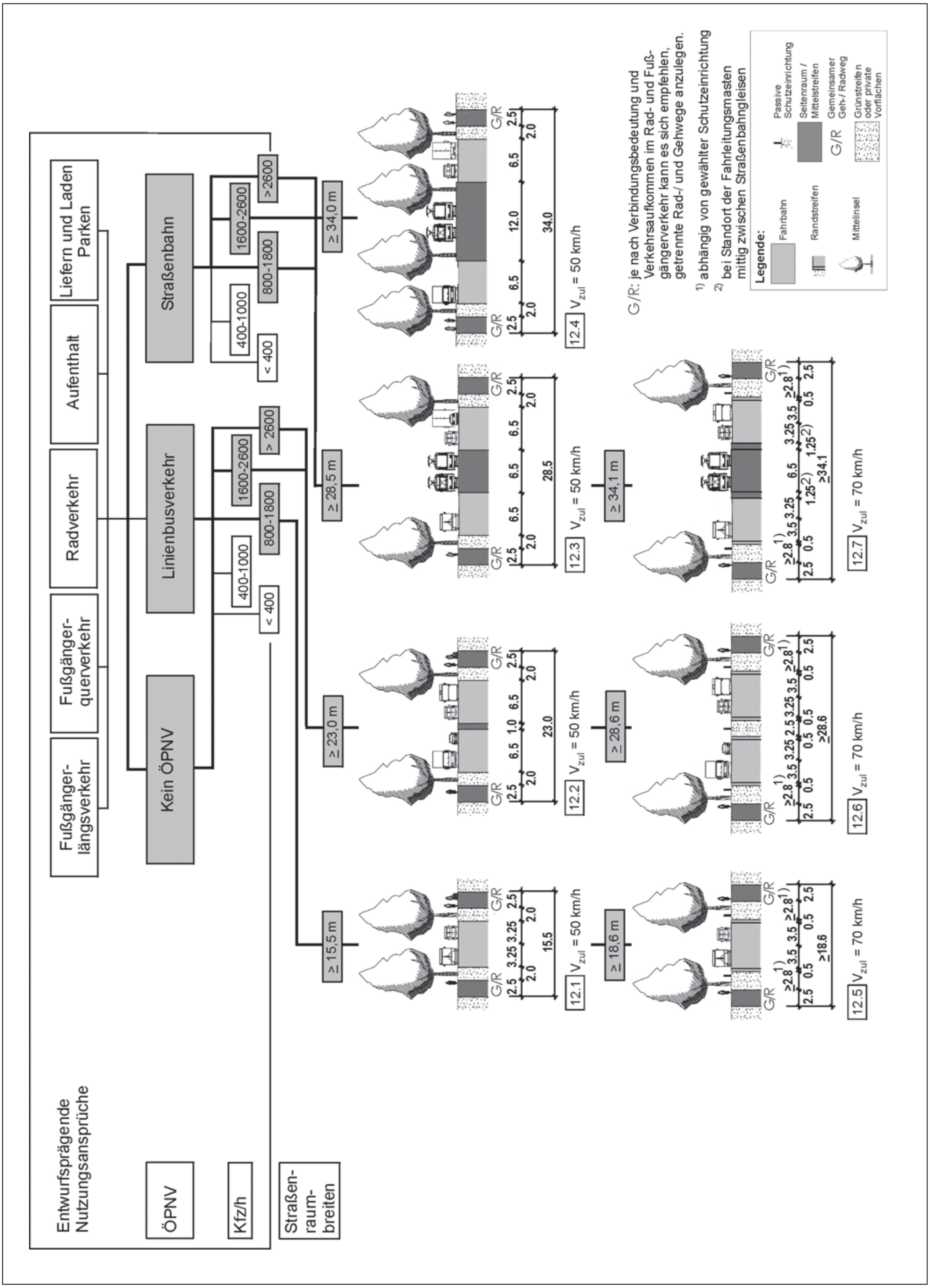


Figure 39: Recommended “No frontage access road” cross-sections

5.3 Junction types

5.3.1 Introduction

The selection of a suitable junction type is based on

- the network function of the roads being linked,
- their traffic volumes,
- their accident statistics, and
- the traffic engineering requirements and the street space available where the junction is to be laid out.

After specifying the junction type, a specific design for the junction is drawn up, the traffic engineering is configured for the expected flows, and the street space is laid out accordingly (figure 40).

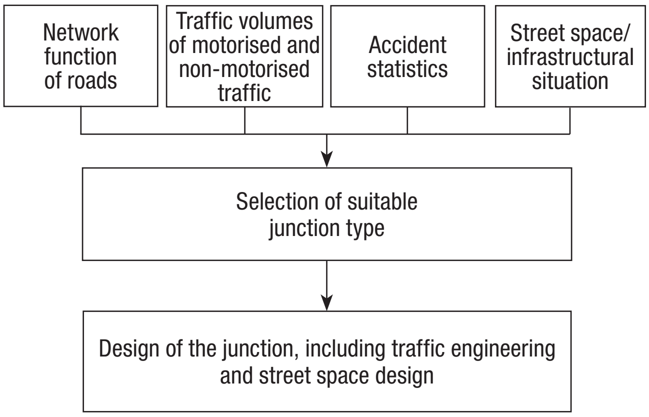


Figure 40: Flowchart of junction design process

5.3.2 Suitability of junction types

The use of the various junction types are set out in table 6. The table is broken down by access roads and main arterial roads, as well as by junctions of "equal" and "different" roads. For ease of understanding, a distinction is made between junctions on access roads and main arterial roads, and junctions joining access roads to main arterial roads. The carriageway cross-sections are broken down into "two continuous lanes" and "four and more continuous lanes".

As two or more alternative junction types are usually suitable (table 6), a balanced preliminary analysis should be made of their advantages and disadvantages – set out in the following. If this is insufficient to select a junction, the alternatives must be developed (see section 6.3) so that they can be comparatively assessed based on the relevant objectives (see section 1.2). When selecting alternative junction types, criteria such as the sequencing of junctions and of preserving the area's character, should also be considered.

Junctions or crossings with the right-before-left rule are generally **suitable** for access roads which

– are of equal ranking;
– are used at low speed, such as in 30 km/h limit zones; and
– where a traffic volume of 800 vehicles per hour, as the all-vehicle sum total, is not exceeded.

This right-of-way causes a reduction in the approach speed.

The right-before-left rule may only be considered for junctions with regular bus services **in exceptional cases,** such as where the delay from traffic coming from the right is low, or justifiable.

For junctions with tram traffic, the right-before-left rule is **not applicable.**

Junctions or crossings with traffic control signs are usually **suitable** if

– the roads are of different ranking;
– the traffic volumes of the roads differ significantly;
– cyclists are to be given priority on cycle routes;
– public transport runs on one of the roads; and
– on the approaching lower-ranked road, single lanes are planned which prevent waiting traffic from queuing next to each other.

Junctions or crossings with traffic control signs are usually **not suitable** for road safety reasons if

– in the event of excessive traffic volumes on the priority road, users on the waiting road attempt to use too short a gap,
– on the lower-ranked road there are high traffic volumes and on the higher-ranked road traffic runs at high speeds;
– it is expected that the speed limit will be exceeded by more than 15 % of the free-flowing traffic.

Junctions or crossings controlled by traffic signals (usually with a left-turn filter) are usually **suitable**

– in the case of new build or remodelling, if it can be seen, from the start of planning the junction, that other designs would create road safety issues;
– at existing junctions, repeated accidents have occurred or are to be expected, which have:
  - involved failure to observe right of way,
  - accidents between left-turning and oncoming traffic or
  - accidents between motor vehicles and crossing cyclists or pedestrians.

If these safety problems could have been avoided by installing traffic signals, and if other measures have proved ineffective or do not offer the prospect of success;

– in order to improve traffic flows in conjunction with appropriate engineering of the junction, if at junctions without traffic signals traffic flows can no longer be managed, or not without significant time loss;
– if public transport is delayed when crossing priority roads or when turning off or onto junctions, or where it is to be enhanced;
– to coordinate traffic flows;
– to improve crossing facilities for pedestrians and cyclists;
– to control the order of priority for specific traffic flows.

Table 6: Suitability of junction types

	Junctions/crossings			Roundabouts			Partially grade-separated solution
	with right-before-left rule	with priority control by traffic signage	with traffic signals	Mini-roundabout	Small roundabout	Large roundabout with traffic signals	
Junctions of access roads							
Equally-ranked access roads	+*)	O*)	–	+*)	+*)	–	–
Access roads of different ranking	O	+	O	+	+*)	–	–
Connecting junctions							
Access road/Main arterial road with 2 continuous lanes	–	+	+	O	+	–	–
Access road/Main arterial road with 4 or more continuous lanes	–	O**)	+	–	–	–	–
Junctions of main arterial roads							
Main arterial road with 2 continuous lanes/Main arterial road with 2 continuous lanes	–	O	+	O	+	–	–
Main arterial road with 2 continuous lanes/Main arterial road with 4 or more continuous lanes	–	–	+	–	O	+	O
Main arterial road with 4 or more continuous lanes/Main arterial road with 4 or more continuous lanes	–	–	+	–	–	+	O
Main arterial road/Urban highway ramps	–	–	+	–	+	+	O

*) Coordinate junction sequence, preserve area character
**) Possibly suitable for junctions on through classified roads with medium and low traffic volumes
\+ Suitable
O Suitable to a limited extent, possibly with supplementary measures
– Not suitable

When designing junctions or crossings with traffic signals, the interaction between the signal programme and the size of the space requirement must be considered:

- Short cycle times with multiple flows at the junction demand short waiting lanes side by side; long cycle times need fewer, but longer queuing lanes.
- Some traffic turning phases require separate turning lanes.

For details of cycle times, numbers of phases, left-turn filters, traffic-actuated signals, operating times etc. refer to the "Directives for traffic light installations" (RiLSA)[33].

In the case of **roundabouts** used in built-up areas, a distinction is made between

- small roundabouts;
- mini-roundabouts;
- small roundabouts with two-lane elements;
- large roundabouts with traffic signals.[34]

Small roundabouts can be particularly **suitable in the urban context**

- as transitional elements on roads with a changing character, such as when roads lead into localities;
- where road categories or the adjoining uses change;
- for creating distinct segments of street and to physically separate street spaces;
- to link equal-ranking street spaces;
- to visually break up continuous carriageway edges; and
- to provide meaning in the urban context by emphasising a public place.

Small roundabouts with single lanes on the roundabout itself, and on the approach and exit routes, with outer diameters of 26 to 40 m and capacities of 1,500 vehicles per hour[35] are particularly **suitable**

- to improve road safety;
- to reduce speeds;
- to simplify traffic systems and provide clearly understandable linking of four and more junction arms, as well as to re-engineer junctions with forked rights of way.

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[33] "Directives for traffic light installations" (RiLSA), edition 2010. Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2010.

[34] For basics and detailing refer to the "Information sheet for the layout of roundabouts", edition 2006, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2006.

[35] At higher traffic volumes the flow of the traffic should be reviewed, and a performance check log kept, for the roads running into and out from the roundabout. See "Information sheet for the layout of roundabouts" and "Handbook for configuration of road traffic installations" (HBS), edition 2001, as amended 2009, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2001/as amended 2009.

The application of small roundabouts **demands special attention to avoid disbenefits**

- if crossing points – such as school walking routes and bicycle traffic – require traffic signals, or where such controls are desired;
- where inflowing roads are very unequal in their traffic-carrying importance;
- on bus routes;
- at railway level-crossings;
- where the topography is hilly.

Trams on separate tracks do not prevent the use of roundabouts, provided they are given priority by traffic signals.

Small roundabouts **should not be used** if

- high traffic volumes result in long waiting times;
- an appropriate and satisfactory urban design cannot be achieved due to a lack of space.

Mini-roundabouts with outer diameters of 13 to 22 m and traversable central islands with capacities of 1,200 vehicles per hour[35)] are usually **suitable** if:

- the maximum speed on all approach roads is 50 km/h or less;
- there is insufficient space for other junction types;
- unacceptably long waiting times and tailbacks occur;
- (the designer can be confident of) compliance with the maximum speed in 30 km/h zones can;
- the primary flow consists of turning traffic and otherwise a forked right of way would be configured.

A mini-roundabout should usually **not be created**

- approaching urban areas;
- where they are inadequately identifiable as such;
- at junction points with incoming one-way roads;
- where there would be an unreasonable loss of comfort for bus passengers;
- on tram routes;
- in case of high volumes of heavy traffic, due to the noise as vehicles drive over the central island.

The **application of two-lane roundabouts** with outer diameters of 40 to 60 m should be considered where existing single-lane roundabouts are overloaded, and should be carefully balanced against alternative junction types, as two-lane roundabouts do not offer the same level of safety as small single-lane roundabouts.

If the capacity of existing small single-lane roundabouts is insufficient, it can be raised in stages by

1. installing separate right-turn filter lanes (bypass lanes);
2. installing two-lane roundabouts; and
3. installing two-lane roundabouts with two-lane approach roads.

Bypass lanes present additional areas of conflict. This applies in particular where pedestrian and cycle traffic is routed over the bypass lane.

Two-lane approach roads should only be installed where there is no – or very little – pedestrian and cycle traffic, as is usually the case only on approaches to built-up areas, such as on trading/industrial estates.

The use of **large roundabouts with traffic signals** is primarily based on the traffic situation and criteria relating to the surrounding environment. Within built-up areas, they should only be considered

- if the road side environment justifies such a dominant junction design;
- as a low-cost, high-performance alternative to constructing a grade-separated or partially grade-separated junction;
- to interrupt the characteristics of the road, particularly in the transition between open and built-up stretches of road;
- in the case of existing, previously unsignalled large roundabouts, to improve road safety and increase capacity.

The capacity of roundabouts with traffic signals depends on the distribution of the traffic flows and thus on the programming strategy for the signals.

Partially grade-separated junctions are usually installed in urban centres only if alternative junction types are unable to handle the very high traffic loads, or only with significant time loss. They should only be installed on limited access roads. The space they require and the construction cossts are very high compared to alternative junction types.

5.4 Transitions between straight road and junction

Particularly for main arterial roads, special attention must be paid to developing the junction design from the incoming roads.

It is usually necessary in such scenarios to provide separate queuing lanes where specific flows meet, to install public transport stops, to safeguard the routing of cycle traffic, and to ensure that all the overlapping uses are integrated neatly into the urban environment and do not detract from the footway space.

Consequently, for a number of selected cross-sections the following sets out development options for the higher-ranked approach road, presented schematically for junctions with traffic signals and roundabouts. These are intended as examples applicable to the specific conditions depicted, which also demonstrate how the changes to the carriageway cross-section can be made without restricting pedestrian walking areas.

Figures 41 to 45 illustrate a two-lane profile with a 6.50 m carriageway and accompanying parking lane, cycle path and pedestrian footpath, turning lanes, on-street cycle traffic routing and the layout of a bus stop on the junction approach, with variations for traffic signal controlled junctions and roundabouts.

In order to create a separate left-turn filter lane, the parking lanes on each side are omitted in the junction zone. The cycle traffic is routed onto the carriageway on the junction approach, and is provided with a central cycle lane leading to an advanced stop line for direct left-turning. A bus stop can be installed at the roadside on the combined straight-ahead/right-turn lane (figure 41).

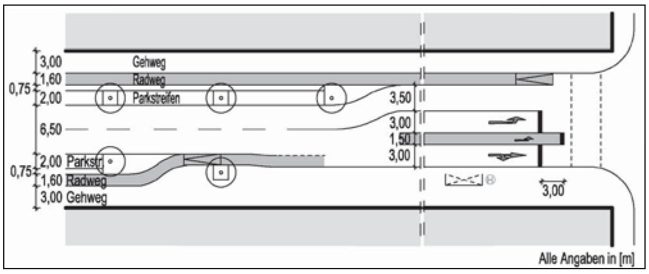

Figure 41: Example of carriageway widening with left-turn lane and bus stop

In order to create a separate right-turn filter lane, the parking lanes on each side are omitted in the junction zone. The cycle traffic is routed onto the carriageway on the junction approach, and shares use of the queuing lanes for motor vehicle traffic. A bus stop can be installed at the roadside on the right-turn lane, from which the bus can also exit straight-ahead with the aid of the traffic signals (figure 42).

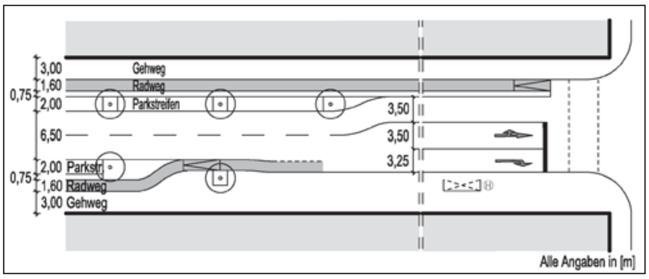

Figure 42: Example of carriageway widening with right-turn lane and bus stop

In order to create a separate left-turn filter lane, the parking lanes on each side are omitted in the junction zone. The cycle path changes into a cycle lane with advanced stop line on the junction approach. Left-turning for cyclists can then be implemented indirectly as an option. A central island can be installed as a crossing facility (figure 43).

In order to create a bus stop on the junction exit road, with a separate left-turn filter lane, the parking lanes on each side are omitted. The cycle path changes into a cycle lane, on the junction approach, with an advanced stop line.. Cyclists must pass a stopped bus on the carriageway, and are then routed onto a cycle path (figure 44).

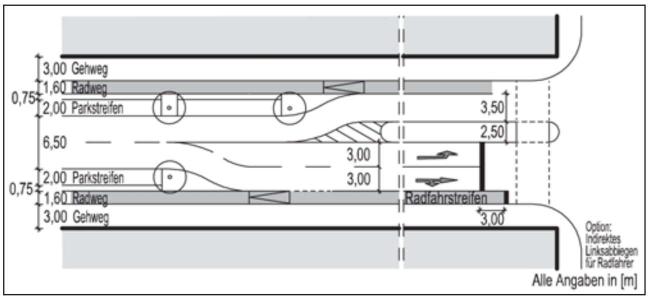

Figure 43: Example of carriageway widening with left-turn lane and central island

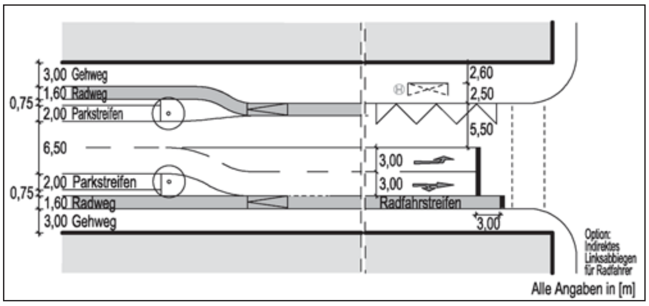

Figure 44: Example of carriageway widening with left-turn lane and bus stop on junction exit road

Installing a small roundabout enables cycle traffic to use the roundabout carriageway. The parking lanes on each side are omitted to install a central island and waiting areas for a bus stop, before the roundabout (figure 45).

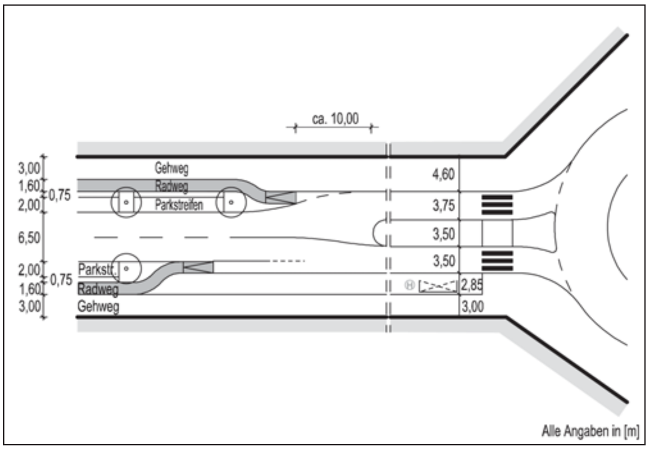

Figure 45: Example of a carriageway widening, with central island and bus stop, before a small roundabout

Figures 46 to 48 illustrate different methods of routing cycle traffic on the approaches to traffic signal-controlled junctions, for a carriageway cross-section with a 7.00 m overall width, including advisory cycle lanes on both sides.

At junctions where no separate turning lanes are required, or where they are not possible due to lack of space, at an overall carriageway width of 7.0 m, depending on the width of the queuing lane, the inflowing advisory lane can either end at the junction approach (figure 46) or be continued through to an advanced stop line (figure 47).

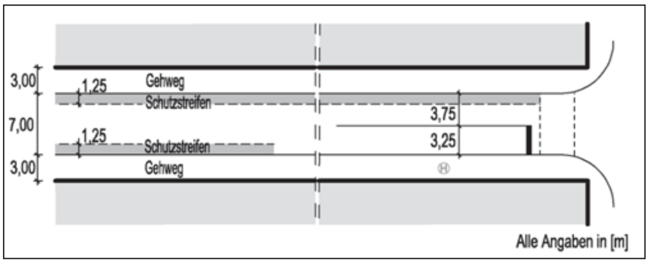

Figure 46: Example of junction approach with an advisory lane ending

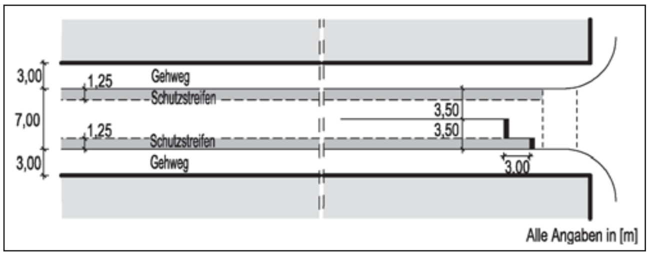

Figure 47: Example of junction approach with continuous advisory lanes

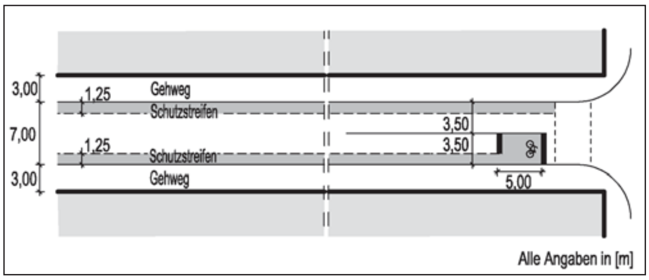

Figure 48: Example of junction approach with an advanced stop-line area deepened to 5m

A deeper advanced stop-line area for cyclists should only be used on a junction approach with a longer red than green cycle (figure 48).

Figures 49 to 51 show a 7.50 m wide carriageway with advisory lanes between the longitudinal parking lanes and their routing to a traffic light-controlled junction and a roundabout with differing routing of cycle traffic and stop layout.

In order to create a separate left-turn filter lane, the parking lanes on each side are omitted. The advisory lane changes into a mandatory cycle lane with advanced stop line on the junction approach. Left-turning for cyclists can be implemented directly after filtering at the appropriate time into the left-turn lane, or indirectly using the cycle lane (figure 49).

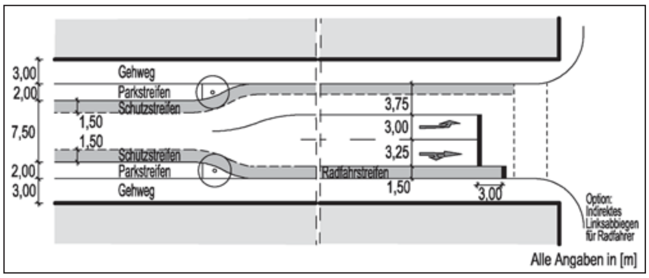

Figure 49: Example of carriageway widening with separate left-turn lane and cycle lane

In order to create a separate left-turn filter lane, the parking lanes on each side are omitted. The advisory lane on the junction approach ends and cyclists share-use of the queuing zones for the motor vehicle traffic. The exiting advisory lane can only be executed as 1.25 m due to the lack of space in the junction zone. A bus stop can be installed in the queuing lane for the straight-ahead and right-turning traffic (figure 50).

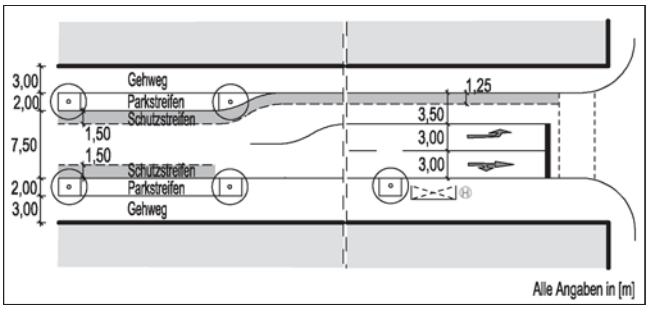

Figure 50: Example of carriageway widening with separate left-turn lane and bus stop

In order to create a central island on the approach to a small roundabout, the parking lanes on both sides are omitted. The advisory lane for the cycle traffic ends on the junction approach. Cyclists are routed along with the motor traffic with no special markings, and around the roundabout. A bus stop can be installed on the approach to the roundabout in the area of an extended central island which prevents passing (figure 51)

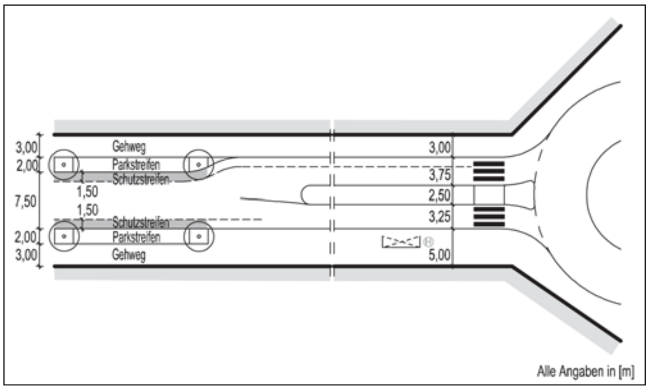

Figure 51: Example of carriageway widening with central island and bus stop, before small roundabout

Figure 52 shows a widening of a four-lane highway with central island with possible cycle traffic routing and busstop layout.

In order to create turning lanes and a bus stop, the parking lanes on both sides are omitted. At the junction approach, the cycle path is changed into a mandatory cycle lane with an advanced stop line; indirect left-turning for cyclists can be implemented as an option. In the bus stop waiting area the cycle path is discontinued for safety reasons, and the pedestrian footpath is shared for use by cyclists (figure 52).

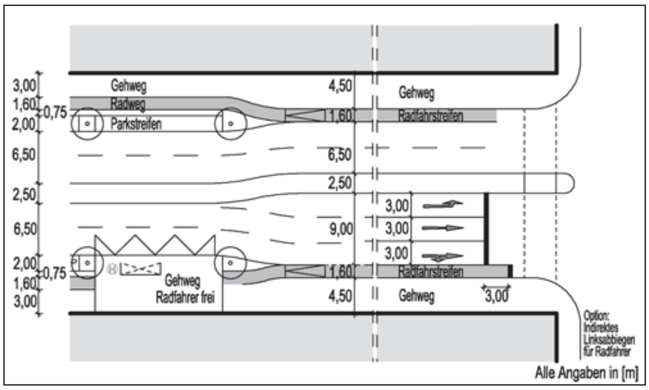

Figure 52: Example of widening of a four-lane carriageway with turning lanes and a bus stop

6 Design elements

6.1 Linear Elements

6.1.1 Carriageways

6.1.1.1 Basic considerations

For the design of carriageway cross-sections, a key factor is whether areas for other user requirements are available or not.

Carriageway cross-sections with a constant width for long stretches are often not appropriate for urban roads, as the functions of individual stretches may vary due to their dependency on the adjoining buildings, the uses and the varying demands over time. Also, remodelling works must preserve the urban character of the road in question (its Place function). On the other hand, the dimensions of continuous carriageways should not be varied without reason.

A distinction is made between two basic design principles for designing carriageways on urban roads:

– Separation principle;

– Shared space principle.

The **separation principle** involves creating a separate carriageway for vehicular traffic, usually physically delineated by kerbs, gutters or channels.

Omitting kerbs has a positive effect in terms of ease of crossing and for the urban context, but it always requires speed reducing measures as well as adequate dimensions for the pedestrian footways and carriageways in order to conform to road traffic law.

The **shared space principle** seeks to make multiple uses as mutually compatible as possible, based on intensive design and engineering measures. This is achieved by forming the entire street space at the same height or – particularly when carrying out a remodelling which retains kerbs – by means of a series of traffic-calming elements (such as speed humps, unit-paved surfaces, pedestrian/cyclist crossings).

The lane widths depend on:

- the volumes of bus and heavy traffic,
- the routing of cycle traffic,
- the area available in its local context, and
- balancing the different user requirements.

Any change from the dimensions specified in the accompanying table must be checked and justified for two-way traffic, when meeting, running alongside and overtaking (see section 4.1).

Reduced lane widths, compared to the stretch of straight road, may be used approaching junctions if queuing lanes, footway space or medians can be created.

The carriageway capacities indicated below are intended as a rough guide for potential application, and do not take into account the limiting capacity of junctions on the stretches of road concerned 36).

6.1.1.2 Two-lane carriageways

Two-lane carriageways on main arterial roads are generally between 5.50 and 7.50 m wide, and on access roads between 4.50 and 6.50 m wide (table 7).

Two-lane roads with standard widths carry a wide range of motor traffic volumes. The capacity of two-lane lengths of main arterial roads are between 1,400 and 2,200 vehicles per hour total for both directions.

Carriageway widths adjacent to medians are set out in table 8.

For special traffic/wide loads, carriageways adjacent to a median may be constructed using a different material laid

Table 7: Two-lane carriageways

Application	Carriageway width, main arterial roads	Carriageway width, access roads
Standard case	6.50 m*)	4.50 m – 5.50 m
with scheduled bus traffic	6.50 m*)	6.50 m
Light scheduled bus traffic with a low use requirement**)	6.00 m	6.00 m
Low frequency of HGV traffic meeting	5.50 m (at reduced speed)	–
High frequency of bus or HGV traffic coming together	7.00 m	–
Advisory lane for cyclists	7.50 m with 1.50 m advisory lane on both sides 7.00 m with a 1.25 m advisory lane***) on both sides) in confined situations	

*) At this dimension a mandatory-use cycle facility must usually be provided.
**) E.g. only an access road function
***) Not next to parking lanes with a frequent parking turnover

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36) More details on determining the different levels of traffic capacity for main arterial roads, including in the road network context, are planned for the next update to the HBS.

Table 8: Carriageways adjacent to central islands/medians

Application	Carriageway width/ Driveable width
Standard case on main roads	3.00 – 3.50 m
with schedule bus service	min. 3.25 m
with agricultural traffic, heavy and wide loads	3.75 m
Snow clearing vehicles	Check in individual case
On roads used in the military network	4.00 m – 4.75 m*)

*) May be restricted in one direction if military vehicles can, when required, pass the island in the opposite direction.

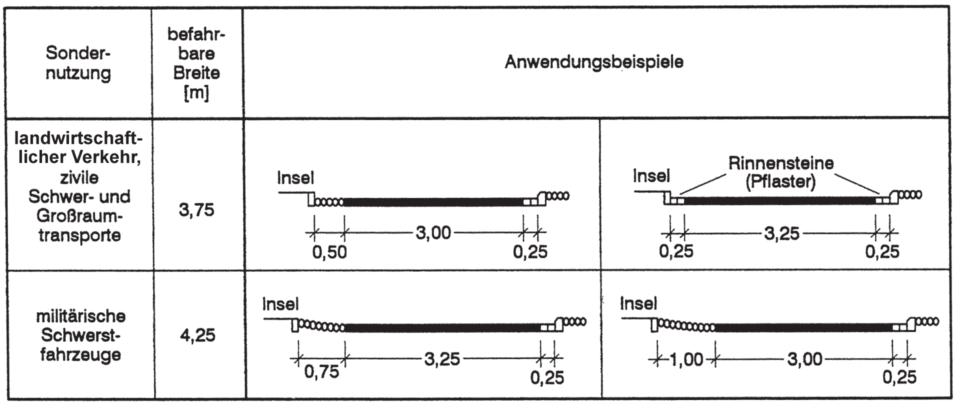


Figure 53: Examples of carriageway widths adjacent to islands on roads carrying special traffic/wide loads

≤ 3 cm higher and textured, so that the impression of a visually narrower carriageway is retained and regular use of the widened area is largely avoided (figure 53).

The layout of central islands on two-lane roads is illustrated in figure 99.

6.1.1.3 Four-lane roads with a central reservation

Four-lane roads with a central reservation consist of two-lane carriageways in each direction which are generally between 5.50 and 7.00 m – usually 6.50 m – wide (table 9).

Table 9: Two-lane roads with Standard widths

Application	Width
Standard case	6.50 m
Low frequency of bus or truck traffic	6.00 m (5.50 m in constrained space situations)
Bus or truck traffic predominant	7.00 m (only where permanent side-by-side driving is to be accommodated)

6.1.1.4 Four-lane roads with no central reservation

Four-lane roads with no central reservation, using the lane widths in Table 9 – four-lane carriageways with a central reservation, result in carriageway widths of 13.00 and 12.00 m. They may be used where the available space is severely restricted and on roads with low bus/heavy traffic volumes. They are difficult to cross. They are only practicable if their high capacity is also available at the adjoining junctions. and if central islands (where appropriate in conjunction with road narrowing) can be incorporated at least at individual points.

Because there is no separation between the carriageways in each direction, special care must be paid in terms of road safety to the traffic mix and the expected speed levels.

6.1.1.5 Widened two-lane roads

Widened two-lane roads are those between 8.5 and 10.00 m wide (table 10). They permit a flexible use of part of the carriageway, such as for delivery and loading, or for short-term parking. This flexibly used area may be carried out in a different material. Special care must be taken to protect pedestrians crossing the road.

Table 10: Widened two-lane roads

Application	Width
Two trucks meeting next to a stationary truck	9.00 m – 10.00 m
Heavy bus/truck traffic with parked cars	8.50 m

The capacity of four-lane roads varies between 1,800 and 2,600 vehicles per hour in each direction.

The capacity of widened two-lane roads varies between 1,800 and 2,600 vehicles per hour, depending on the cross-section and the traffic mix.

6.1.1.6 Single-lane carriageways

One-way roads and single-lane carriageways are designed with a width of 4.25 to 3.00 m where space is severely restricted (table 11).

On single-lane carriageways with lane widths up to 3.50 m it may be useful

- to delineate central reservations using half-height kerbs which can be driven over;
- to design the edges of the central reservations as traversable; and
- to design the inner edge of the carriageway also as traversable, for special transports and very-wide vehicles.

Carriageway widths adjacent to central islands are set out in table 8.

Table 11: Single-lane carriageways

Application	Carriageway width, main arterial roads	Carriageway width, access roads
Standard case (with cyclists on the carriageway)	4.25 m (in restricted space conditions 3.00 m)	3.50 m (in restricted space 3.00 m)*)
Cycle traffic on carriageway, in contra flow	not applicable	3.50 m (3.00 m with adequate passing points)*)
Carriageway with advisory cycle-lane	3.75 m (2.25 m – 1.50 m) with light truck traffic	Infrequent occurrence

*) The requirements of Winter service vehicles should be considered in each individual case

6.1.1.7 Widened single-lane carriageways

Widened single-lane carriageways, separated from each other by medians, may also incorporate tram tracks. They are easier to cross than four-lane carriageways. They are between 5.00 and 5.50 m wide (table 12).

Table 12: Widened single-lane carriageways

Application	Width
Trucks/cars driving side-by-side Trucks passing stationary trucks	5.50 m
Two-lane car traffic	5.00 m

The capacity of widened single-lane carriageways is 1,400 to 2,200 vehicles per hour in each direction. Where cars traffic predominates, it may attain the capacity of two-lane carriageways of 1,800 to 2,600 vehicles per hour.

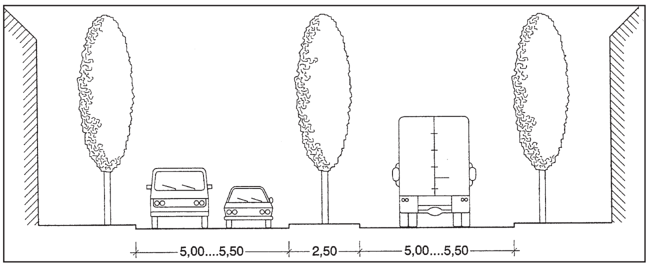


Figure 54: Example of widened single-lane carriageways

6.1.1.8 Side access lanes on main Highways/Boulevards

Side access lanes on main Highways/Boulevards allow for separation of the access and link functions of main roads in built-up areas. The lanes usually work in the same direction as the adjoining main carriageway.

These lanes are to be integrated with the neighbouring development and give access to properties. In contrast to frontage carriageways, they are based on the shared space principle (table 13).

Table 13: Side access lanes

Application	Width
Side access lanes (separation principle)	4.75 m (delivery traffic possible on carriageway)
Side access lanes (shared space principle)	3.00 m (delivery traffic and parking on adjacent areas)

They can be applied where road stretches are short and access traffic volumes are low. Shared Space use of the street is favoured when the parking bays are on the left-hand (or main carriageway) side of the side access street.

Side access lanes with one-way for motor vehicles may have two-way cycle traffic if it is appropriately signed and special safety measures for cyclists (speed humps, islands, cycle symbols) are installed at junctions and at the start and end.

6.1.1.9 Carriageway narrowing at bottlenecks

At bottlenecks due to infrastructure or local context, carriageway narrowing is necessary if a minimum width footway space cannot be created for non-motorised users without discontinuing the footway or widening a bridge structure (table 14).

Carriageway narrowing at bottlenecks should be suitably highlighted (with a change of material, physical narrowing) clearly indicating the possibility of meeting oncoming traffic. The carriageway width in the narrowed area should be made so that it is clearly different from the width of the approaching carriageway (table 15). The visibility of oncoming traffic must be checked regarding the start and length of the narrowed zone.

Table 14: Routing of non-motorised road users at bottlenecks

Road users	Routing at bottlenecks
Pedestrians	Delineation of pathway by raised kerbs
Cyclists	Shared pedestrian and cycle paths instead of dedicated cycle paths or cycle lanes

Table 15: Carriageway narrowing at bottlenecks

Application	Routing of motor vehicle traffic at bottlenecks	Carriageway width
Two-lane carriageway	Two-lane	4.75 m – 5.00 m
	Single-lane (a short length of narrowing allows up to 500 veh/h; a narrowing up to 50 m length allows up to around 250 veh/h, otherwise narrowing to be signalled)	3.00 m – 4.75 m
Four-lane carriageway	Four-lane with no central reservation	5.50 m in each direction (11.00 m in cross-section)
	Widened two-lane (four-lane car traffic possible)	5.00 m – 5.50 m in each direction (10.00 m – 11.00 m in cross-section)
	Widened two-lane (a ‘merge-in-turn’ system required)	< 10.00 m in cross-section

6.1.1.10 Narrow two-way carriageways with passing places

Narrow two-way carriageways between 3.50 and 4.75 m wide are used on lightly loaded access roads (table 16).

As a rule, carriageway width less than 4.00 m usually require passing places.

The desired speed is a maximum of 30 km/h. It can be less than 20 km/h.

Table 16: Narrow two-way carriageways

Application	Carriageway width
with fewer than 30 trucks per h (section length 50 m – 100 m)	4.75 m (in tight spaces up to 4.50 m)
with fewer than 70 veh/h, light truck traffic (section length approx. 50 m)	3.50 m (in exceptional cases up to 3.00 m)

6.1.1.11 Streets in shared space areas

In shared space areas, all road users are essentially able to use the entire street space. As a safety measure to protect pedestrians – especially in front of building entrances and along buildings directly adjoining the street space – areas should be provided which are not accessible to motor vehicles. Consequently, driving lanes and areas used primarily as pedestrian footpaths should usually be identified by different surface finishes (material, texture, colour). The driving lanes in shared space areas are usually 3.00 to 4.50 m wide. On streets where parking is tight, parking bays must be physically designed so that they are complied with. As a traffic-calming measure (see section 6. 2), streets should run straight and uniform for no more than around 50 m. The aim should be to create a series of places along the street of approximately similar lengths.

6.1.2 Physical traffic management elements

6.1.2.1 Culs-de-sac

Culs-de-sac are suitable means of keeping non-local motor vehicle traffic out and minimising development costs.

The end of a cul-de-sac should be designed as a turning area (see section 6.1.2.2). Property driveways and lowered pavements may also be used for the required turning areas.

The ends of cul-de-sacs should be passable by cyclists and – with appropriate construction of the crossover – and where appropriate be crossable by utility, street cleaning and emergency service vehicles.

The end of the cul-de-sac can be combined with vertical elements (e.g. trees). It must be clearly identifiable in the dark, too, by means of appropriate lighting.

Turning facilities can be incorporated into squares or result in squares being created which, in addition to their traffic role, also perform key urban and street space functions, such as providing a place for people to meet and children to play. Consequently, turning facilities must usually also meet urban design requirements in addition to the geometric requirements of turning traffic (figures 55 to 61). Small green areas and trees can be used to highlight the difference between the street and space function.

6.1.2.2 Turning areas

Turning areas are to be created at the ends of culs-de-sac and lanes, or installed at road closures, when lowered pavements or garage driveways cannot be used for turning.

Turning facilities in shared space areas and in conjunction with (unit-) paved surfaces raised to footway level are not defined by kerbs.

Table 17: Dimensions for turning circle radii (selection)

Standard vehicle	Length	Outer turning circle radius*)
Car	4.74 m	5.85 m
Van	6.89 m	7.35 m
Large truck (3-axle)	10.10 m	10.05 m
Articulated truck	18.71 m	10.30 m
Coach/ bus	12.00 m	10.50 m
Refuse collection vehicle		
2-axle	9.03 m	9.40 m
3-axle	9.90 m	10.25 m
3-axle**)	9.95 m	8.60 m

*) Clearances 1.00 m wide should be allowed around the outsides of turning facilities for vehicle overhang.

**) With trailing axle

It is only necessary that an appropriate area (including use of a 'keep-clear' zone) is available for turning. To prevent illegal parking in the turning zone, it may be useful to lay out parking bays in a suitable form.

Turning facilities should be larger on the left-hand side, asymmetrically, as an aid to steering. For safety reasons, the standard vehicle should be able to turn without extra manoeuvring. The required turning radii for different design vehicles are set out in Table 17. If other vehicles are used, their corresponding swept paths should be used.

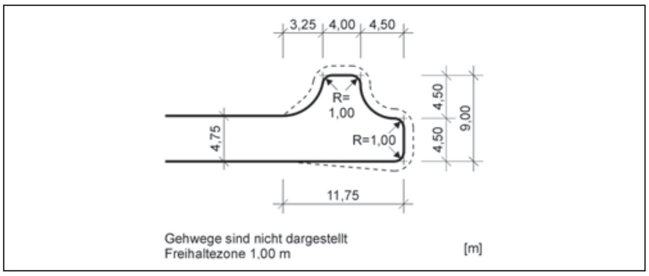
Turning areas may be designed in the form of turning bays, turning circles or turning loops (figures 55 to 61). Turning facilities as shown in figure 60 can be driven even by the largest vehicles licensed under German road vehicle licensing regulations (StVZO).

Turning bays require manoeuvring, and so for road safety and emissions reasons, are less favourable than turning circles and turning loops – at least where regular truck traffic is expected.

If turning facilities cannot be created, for some regularly occurring vehicle traffic, through-ways should be created (such as using removable or retractable bollards).

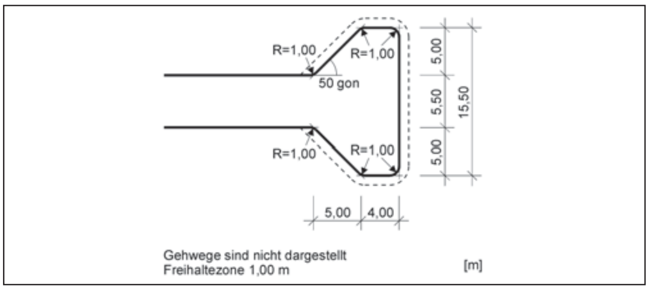
6.1.2.3 Loop roads

Loop roads are planned or incorporated into existing schemes in order to keep out non-local motor traffic.



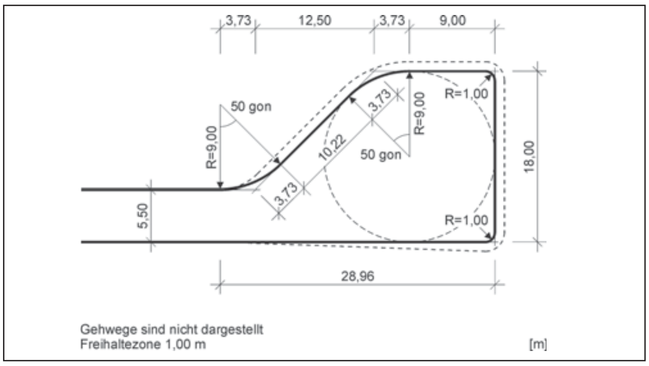
Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

Figure 55: Area required for a three-point-turn: cars



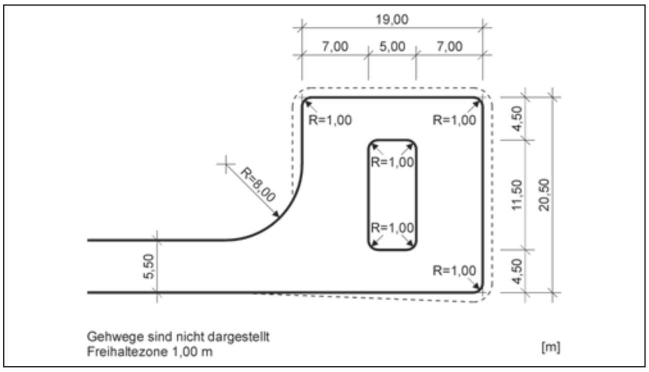
Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

Figure 56: Area required for a three-point-turn: vehicles up to 9.00 m long (2-axle refuse collection vehicle)



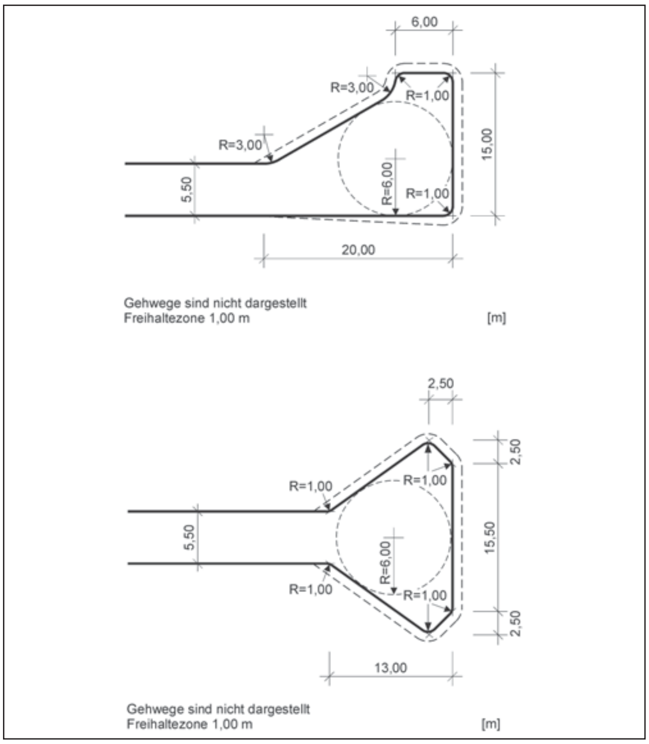
Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

Figure 57: Area required for a 180° turn: 2-axle refuse collection vehicle



Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

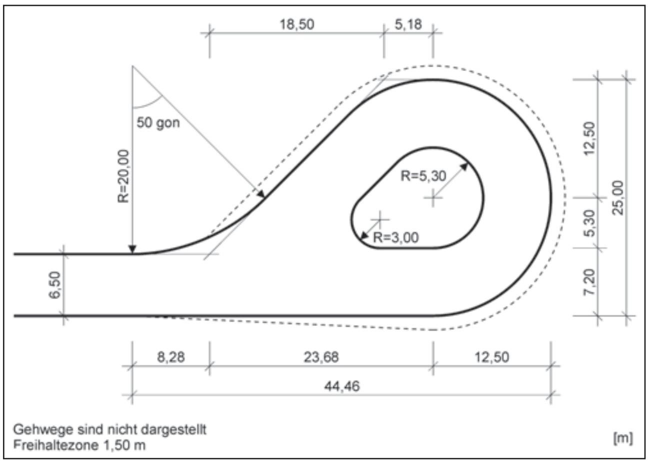
Figure 58: Area required for a 180° turn: 3-axle refuse collection vehicle



Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

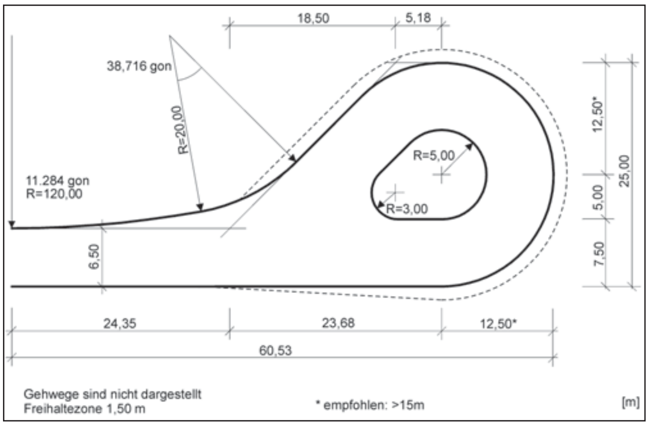
Gehwege sind nicht dargestellt
Freihaltezone 1,00 m

Figure 59: Area required for a one- and two-sided three-point-turn: vehicles up to 10.00 m long (3-axle refuse collection vehicle)



Gehwege sind nicht dargestellt
Freihaltezone 1,50 m

Figure 60: Area requirement for an articulated truck turning loop



Gehwege sind nicht dargestellt
Freihaltezone 1,50 m

* empfohlen: >15m

Figure 61: Area requirement for an articulated bus turning loop

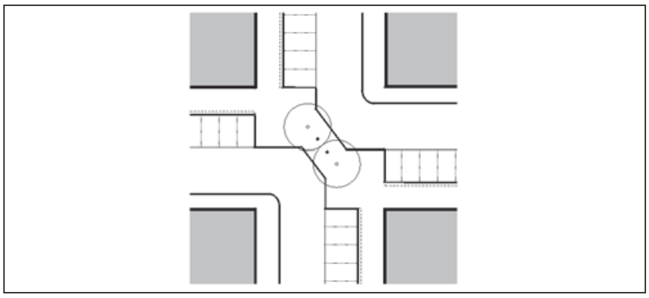


Figure 62: Example of diagonal barrier with passage for cyclists, emergency services and utility vehicles (outline sketch)

Creating loop roads in an existing road network requires the installation of diagonal barriers which are passable by cyclists (figure 62).

Where kerbs are installed, diagonal barriers should allow just enough carriageway width for the standard vehicle to pass, where necessary making temporary use of the opposite lane. It is advisable to make the diagonal speed hump area more than 1.50 m wide, to enable crossing and to accommodate planting.

6.1.2.4 One-way streets

One-way streets are used to guide motor vehicle traffic into and out of an area, to influence the distribution of traffic loads across different roads, and to take space from the carriageway to meet other user needs. Attention should be paid to the potential effect on speeds.

For cross-section dimensions see section 6.1.1.6.

Under certain conditions, counter-flow cycle traffic may be allowed on access roads in order to avoid cyclists having to take circuitous routes and to create attractive cycle traffic links away from main arterial roads (section 6.1.7.6).

6.1.2.5 Turning bans

Turning bans are used to direct motor traffic flows at junctions in order to enhance road safety and improve traffic quality for motor vehicle circulation and local public transport. They are enforced by signage, and should be supported by appropriate physical measures, such as tight radii. Consideration should be given as to whether and how cycle traffic can be exempted from the no-turning ban.

6.1.3 Kerbs and channels

The separation of the carriageway from the footway must be clearly identifiable. This can be achieved by using kerbs, guttering and channelling.

6.1.3.1 Kerbs

The effects of the kerb height as an obstacle should be considered (see sections 4.7 and 6.1.6.2). Raised, half-raised and low kerbs can be used[37] (table 18).

6.1.3.2 Gutters

Gutters consist of channels and kerbs or some other form of design, installed flush to the carriageway.. They are the standard elements for draining surface water from the carriageway (figure 63).

In the case of **gutters designed to be crossed**, slabs or rows of unit paving can be used to provide delineation**,** or kerbs with integrated gullies may be installed. On narrow carriageways, the wider the paved channels, the more noise will be generated when they are driven over.

If cyclists are using the carriageway, narrow channels are advantageous.

If a 0.5 % minimum longitudinal slope of the carriageway cannot be maintained, V-shaped and variable-angle channels can be used. These channels **are not to be driven over** and do not form part of the carriageway. They should be avoided near bus stops.

6.1.3.3 Open drainage channels

Open drainage channels are usually 0.50 to 1.00 m wide rows of paving, slabs or other materials used to delineate them from the road surface. They separate the carriageway from the footway when at the same height or from

Table 18: Kerbs

Design	Height	Function	Areas of application
Raised kerbs	10 cm – 14 cm (maximum 20 cm)	Separation Carriageway/pathway (cycle path)	Main arterial roads outside built-up areas. Main arterial roads in built-up areas with four lanes and over
	8 cm – 12 cm	Separation of carriageway/pathway or parking lane/pathway (cycle path)	Two-lane main roads and access roads
Half-height kerbs	4 cm – 6 cm	Separation of carriageway/pathway (cycle path) carriageway/parking lane	Two-lane main roads and access roads
Low kerbs*)	less than 4 cm to 0 cm	Separation of carriageway/pathway (cycle path) carriageway/parking lane	Two-lane main roads with low traffic volumes Access roads Lowered kerb at crossing points for pedestrians and cyclists

*) Alternatively: Raised natural stone paved footways

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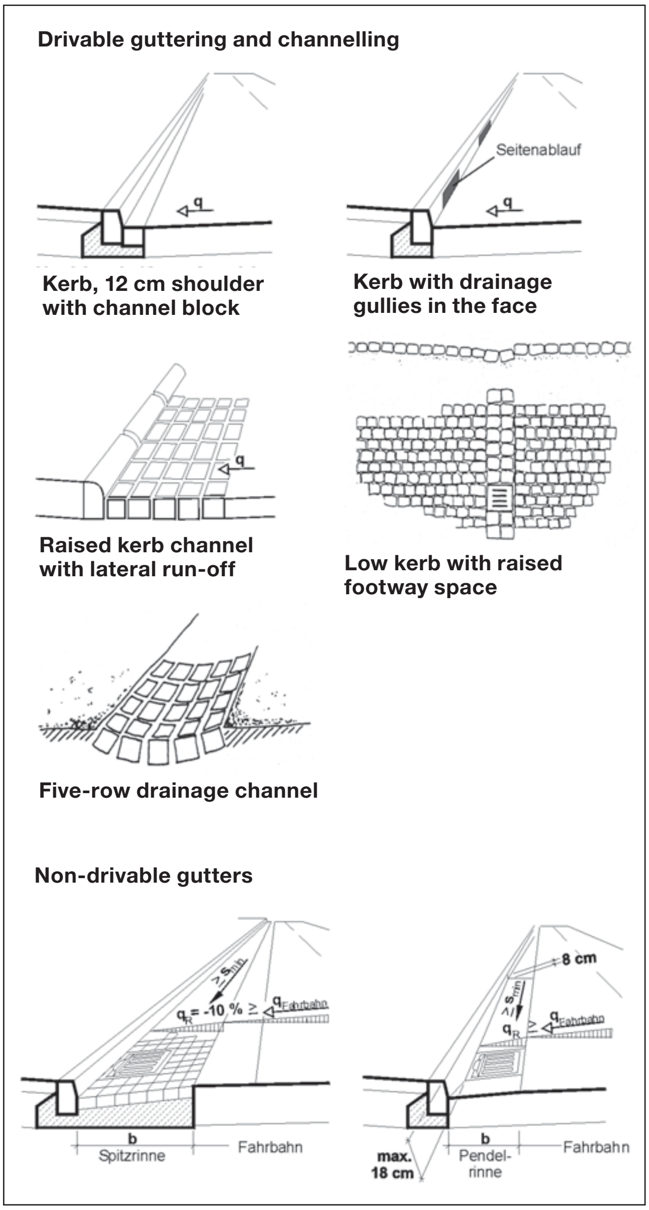
[37] For special kerbs at bus-stops see sections 6.1.10.7 and 6.1.10.8.

Drivable guttering and channelling



Kerb, 12 cm shoulder with channel block

Kerb with drainage gullies in the face

Raised kerb channel with lateral run-off

Low kerb with raised footway space

Five-row drainage channel

Non-drivable gutters

Figure 63: Examples of drivable and non-drivable gutters/channels

incoming roads. Channel widths of more than 0.50 m may be useful for in design, as they narrow carriageways visually (figure 63). With a narrow asphalt surface, however, noise must be expected due to them being driven-over.

The channel depth should be at least 3 cm, and owing to the necessity of being driven over must not exceed 1/15th of the width. The minimum longitudinal slope is 0.5 % when using smooth materials. When using natural stone paving, this should be increased to 1.0 %.

Open dished channels are suitable means for separating the carriageway from the footway areas on urban streets and lightly-loaded two-lane main roads.

6.1.4 Horizontal and vertical alignments

6.1.4.1 Basic considerations

Decisions on horizontal and vertical alignments vary between main roads in urban and non-urban locations.

On local streets and main roads in built-up areas, it is not necessary to calculate horizontal and vertical alignment elements in terms of driving behaviour because speeds are usually

- determined by the driver's response to the street environment and
- are limited by law to 50 km/h and less, or
- impossible, because the necessary changes in the surrounding environment or built structure could not be justified.

For non-built-up main roads, with large intervals between junctions and which are of major link importance for motor traffic, the threshold values for the geometric designs are differentiated by speed. V_{limit} = 50 km/h where frontages are facing away from the road and V_{limit} = 70 km/h where frontages are distant from the road.

On roads with trams the BOStrab directives[38] must also be followed.

Table 19: Limit values of the design elements for carriageways on built-on urban roads

	Design elements	Limit values
Horizontal alignment	Curves: minimum radius, min R [m]	10
Vertical curvature	Maximum longitudinal gradient, max s [%]	8,0 (12,0)
	Peak minimum radius, min H_k [m]	250*)
	Trough minimum radius, min H_w [m]	150*)
cross-section	Maximum lateral slope on curves, max q_K [%]	2,5
	Minimum ramp slope, min Δ s [%]	0.10 · a where a[m] = distance of carriageway edge from centre of rotation
Visibility	Minimum visibility for s = 0 % min S_h [m]	20 (with v_{limit} = 30 km/h) 43 (with v_{limit} = 50 km/h)

*) On residential estate roads with predominantly car traffic, smaller radii can be selected, though the radii should not fall below the min H_k = 50 m and min H_w = 20 m

6.1.4.2 Overview of horizontal and vertical alignment elements

Table 19 sets out the limit values of the main design elements for carriageways on access roads and built-on main arterial roads. The design parameters for autonomous cycle traffic installations are contained in the ERA.

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[38] "Directives for the routing of rail tracks in accordance with the Regulation governing the construction and operation of trams" (BOStrab routing directives), in: Verkehrsblatt (1993), volume 15, p. 571–576.

Table 20: Limit values of the design elements for carriageways on main roads with no frontage access (figures in brackets = exceptions)

Design elements			Limit values	
			V_{lim} = 50 km/h	V_{lim} = 70 km/h
Horizontal alignment	Minimum curve radius	min R [m]	80	190
	Minimum clothoid parameters	min A [m]	50	90
	Minimum curve radius with adverse camber	min R [m]	250	700
Vertical alignment Longitudinal section	Maximum longitudinal gradient slope	max s [%]	8,0 (12,0)	6,0 (8,0)
	Minimum longitudinal gradient slope on winding roads	min s [%]	0.7; s – Δ s ≥ 0.0…0.2 % (without raised kerb) 0.5; s – Δ s ≥ 0.5 % (with raised kerb)	
	Peak crest minimum radius	min H_k [m]	900	2 200
	Trough minimum radius	min H_w [m]	500	1 200
Cross-section	Minimum lateral camber	min q [%]	2,5	
	Maximum lateral camber on bends	max q_K [%]	6.0 (7.0)	
	Maximum ramp slope	max Δ s [%]	0.50 · a 2.0 (a ≥ 4.0m)	0.40 · a 1.6 (a ≥ 4.0m)
	Minimum ramp slope	min Δ s [%]	0.10 · a a [m] = distance of carriageway edge from centre of rotation	
Visibility	Minimum visibility for s = 0 %	min S_h [m]	47	80

Table 20 sets out the main design elements. Figure 64 shows the lateral slopes for carriageways on open main arterial roads.

6.1.4.3 Carriageway widening

To obtain a visual satisfactory alignment of the continuous lanes, in the case of a small radius, adjustment should be made on the inner edge of the curve, in the case of an extended longitudinal layout both sides of the road should be adjusted with respect to the road axis.

The carriageway edges should where possible be designed independently from the road axis, or be designed with two quadratic parabolas joined as an S-bend.

After parking lanes and central islands it may also be useful in design terms for turning lanes to begin abruptly but the minimum adjustment length must be observed.

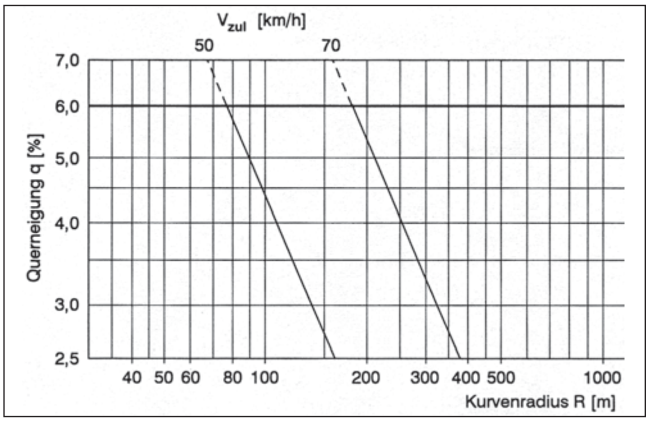

Figure 64: Lateral slopes for carriageways on open main arterial roads Cambers for Main roads with no frontage access

On access roads and built-up main roads, the adjustment length should be L_z = 20 m.

The adjustment length for interurban main roads is given by:

$$L_z = V_{limit} \cdot \sqrt{\frac{i}{3}}$$

L_z [m] = adjustment length

V_{lim} [km/h] = maximum speed limit
i [m] = widening.

6.1.4.4 Carriageway widening on curves

Where the standard vehicles meet infrequently the opposite lane can be used by larger vehicles on bends.

The **carriageway widening** required for the different cases of single-part standard vehicles meeting, is determined by the **sum of the lane widenings**.

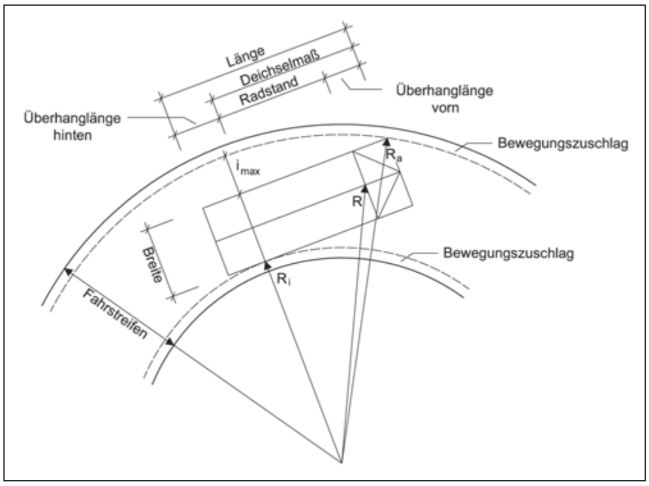

Figure 65: Curve geometry

The maximum lane widening arc is calculated according to the formula:

$$i_{max} = R_a - \sqrt{(R_a^2 - D^2)}$$

In the case of radii R ≥ 30 m, assuming Ra ≈ R adequate accuracy can be achieved with the formula

$$i_{max} = \frac{D^2}{2R}$$

i_{max} [m] = lane widening
R_a [m] = swept outer radius
D [m] = Drawbar length (wheelbase plus front vehicle overhang; table 21)
R [m] = radius of the centre of the front axle.

Table 21: Drawbar length D for selected rigid standard vehicles

Standard vehicle	Drawbar length D
Car	3.64 m
Truck, 2-axled 3-axled	6.60 m 6.78 m
Standard service bus	8.72 m*)
Articulated bus	9.11 m*)
Coach/bus 15.00 m	10.05 m

*) as per StVZO

The full lane widening imax is required only if, at the full lane widening point, the change of direction angle exceeds the value

$$\gamma i_{max} = 2\frac{D}{R_a}\cdot\frac{200}{\pi}$$

Intermediate values for $\gamma_{existing} < \gamma i_{max}$ are produced as

$$i_{req} = 3\sqrt{\frac{\gamma_{existing}}{\gamma i_{max}}}\cdot i_{max}$$

i_{req} [m] = required lane widening with $\gamma_{existing}$
$\gamma_{existing}$ [gon] = existing change of direction angle
γi_{max} [gon] = change of direction angle with i_{max}

Calculated carriageway widenings below 0.25 m can be omitted at carriageway widths B ≤ 6.00 m; those below 0.50 m can be omitted at widths B > 6.00 m. The calculations necessary for these widenings relate to the carriageway axis for all lanes. The carriageway widening i is effected with the exception of turns on the inner bend margin – that is to say, on the inside lane.

For multi-part standard vehicles (tractor-trailer combinations, semi-trailers) tractrix curve verification is required.

6.1.5 Parking and loading areas in the street

Parking and loading, related to local requirements, can be located in the street

- on the carriageway (unmarked);
- in parking lanes (marked) or in bays (with modified kerbs);
- in (wide) central reservations; or
- on the footway (in marked areas or without allocated space).

Parking bays and lane dimensions, for the ‘standard design vehicle’, are set out in table 22. Dimensions for larger vehicles, as well as special features relating to the choice of parking bay width, are contained in EAR[1].

For delivery vehicles, parallel parking in bays 2.30 to 2.50 m wide is the norm (depending on the standard vehicle); for trucks the standard parking bay width is 3.00 m.

Where parking areas are angled or perpendicular to adjacent planting, footways or cycle paths, the width of any overhang must be considered (see table 22). For parallel parking an allowance must be made for opening vehicle doors (0.75 m).

When selecting materials for parking bays and adjacent footway surfaces, the benefits of water-permeable or green-surface construction (such as perforated stones, gravel or grass) should be investigated.

6.1.5.1 Parking and loading on the carriageway

Parking and loading on the carriageway takes place parallel to the kerb.

To check the clearance of the remaining carriageway, adjacent to parked and loading vehicles, refer to the basic dimensions (see figure 17).

For delivery traffic, areas for time-limited loading can be reserved by signage and markings or differentiation by material.

6.1.5.2 Parking and loading areas on lanes and in bays

The beginning and end of parking lanes or bays at junctions should take into account adequate visiblity. Parking bays should be delineated from pedestrian footpaths or cycle paths by raised kerbs (8 to 10 cm, see table 18).

Providing for parking traffic in **parking bays** should normally be preferred rather than creating **parking lanes** on the carriageway because as a result:

- visibility is improved for motorists at junctions as well as between motorists and pedestrians;
- at high levels of parking density, pedestrian crossings can be concentrated at suitable points and visibility improved by interrupting the parking row; clearer definition of the street-section is enabled when making advisory or mandatory cycle lanes;
- designed areas and added greenery mitigate the dominance of the carriageway in the street space.

Parallel parking bays (figure 66), provided that the bay and the safety separation strip are of sufficient depth, allow vehicle doors to be opened without endangering cyclists in the footway space.

Marking individual parking bays is not essential in terms of moving traffic and not desirable in design terms, though it can be required by road traffic regulations (such as

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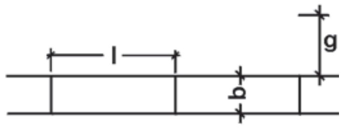
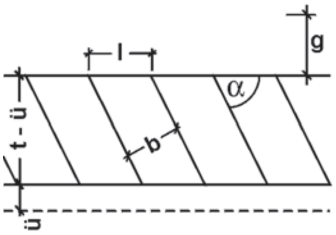
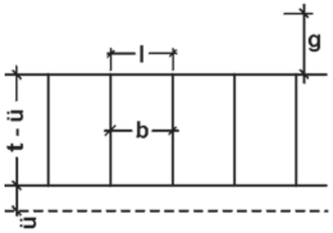
[1] “Recommendations for resting traffic installations” (EAR), Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2005

Table 22: Dimensions of parking bays and area requirement for cars in the street space

	Parking angle a [gon]	Depth from street edge t – ü [m]	Width of over-hang strip ü [m]	Width of parking bay b [m]	Street frontage length l [m]		Lane/carriageway width g [m]	
					when parking		when parking	
					forward	backward	forward	backward
Parallel 	0			2.00	6.70[1]	5.70 5.20[2]	3.25	3.50
Echelon 	50	4.15	0.70	2.50	3.54		3.00	
	60	4.45	0.70	2.50	3.09		3.50	
	70	4.60	0.70	2.50	2.81		4.00	
	80	4.65	0.70	2.50	2.63		4.50	
	90	4.55	0.70	2.50	2.53		5.25	
Perpendicular 	100°	4.30	0.70	2.50	2.50	2.50	6.00	4.50

[1] In special cases, such as to avoid impeding cycle traffic when parking backwards,

[2] Average value without marking

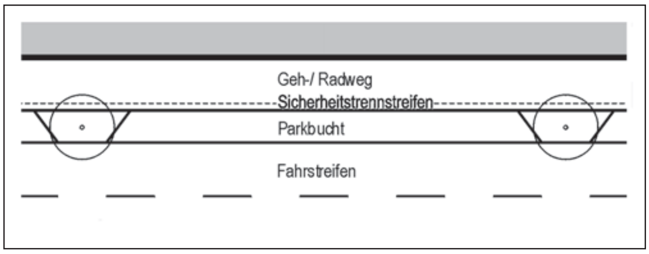


Figure 66: Example of layout of parallel parking bays (without marking individual parking spaces)

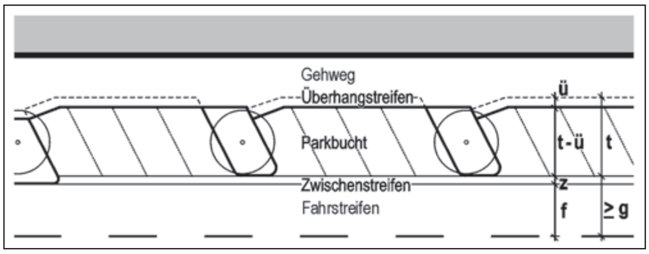


Figure 67: Example of layout of echelon parking bays

- delineation of a disabled parking space by sign 314 according to StVO,
- “Parking space”, with additional signage 1044-10 StVO,
- “Severely disabled only; persons with seriously restricted mobility and blind persons”).

To provide separation from cycle paths, a safety strip ≥ 0.75 m wide should be installed, and to provide delineation from pedestrian walkways a strip ≥ 0.50 m should be allowed, in order to prevent obstacle or injury caused by carelessly opened vehicle doors. For blind and visually impaired persons, the safety separating strip may be given a different surfacing from the pedestrian footpath or cycle path, as necessary.

Combinations of parallel parking bays with loading lanes alongside them should be avoided, as too any parallel or echelon parking on loading lanes must be prohibited. Even with sign 286 StVO (“Restricted no stopping”) it may not reliably prevent parking.

Echelon parking bays (figure 67) should be configured preferably at angles from 50 gon to 70 gon, as they may than be entered and exited from the adjoining traffic lane without encroachment.

The configuration is based on table 22, allowing for the overhang strip “ü” in dimensioning the footway space. Guidance for visually impaired persons can be provided by designing the overhang lane in a different material.

Perpendicular parking bays (figure 68) provide the highest parking bay density per m of street frontage, provided the street space is of adequate width.

If trams run on the adjoining roadway, perpendicular parking bays should be avoided.

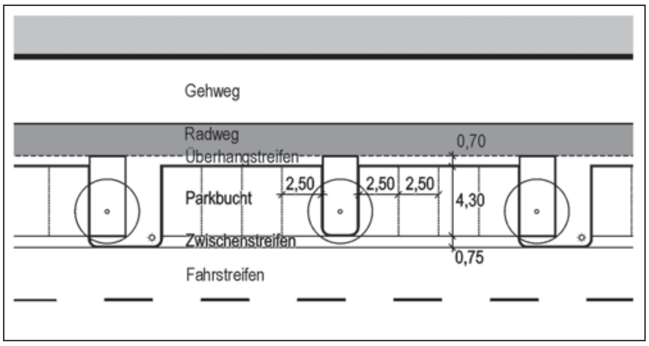


Figure 68: Example of layout of perpendicular parking bays

It is usually useful to install an **intermediate strip** between the carriageway and echelon and perpendicular parking bays. An intermediate strip can –

- make available parking spaces more easily identifiable and enable prompt parking;
- aid reversing out of a tight parking bay and improve emerging drivers' view of the flowing traffic;
- in and out parking manoeuvres can be limited to the adjoining lane;
- enable delivery vehicles to stop for a short-time and so make it unnecessary to install a loading lane which is difficult to keep free of illegally parked vehicles, while maintaining the required cross-sectional width for vehicles passing or meeting oncoming vehicles;
- enable oncoming trucks to use carriageways designed only for truck/car meeting; and
- create a space for pedestrians, crossing between parked vehicles and flowing traffic, which improves their visibility and thus pedestrian safety.

In order to avoid unwanted parking on the intermediate strip, it should not be more than 0.75 m wide. Then, as a result, and with a parking bay width of 2.50 m for example –

- where the lane width is 3.00 m, manoeuvring can be restricted to a parking angle of 65° to the nearside lane;
- where the lane width is 6.50 m a stopping space for delivery vehicles can be created, while retaining adequate clearance for oncoming truck/cars meeting at reduced speed; or
- forward-in parking is possible, without manoeuvring, even where the carriageway is only 5.25 m wide.

However, wider intermediate strips are required if trams run on the adjoining roadway.

To prevent the intermediate strip looking like a part of the carriageway, or a cycle traffic area, it should be a different material from the carriageway and, where appropriate, the parking bay, and be built with a distinct difference.

Loading lanes in front of echelon or perpendicular parking bays should be 2.30 to 2.50 m wide, depending on the standard vehicle, and where possible should be linked, visually, by the choice of materials, to the footway.

Even when using sign 286 StVO ("Restricted no stopping"), loading lanes cannot reliably be kept free of illegitimate usage.

Loading bays may be useful at locations where delivery traffic is heavy and regular. The basic dimensions apply set out in table 23.

6.1.5.3 Parking and loading space in footway areas

Parallel, echelon and perpendicular parking in footway areas is applicable in the same way as in parking bays, provided that the local situation permits and the conditions for entering and leaving parking spaces can be met. If no physical controls are used, care should be taken to ensure that pedestrian footpaths and other pedestrian areas are not driven on illegally or used for parking (table 24).

Table 23: area requirement for delivery and loading

Minimum area requirement for delivery vehicles	Width	Length
Van and small truck	2.30 m	10.00 m – 12.00 m
Large truck	2.50 m	12.00 m – 14.00 m
Articulated vehicles	2.50 m	16.50 m
Additional requirement	**Area**	
Unloading area for goods deliveries	3 m² – 5 m²	

Table 24: Parking and loading areas on footways

Parking provision	Users	Layout, control
Parking and loading bays close to carriageway (between carriageway and cycle paths and pedestrian footpaths)	All user groups (delivery/ loading concentrated when pedestrian traffic is light)	Restricted by time or to specific users: Indicated by signage
		Without time limit on use: Marked or defined by materials
Parking bays inbord of cycle paths and pedestrian footpaths	Longer stays and residents parking	Marked or defined by materials
Unallocated parking and loading	All users (low intensity of use and low parking demand)	Design integrated into public footway

Parallel parking bays close to the carriageway need to be particularly well integrated into the footway.

All the different alignment modes may be used for parking in footways areas provided that, for clarity, half-height kerbs or dished drainage channels are used between the carriageway and footway.

6.1.5.4 Parking spaces on central reservations

Parking spaces installed on the central reservations of main roads should usually be arranged in echelon bays. On access roads, perpendicular parking bays may also be considered. Designs should take into account the safety clearance, an overhang strip and an intermediate buffer strip (figure 69).

If parking bays are designed as drive-through, they can be entered by traffic approaching from either direction and can be exited both backwards and forwards. In each case it needs to be ensured that this greater flexibility does not impair road safety.

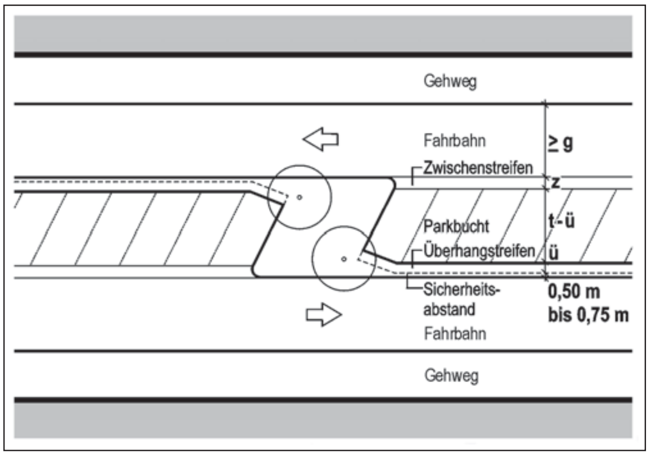


Figure 69: Example of layout of parking bays on central reservations

6.1.6 Facilities for pedestrians

6.1.6.1 Pedestrian footpaths alongside roads

Facilities for pedestrians are required everywhere along built-up roads. They comprise facilities for walking along and crossing traffic. Gaps in the built frontage on an otherwise built-up road must not interrupt this basic configuration. Streets designed as shared space meet these requirements without special provisions (see section 6.1.1.1). Demands beyond these basic requirements must be determined individually depending on the built context and any traffic use of the footway space.

Roads with building frontages only on one side, usually need facilities for walking along that side only. If the other, un-built side attracts pedestrian use (such as to public transport stops or vehicle parking), then crossing facilities must be incorporated into the planning.

When deciding on dimensions for pedestrian footpaths alongside roads, a standard mix of pedestrian flows is assumed. Unusually high proportions of pedestrians with increased needs in terms of space and facilities (carrying loads, in wheelchairs, with restricted physical abilities, etc.) may make it necessary to expand these basic requirements.

The standard width of a footway derives from the requirements in terms of adequate footpath width (traffic space) as well as the necessary clearances:

- Two oncoming pedestrians should be able to meet and pass: this requires clearance (traffic space) in addition to the width required for the two pedestrians to walk.
- Clearance distances must be maintained from the carriageway and from the wall of any building.

As shown in figure 70, this usually results in a footway width of 2.50 m. It may be wider depending on the context. For other standard cases refer to the footway widths of the typical design situations.

Where there is restricted space at bottleneck points due to existing infrastructure or adjacent use (such as narrow points on through-roads), it should be considered that at less than 2.50 m pedestrians can only pass by each other by using the safety space, or motor traffic space has to be restricted.

If street spaces need to take account of special local features which entail substantially increased requirements at specific points or over a distance, then the values set out in table 25 are used. The crucial question is whether the requirement concerned necessitates widening a length of the footway, or whether narrowing at specific points can be accepted.

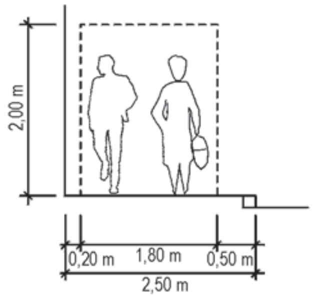


Figure 70: Standard width of a footway

Table 25: Directives for additional footway width based on special requirements

Footway requirements	Space needed
Children's play areas	≥ 2.00 m
Window-shopping areas	≥ 1.00 m
Green strips without trees	≥ 1.00 m
Green strips with trees	≥ 2.00 m – 2.50 m
Benches	≥ 1.00 m
Waiting areas at stops	≥ 2.50 m
Shop displays and showcases	1.50 m
Bicycle parking areas Angle 100 gon Angle 50 gon	2.00 m 1.50 m
Vehicle overhang on perpendicular or echelon parking lanes	0.70 m

6.1.6.2 Designing for accessibility

For people with restricted mobility, incorporating the following points will facilitate good accessibility:

- Creation of obstacle-free footpaths, with few changes of direction, featuring contrasting tactile and visual delineation.
- Low slope angles (0.5 % up to a maximum of 3.0 %) (total slope, e.g. on driveways with lowered footpaths).
- Lowering of kerbs at crossing points to 0 to 3 cm (see section 6.1.8.1).
- Installation of tactile aids such as kerbs, paving, delineation strips
- Provision of orientation strips and 'attention-drawing markings' as guidance and warnings on key street furniture and paving elements, such as crossing points, bus stops, poles/masts, planters, benches or bicycle racks.
- Installation of benches at appropriate intervals.

Delineating kerbs/edges and strips must be perceptible by foot and by long-sticks, and must have a visually perceptible contrast.

Footpaths on main interurban roads should be separated by features such as greenery strips. These strips should have a border at least 3 cm high separating them from the footway. If rainwater from the footway is intended to irrigate the greenery, then the green area must be set 3 cm deeper so that its border can serve as a touch guide.

6.1.6.3 Public Spaces

Public Spaces should primarily be created by widening a section of footway additional to the area provided for moving along. This also includes the creation of play spaces.

Public Spaces are required in particular

- on all city streets with (dense) housing, commercial and small business/light industrial use, as well as
- in streets with high density of shops.

6.1.6.4 Shared paths with cyclists

Shared pedestrian and cycle paths on the footway (sign 240 StVO) should only be considered in areas of light pedestrian and cycle traffic. This applies where separate provision cannot be used, where cycle paths or cycle lanes are not feasible, or where putting cyclists on the carriageway with motor vehicles is considered unjustifiable in terms of safety, even if an 'advisory lane' were to be installed. The cycle traffic must give due consideration to pedestrians on such shared paths.

Where pedestrian footways are made available for use by cycle traffic and with sign 239 StVO ("Pedestrians") in conjunction with additional sign 1022-10 StVO ("Open to cyclists"), cyclists can choose whether to use the footpath or the carriageway. On footways signed in such a way the cycle traffic may only travel at walking speed, and must give priority to pedestrians.

If pedestrians and cyclists are to share the footways along built-up roads, where cyclists may be fast-moving (and the danger they pose to pedestrians, as well as issues relating to junctions) signage indicating a pedestrian footpath open to cyclists (sign 239 StVO with the additional sign 1022-10 StVO) should be preferred, provided that cycling on the carriageway is acceptably safe (table 26).

Table 26: Signing shared routes for pedestrians and cyclists

Signs	Use by cyclists
Sign 240 StVO (shared pedestrian/ cycle path)	Mandatory use
Sign 239 StVO ("Pedestrians") with additional sign 1022-10 StVO ("Open to cyclists")	Permitted

Roads which are generally unsuitable, for mandatory shared-use footways, are those:

- with intensive business (shop) use;
- with above-average use by particularly vulnerable pedestrians (such as senior citizens, the disabled, children);
- carrying main links for cycle traffic;
- with a steep gradient (> 3 %);
- featuring a numbers of entrances adjacent to (narrow) footpaths;
- featuring numerous minor junctions and driveways; as well as
- with numbers of heavily used bus or tram stops along the footway without separate waiting areas.

The required dimensions are set out in table 27.

Table 27: Shared pedestrian footpaths and cycle paths

Maximum compatible volume of pedestrians and cyclists in the peak hour*)	Width required plus safety separating strip
70 (Pedestrians + Cyclists)/hour	≥ 2.50 m – 3.00 m
100 (P+C)/h	≥ 3.00 m – 4.00 m
150 (P+C)/h	≥ 4.00 m

*) The number of cyclists as a proportion of the total volume should not exceed one third

6.1.7 Designing for cyclists

6.1.7.1 Basic considerations

With regard to designing for cycle traffic, a basic decision has to be made whether provisions should/can be implemented

- on the carriageway or on the footway;
- on separate surfaces or on usable areas shared with other traffic modes (cyclists/motor vehicles, cyclists/pedestrians);
- on one side of the road or both; and
- as one-way or in both directions.

In considering design for cycling, it may also be useful to implement different cycle traffic installations at junctions, on straight stretches, and for the two directions.

The most beneficial method in each individual case depends on a wide variety of traffic-related, operational and infrastructural factors.

6.1.7.2 Cycling provision on the carriageway

On low-traffic roads and on roads subject to low motor vehicle speed limits (such as 30 km/h zones), cycle traffic can generally be comfortable and travel quite safely on the carriageway. On other roads, measures should be investigated in order to enhance the safety and comfort of carriageway use. This includes:

- enhanced precautions to ensure that the maximum speed limit is observed;
- reducing the permissible maximum speed.

Suitable parameters are carriageway widths up to 6.00 m at low traffic volumes, up to 500 vehicles per hour and carriageway widths of over 7.00 m up to medium traffic volumes from 800 to 1,000 vehicles per hour with 6 % heavy traffic. At a speeds of $V_{85} < 50$ km/h and with little or no heavy traffic, the traffic volumes above may be exceeded in individual cases.

Two-lane carriageways with lane widths between 3.00 and 3.50 m are classed as critical in relation to car/cycle traffic passing/running alongside each other. In such cases it is only possible to overtake cyclists in the face of oncoming traffic by encroaching on safety clearances. Consequently, they are suitable for mixed-use by cycle and motorised traffic only where traffic volumes and speeds are low.

Adverse impacts, due to stopping, loading or deliveries on the carriageway should be minimised by time restrictions. Traffic checks should ensure that parking regulations are observed.

6.1.7.3 Cycle facilities on carriageway: advisory lanes

Advisory lanes mark an area at the side of the carriageway to provide cyclists with a space which generally is not used by cars and used infrequently by trucks and buses when passing by each other. Advisory lanes are used mostly on two-lane roads. They may also be installed on single-lane carriageways and on multiple-lane approaches to junctions and within the directional lanes

Advisory lanes should meet the following criteria:

- They should be installed where mixed traffic on the carriageway is acceptable but, for road safety reasons, the cycle traffic needs to be provided with a dedicated area and there is insufficient space to create mandatory cycle lanes.
- As no stopping is allowed on advisory lanes, facilities for parking and for delivery and loading should be provided as necessary outside of the carriageway, such as in parking bays. Advisory lanes should be enforced by no-stopping sign (sign 283 StVO).
- The volume of truck and bus traffic should be less than 1,000 vehicles per day.

The standard width of a advisory lane, including markings, should be 1.50 m. It must not be less than 1.25 m. The remaining carriageway width on two-lane roads must be at least 4.50 m, in order to allow cars to pass by each other (figure 71). Advisory lanes thus require carriageway widths of 7.00 m and more (excluding parking). The remaining carriageway width on single-lane carriageways must not be less than 2.25 m.

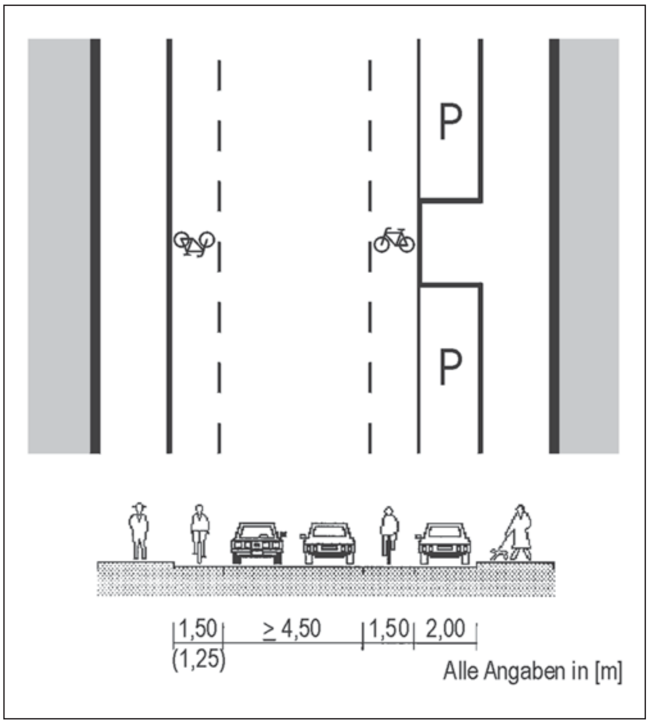


Figure 71: Example of dimensions of advisory lanes

Where there are adjoining parking bays, the area for cycle traffic, including the safety clearance from parked vehicles, should be 1.75 m. This is usually achieved with a 1.50 m wide advisory lane adjacent to 2.00 m wide parking bays.

Advisory lanes are marked by broken lines (sign 340 StVO) with alternate bands of 1.00 m length and 1.00 m gaps. On the remaining carriageway, with a width of less than 5.50 m no line must be marked. The designated purpose of advisory lanes should be illustrated by cyclist symbols.

6.1.7.4 Cycle lanes

Cycle lanes on the carriageway are separated from vehicles visually by a lane edge marking, sign 295 StVO (usually a solid broad line 0.25 m wide). The lanes may have colour and/or material differentiation from the carriageway when built, or may be marked out later, on the existing (unmodified) carriageway. Sign 237 StVO (“Cyclists”) makes it mandatory for cyclists to use them. In addition to the traffic sign this sign may be applied as a road marking –– on the cycle lane.

Cycle lanes are taken on **cycle crossings** to cross junctions. Cycle crossings should always be marked out on main roads and at traffic lights. The marking consists of two broad, broken lines 0.50 m wide, with a 0.25 m gap length. The crossing is usually 2.00 m wide, or at least

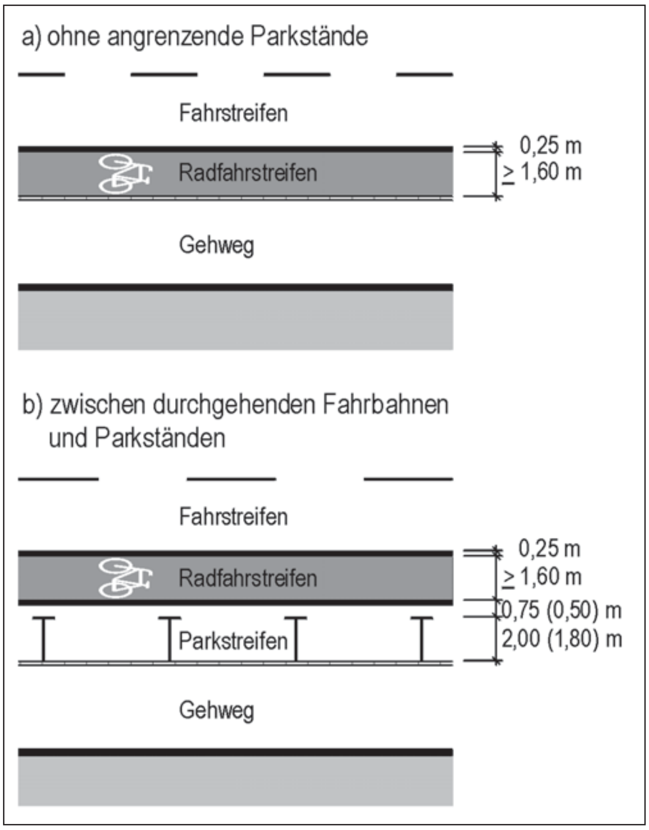


Figure 72: Example dimensions of on-street cycle lanes without car parking and alongside parking bays

as wide as the adjoining cycle lanes. On roundabouts no cycle lane may be marked.

The main dimensions of cycle lanes and those alongside car-parking spaces are shown in figure 72. A usable width of 1.60 m allows cyclists to overtake each other. The minimum usable width of 1.00 m must be free of gutters and drains.

Separating safety strips between cycle lanes and parking bays should always be provided – at least where parking bays are of minimum dimensions.

6.1.7.5 Cycle paths alongside roads

Cycle paths alongside roads should be separate from the carriageway or from parking lanes or bays by a separating safety strip. In one-way traffic streets in built-up areas they are usually installed on both sides. They should be clearly differentiated from the footpath areas and marked out accordingly. They should be separated by a tactile and visually contrasting delineation at least 0.30 m wide. Height difference should generally be avoided due to the risk of cyclists crashing. Their mandatory use by cyclists is enforced by sign 237 StVO (“Cyclists”).

Cycle paths alongside roads can in exceptional cases also be implemented with two-way cycle traffic on one or both sides (table 28).

Table 28: Cycle paths alongside roads

Cycle path	Standard width	Safety clearance
One-way cycle path	2.00 m (1.60 m)*)	0.75 m (0.50 m)**) with adjacent carriageway or adjacent to parallel parking; 1.10 m with perpendicular and echelon parking bays***)
Two-way cycle path	2.50 m (2.00 m)*)	0.75 m

*) With low cycle traffic flow

**) With no obstructions in the safety clearance strip; figures in brackets for low cycle traffic flow

***) Overhang strip can be added on

The standard widths should be consistent, and widths may only be reduced on short stretches (such as at restrictions due to building infrastructure or adjoining uses.) (figure 73).

Greater widths than the guide values cited may be required

- on main cycle network routes;
- in case of existing or planned high cycle traffic loads (such as close to schools);
- in case of frequently occurring peak loads;
- in case of intensive side space uses;
- on major gradients.

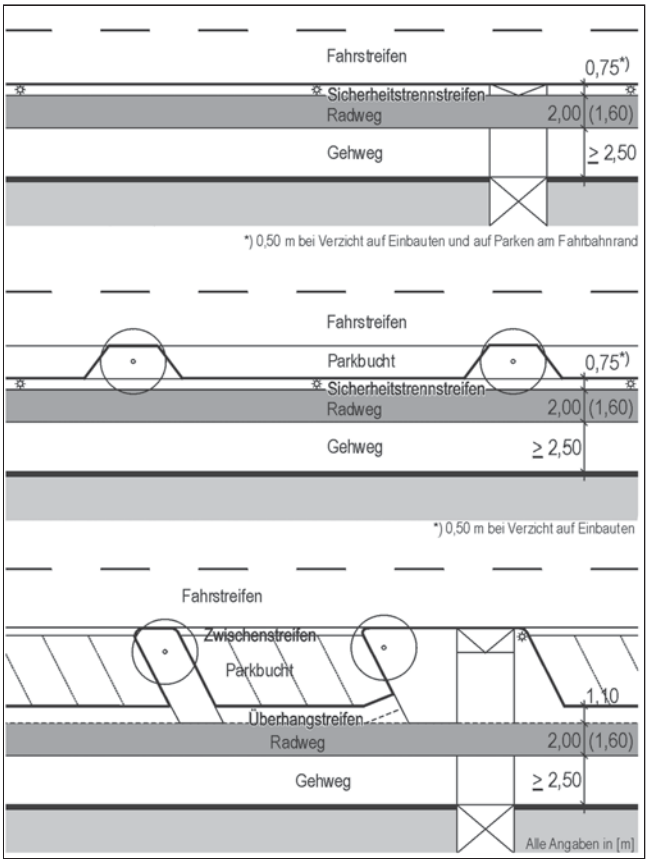


Figure 73: Examples of dimensions of cycle paths alongside roads adjacent to the carriageway and parking bays (figures in brackets: low cycle traffic load)

For cycle path widths below 1.60 m, overtaking is no longer possible (see figure 19). Consequently, no mandatory use should be imposed at path widths below 1.60 m[39]. The cyclist is then allowed to use the carriageway or the cycle path.

Cycle paths not subject to mandatory use can be used to offer cyclists a choice of route where cyclists' speeds are highly varied and where mixed traffic on the carriageway is acceptable.

In the case of two-way cycle paths the following recommendations should be observed:

– Enforcement of mandatory use by cyclists by sign 237 StVO ("Cyclists").
– Indication to other traffic, turning and crossing, by sign 205 StVO ("Give way!") or 206 StVO ("Stop! Give way!") and additional sign 1000-32 StVO ("Cyclists crossing from right and left") of cyclists from both directions.
– Where appropriate, indication for cyclists of possible oncoming traffic is given by adding sign 1000-33 StVO ("Oncoming cycle traffic") to sign 237 StVO with contraflow vertical arrows or by marking contraflow arrows directly onto the cycle path.

In order to avoid the risk of cyclists falling and pedestrians with visual impairment stumbling, there should be no height difference between cycle paths and adjoining footpaths and leisure areas. However, cycle paths should always be differentiated from pedestrian footpaths in a visually contrasting style and with tactile materials. Separation by marking alone is not sufficient (figure 74).

If height differentiation is planned in order to provide a particularly effective separation between cycle and footway areas, cycle paths of at least 2.00 m should be provided (table 29).

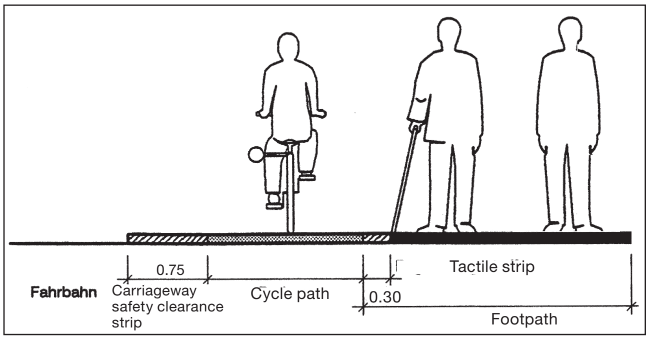


Figure 74: Tactile strips, between cycle paths and footpaths, as aids to visually impaired pedestrians

Table 29: Possible forms of differentiation between cycle paths and adjoining footpath areas

Delineation	Properties
Moderate height difference (e.g. stone edging, kerb)	Effective separation between cycle and pedestrian traffic areas Good direction orientation for visually impaired pedestrians, both travelling along and crossing. Implementation is only possible where adequate widths are available
Horizontal differentiation (e.g. Tactile strip in a different material)	No risk of cyclists falling when taking evasive action Simplified engineering Simpler, cheaper maintenance (sweeping, snow clearing) with large machines

Where cycle paths alongside roads come to an end, or convert into cycle lanes or cycle crossings at junctions, as a safety measure the end of the cycle path must be designed so that cycle traffic in the transition zone (10 to 20 m) is routed parallel to the motor vehicle traffic and in plain sight (figure 75).

Where a cycle path, running alongside a road, changes into a cycle lane on the straight road, protection for cyclists can be achieved by markings or by a physical safety measure. A physical safety measure is preferable for road safety reasons (see section 5.4).

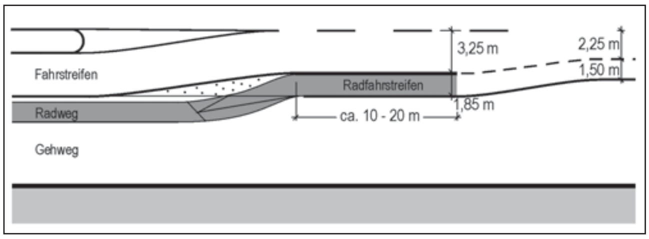


Figure 75: Example of a cycle path re-entry to the carriageway

6.1.7.6 Contra-flow cycle provision.

To open one-way streets, for cyclists travelling in the opposite direction, the following pre-conditions must be met:

– 30 km/h speed limit.
– For motor traffic a standard lane-width of 3.50 m should be provided or at least 3.00 m with adequate passing points. On scheduled bus routes or where there is heavy truck traffic, the width must be more than 3.50 m.

If contra-flow cycle traffic on one-way streets is allowed, additional sign 1000-32 StVO ("Cyclists crossing from right and left") must be appended to all signs 220 StVO ("One-way street").

From the opposite direction, sign 267 StVO ("No entry") must be appended by additional sign 1022-10 StVO ("Open to cyclists"). Sign 353 StVO ("One-way street") must be appended by additional sign 1000-33 StVO ("Contra-flow cycle traffic").

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[39] This requirement extends beyond the minimum laid down by the general administrative regulation relating to the German road traffic law (VwV-StVO).

It is important to ensure that the flow of traffic along a route, at crossings and at junctions, is clearly defined and that a safe space is created for cyclists where physical and traffic-related factors are present (e.g. constrictions due to building structures or on bends). Potential problem areas – such as junctions, partially hidden sections or areas with competing uses – should be ameliorated by improvement measures:

- A separate entry and exit zone can be provided for contra-flow turning into and out of a one-way street.
- At side accesses, the right of way – especially the obligation for cycle traffic travelling in the opposite direction to wait – should be made clear.
- Crossing traffic must clearly be made aware of the possibility of meeting oncoming cyclists. If required, at junctions subject to the right-before-left rule, crossing traffic can be made aware of oncoming cycle traffic by sign 138 StVO (“Both directions”) in conjunction with additional sign 1000-30 StVO (“Cyclists crossing”).
- On bends, to prevent cutting across, it may be useful to mark out advisory lanes or cycle lanes, or to install a physical safeguarding measure.

6.1.7.7 Cycle-streets

Cycle-streets can be created on main cycle network links to enable fast journeys by bicycle where cycling is the predominant traffic mode, or if planners intend it to be so.

Cycle-streets can be implemented on urban streets with flows up to around 400 vehicles per hour. The speed limit must not be higher than 30 km/h.

Vehicular traffic other than cycling (such as residents’ access), is permitted on cycle-streets only where indicated by additional signs. Motor traffic must be taken into account by, for example, acceptable, parallel traffic routes. At junctions, cycle-streets should be given priority over other roads. To ensure appropriate motor vehicle speed on cycle-streets, traffic controls and physical measures are usually required as a means of traffic calming.

6.1.7.8 Uphill and downhill facilities for cyclists

The gradients of cycle paths alongside carriageways are related to the carriageway gradient. For slopes of more than 3 % an asymmetric cross-section layout (dependent on the motor vehicle and cycle traffic volumes) is often advisable, to cope with the often widely varying uphill and downhill speeds of cyclists, as set out in table 30.

Table 30: Asymmetric cycle provision on uphill stretches and descents

Protection requirement	Element combination
High	Uphill: Cycle path/shared pedestrian/ cycle path Downhill: Cycle lane, advisory lane
Medium	Uphill: Cycle lane Downhill: Mixed traffic, no separate cycle lane
Low	Uphill: Wider traffic lane, where appropriate in conjunction with pedestrian footpath open to cyclists Downhill: Normal or narrower lane

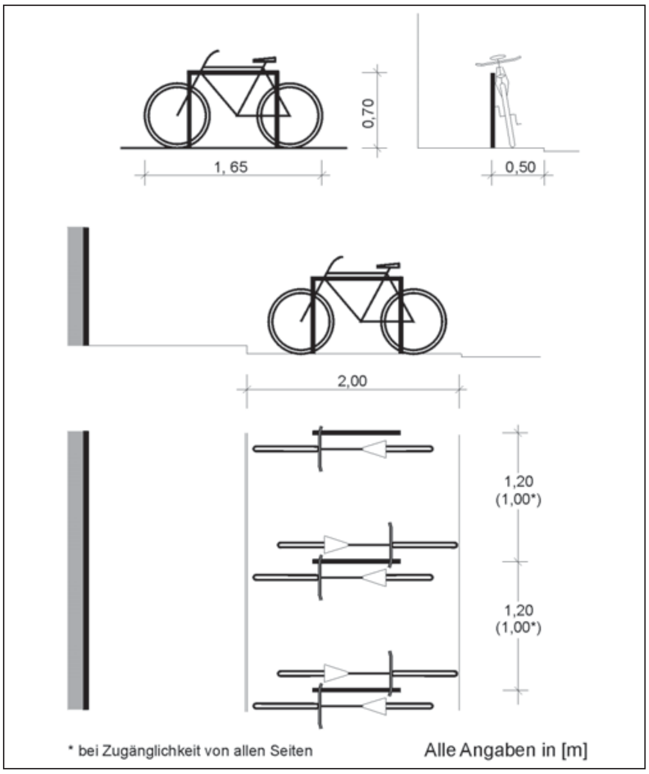

Figure 76: Basic measures for bicycle parking facilities

On severe gradients (> 5 %), cycle paths, cycle lanes and advisory lanes should be built wider than normal.

6.1.7.9 Bicycle parking

Bicycle parking should be provided for cyclists at all major destinations. They should be located so that the remaining walking distances are as short as possible. Large bicycle parking facilities (e.g. bicycle parking garages) should be signposted.

Parking facilities may be open, covered, or provided as lockable bicycle boxes, and should provide suitable means of supporting a bike and for securing them. Parking provision in the street should be protected from abuse (being blocked-off by parked motor vehicles). Parking facilities in the footway must not impede pedestrians (figure 76).

Details of the requirements for bicycle racks and their various kinds of installation are to be found in “Instructions for bicycle parking (40).

6.1.8 Crossing the road by pedestrians

6.1.8.1 Basic considerations and applications

In addition to traffic controls, crossing points may be enhanced by various physical features in order to assist pedestrians crossing. These are designed for visual emphasis of the crossing point, or to physically calm traffic speeds (speed humps or raised plateaux). They help to

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[40] “Instructions for bicycle parking”, edition 2012, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2012.

Indicative limits:
1) 750 veh / h peak hour in cross-section
2) 100 pedestrians in the peak hour
3) Speed 50 km / h
Choice of provision:
a) Median separation (island or strip). With peak hour load in one direction: No further measures
b) Any traffic construction measure without precedence; (plateau / raised block-paved area
c) Pedestrian Crossing
d) pedestrian crossing with physical measure

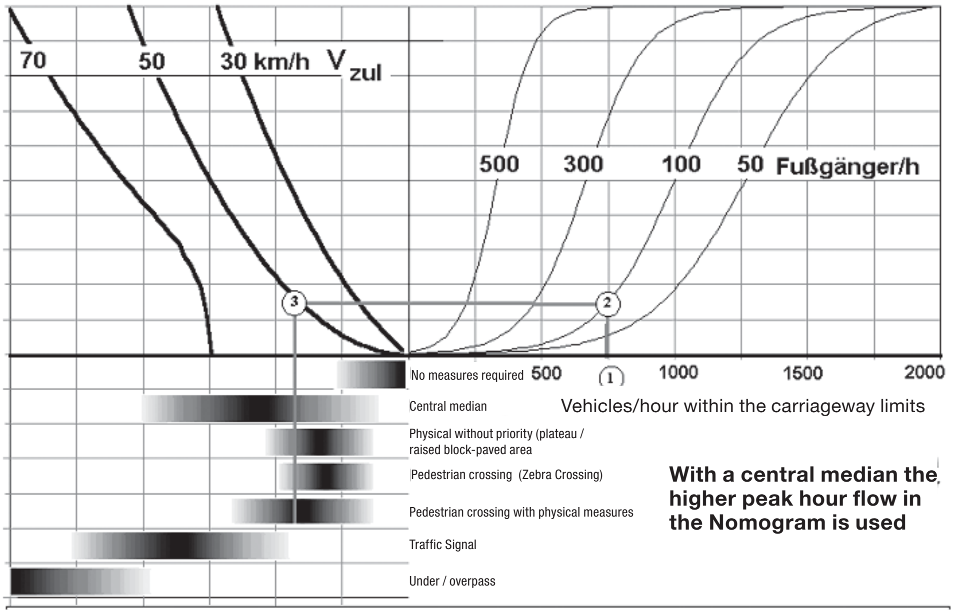

Figure 77: Chart for selecting provision of crossing facilities on two-lane roads. Carriageways below 8.50 m

make the crossings shorter (by narrowing the roadway), or divide the crossing into two sections (such as by central islands).

When designing crossing facilities, points to consider are:

- the legal situation for traffic (priority rule);
- the importance of the crossing point for pedestrians;
- the urban design context;
- the volume of motor vehicle traffic.

At all crossing facilities, to consider pedestrians with limited mobility, wheelchair users, visually impaired persons and pedestrians pushing prams or luggage trolleys any difference in level between the (lowered) footpath and (raised) carriageway should be 3 cm. The kerb should be squared-off. Rounded kerbs should have a radius of not more than 10 mm. Angled kerbstones with a maximum height of 7 cm may also be considered in order to avoid the footpath having too severe a cross-slope. Where the kerb is flush with the road (such as where there are large numbers of wheelchair users) the safety of blind and visually impaired persons must be ensured, by using delineating materials with a strong visual contrast at the carriageway edge and by providing tactile paving, to help prevent people from straying-off the footpath unintentionally.

For visibility and usability, parking of vehicle near crossing facilities should be prohibited by means of suitable street furniture or bollards.

Special crossing facilities are usually not necessary if

- there is no distinct crossing need;
- the motor vehicle traffic volume, in a 30 km/h zone, is no more than 500 vehicles per hour in the section;
- the speed limit is 50 km/h and motor vehicle traffic volume is no more than 250 vehicles per hour in the section; or
- traffic travels slowly (V_{85} ≤ 25 km/h, due to traffic calming measures).

Crossing facilities are necessary if

- there is a distinct crossing need;
- the traffic volume is more than 1,000 vehicles per hour in the section and the speed limit is 50 km/h; or
- the traffic volume is more than 500 vehicles per hour in the cross section and the speed limit is above 50 km/h.

Crossing facilities are useful, regardless of the amount of traffic, and are to be recommended where vulnerable pedestrians, such as children and older people, are expected to be regular users.

The specific choice of crossing facility for lengths of road between junctions depends on the surrounding environment and uses. They may be derived from the traffic volumes shown in figure 77. Where central islands or medians are used, the permissible traffic volume in the road section is increased, as the volume in the diagram relates only to the peak hour for the direction carrying the heavier load.

Attention should be paid to making sure the crossing point can be recognised from a distance. Obstruction caused by traffic signs, planting, advertising hoardings, telephone booths, electricity substations and the like should be avoided. Parked cars can likewise obstruct visibility for, and of, crossing pedestrians. Parking should therefore be prevented at crossings and near junctions and in the visibility splay at other crossing facilities by suitable measures.

Where vehicles are required to stop, they must be able to do so when approaching the pedestrian priority crossing point. A stopping sight distance S_h must be allowed for. Where pedestrians do not have priority for crossing, they must have adequate visibility towards approaching vehi-

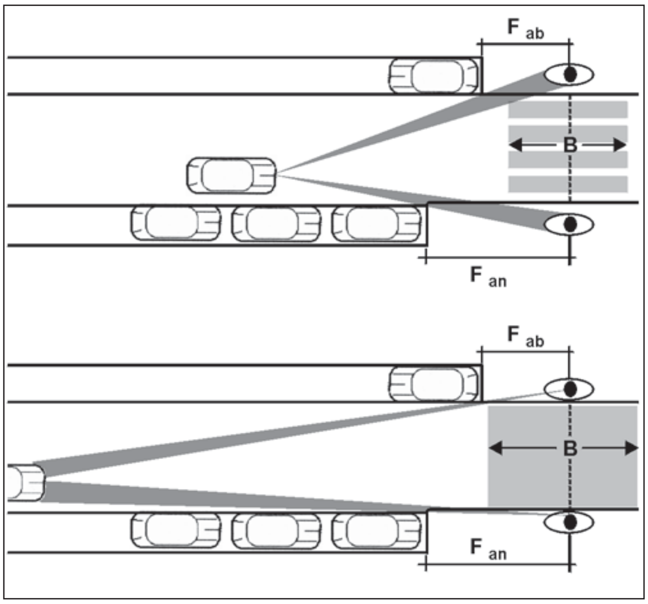

Figure 78: Zones to be kept clear at crossings with and without pedestrian prioritisation

cles. Both visibility requirements are dependent on the speed limit.

The differing values, for areas where pedestrians have priority crossing and where they are required to wait, can be grouped together. It is assumed that a pedestrian who does not have priority for crossing will tend to be closer to the roadside, whereas a pedestrian with crossing priority must also be detected at a distance of 1.00 m from the kerb.

Table 31: Zones to be kept clear at crossing points

Side spaces	V_{limit}	V_{near}*)	V_{far}*)
Normal kerb-line	30 km/h 50 km/h	10 m 20 m	5 m 15 m
Widened side space alignment**)	30 km/h 50 km/h	5 m 12 m	3 m 6 m

*) Minimum: $V_{near} \geq B/2$, $V_{far} \geq B/2$

**) In the case of widening of more than 30 cm (maximum 70 cm) in front of the line defining the obstacles to visibility the minimum value of B/2 applies; at pedestrian crossings the minimum value stipulated by StVO of 5 m before the crossing applies

Table 31 sets out the zones to be kept clear of obstructions dependent on the speed limit, with and without widening of the side space. In each case the values indicate the zone which must be kept free of obstructions (figure 78) for the near side vehicle $V_{approach}$ (vehicle from left) and far side vehicle V_{far} (vehicle from right), and are taken from the centre of the crossing (or at least half the width of the crossing). They apply to straight stretches of road and to carriageway widths (between kerbs) of up to 7 m (or 11 m where there is parking on both sides). Wider carriageways tend to result in lower values for $V_{near/far}$.

6.1.8.2 Central islands

Central islands are especially helpful to pedestrians in crossing roads. They may be made as single islands or as a linear sequence at not too great an interval (maximum 80 m). These islands should be linked as directly as possible to the most frequently-used pedestrian desire lines, since off-line provision of an island, as at other single crossing points, would be likely to impede free pedestrian movement. Islands may be formed with, or without, aligning lanes (figure 79).

Islands should be wide enough to provide adequate waiting areas for pedestrians and cyclists, allowing for 0.50 m safety clearances to adjoining traffic lanes (table 32).

Table 32: Central islands and waiting areas

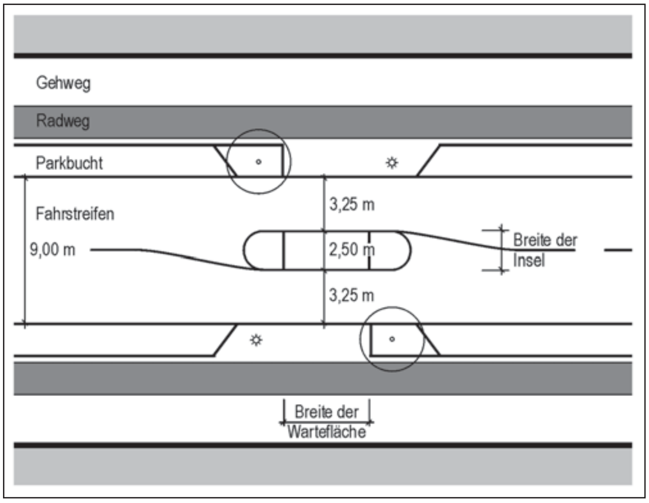

Figure 79: Example of a central island design on widened two-way carriageways

Application	Width of island	Width of waiting area
Crossing facility for pedestrians	2.00 m	4.00 m
Crossing facility for cyclists and wheelchair users	2.50 m – 3.00 m	≥ 4.00 m

In special cases, such as where the carriageway is narrow and where pedestrian crossing traffic is light, central islands may also be narrower than 2.00 m (e.g. 1.60 m), to ensure that pedestrians and cyclists are still provided with a protected space when crossing the road.

In the design, planting and signing of islands, care should be taken to ensure that there is no obstructed visibility either for, or of, pedestrians waiting on the island. As a road safety measure, the nose of all islands should be checked to ensure they are clearly visible, including at night. The location of stationary lighting is important. This applies particularly where the lane marking is aligned to the island's nearside edge. Where possible, light-coloured kerbs, or kerbs with white edges should be installed.

Central islands may be designed to be fully or partially traversable, outside the waiting areas, where traffic occasionally needs to access adjoining properties or where the swept-path of heavy vehicles does not permit the use of normal central islands. However, such designs must always preserve visibility, including where they are at road level.

6.1.8.3 Central medians

Central medians serve pedestrian crossing demands, such as in city streets with businesses on both sides. In addition they can include the following elements:

- Landscaping, plantings;
- Physical elements to separate the motor vehicle traffic in each direction;
- Parking bays;
- Footpaths.

These purposes necessitate differing widths (table 33).

Table 33: Central medians

Usage	Width
Crossing for pedestrians	2.00 m
crossing for cyclists	2.50 m
Parking strip	6.00 m
Footpath (promenade)	> 6.00 m

At property driveways central medians can be designed to be traversable.

6.1.8.4 Side space extensions

Side space extensions are created where parking lanes or strips of greenery are interrupted in some locations. By creating side space extensions which extend beyond the depth of the parking bays, hazards due to parked vehicles on the roadside impeding visibility can be reduced. They should be at least 5.00 m long, and are applicable on all built-up urban streets.

The boundary lines of the pedestrian areas should generally be up to 0.70 m (at least 0.30 m) in front of the parking bay marking or the rows of parked vehicles. Where vehicles are parked in echelon or perpendicular to the kerb, a slightly larger separation (maximum 1.20 m) may be used as appropriate.

In designing such arrangements, the carriageway on main roads should not fall below the standard width (see section 6.1.1).

If side space extensions are created which result in lane widths below the standards in table 7 (figure 80), it should be noted that this cannot be relied upon as a traffic calming measure. Where there is little probability of oncoming vehicles meeting they have no influence on the choice of speed. Where the probability of oncoming vehicles meeting is higher they may result in higher speeds because drivers may be tempted to try to get past the narrowed point before the oncoming traffic. In such cases, therefore, additional traffic-calming measures should be considered, such as speed humps or raised block-paved areas.

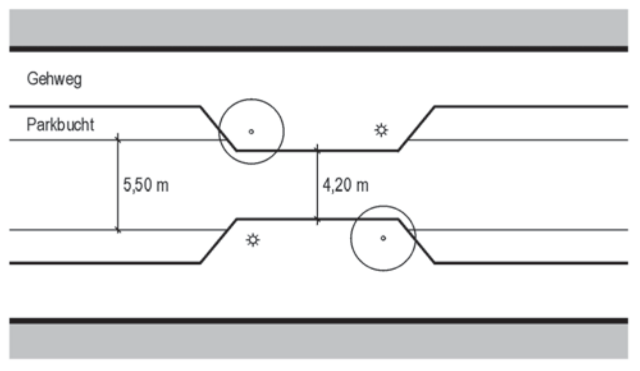

Figure 80: Example of side space extension in an urban street

Side space extensions should be clearly visible to vehicle traffic (with lighting, where appropriate white-coloured kerb edges). Planting and signs must not impede the visibility of pedestrians.

6.1.8.5 Pedestrian crossings

Pedestrians have priority when crossing the carriageway at pedestrian crossings as stipulated by § 26 para. 1 StVO. The application and design of pedestrian crossings are controlled, in addition to the requirements of the Road Traffic Regulations § 26-VwV pertaining to § 26 StVO, by the “Directives for the layout and elements of pedestrian crossings” (R-FGÜ)[41].

The use of pedestrian crossings should be considered in particular

- where a convenient crossing facility for pedestrians is required owing to the importance of the pedestrian links;
- where heavy pedestrian flows are to be given priority at minor road junctions, including over turning traffic;
- at small roundabouts.

The approaches to the pedestrian crossing, the crossing itself and the associated waiting areas must be recognisable and clearly visible both by day and night. The minimum visibility requirement set out in table 31 must be indicated with a traffic sign (sign 350 StVO). Overhead installation of signs above the traffic lanes is useful, especially on tree-lined roads or where there is parking at the roadside. Others key factors in addition to visibility/recognisability are appropriate control of motor vehicle speed as well as suitable routing of cyclists in order to prevent cyclists from illegally riding on pedestrian crossings, where they are particularly at risk.

Pedestrian crossings may be constructed with islands, widened side spaces and raised block-paved areas where appropriate according to local conditions or traffic flows. These elements enhance pedestrian safety, and can be implemented together on a pedestrian crossing.

Installing pedestrian crossings at bus stops is only permissible if driving past the stopped bus is reliably prevented (figure 81).

The absolute no-stopping prohibition imposed at pedestrian crossings and up to 5 m in front of them (§ 12 para. 1 clause 4 StVO) cannot in itself guarantee the necessary visibility from and to waiting areas stipulated by R-FGÜ. The zones to be kept free, before and after the pedestrian crossing and in compliance with that guideline, are

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[41] “Directives for the layout and component elements of pedestrian crossings” (R-FGÜ), edition 2001, Federal Ministry of Transport, Construction and Housing, Bonn 2001.

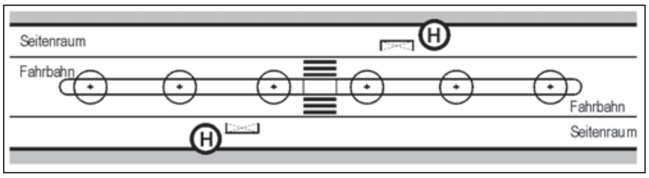

Figure 81: Examples of bus-stops at the pedestrian crossing

indicated in figure 78 and table 31. Consequently – and regarding the limitation of usable carriageway width to a maximum of 6.50 m recommended by R-FGÜ – building side space extensions is the best solution. Where there are low volumes of truck or bus traffic, the carriageway may be narrowed down to 5.50 m at the pedestrian crossing.

Combining pedestrian crossings with central islands or medians is particularly advantageous because pedestrians are able to concentrate on each line of moving vehicles separately as they cross each carriageway. Such installations can be applied on roads with traffic volumes of up to 750 vehicles per hour.

6.1.8.6 Controlled crossings

Traffic signals are appropriate for managing locations with high volumes of vehicle traffic, high speeds and concentrated pedestrian and/or cycle traffic. Crossings are marked out across all locations where cycle and/or pedestrian traffic is taken across the carriageway controlled by traffic signals.

The RiLSA directives must be followed in all matters relating to the application and operation of traffic signals. Traffic signals must be kept in operation day and night as a key principle. Even when traffic is light they should only be switched-off, for given periods, if the reasons which led to the signals being installed in the first place no longer apply. A detailed check must ensure that, even when the traffic signal is switched off, road safety is maintained and that switching-off the signals does not give rise to any other hazards.

If traffic signals feature central islands, for safety reasons and to avoid misunderstanding, the design must ensure that pedestrians are able to cross the carriageway in one go whenever possible, without stopping on the island.

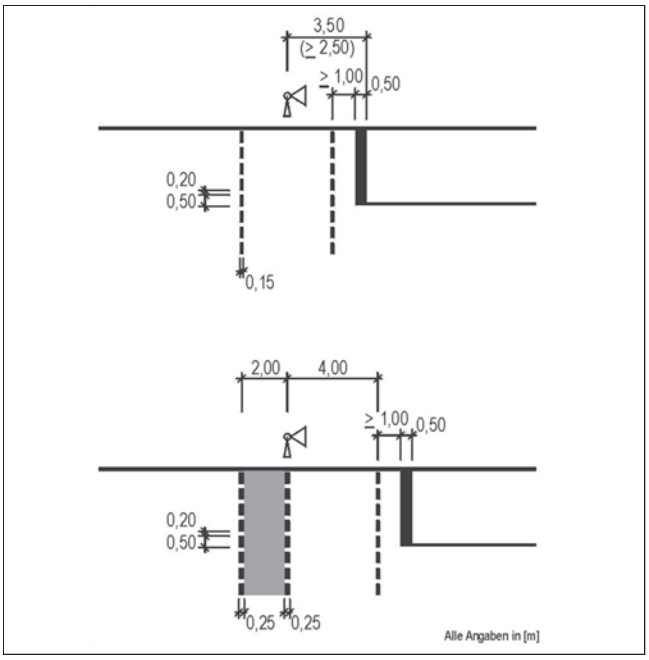

Figure 82: Dimensions and markings of pedestrian and cycle crossings

Additional facilities for visually impaired should be installed at traffic signals in consultation with the local organisations for the blind.

Problems can arise where single, signal-controlled pedestrian crossings, are close to junctions with no signal control. It is then often a better solution to install signal controls for the entire junction. A separate pedestrian crossing near a junction can only be considered if

– the crossing is at least 200 m away from the next junction; and
– other physical crossing facilities are considered to be inadequate.

For shorter distances, e.g. due to a tram stop in the middle, coordinated phasing with the junction signal controls should be considered.

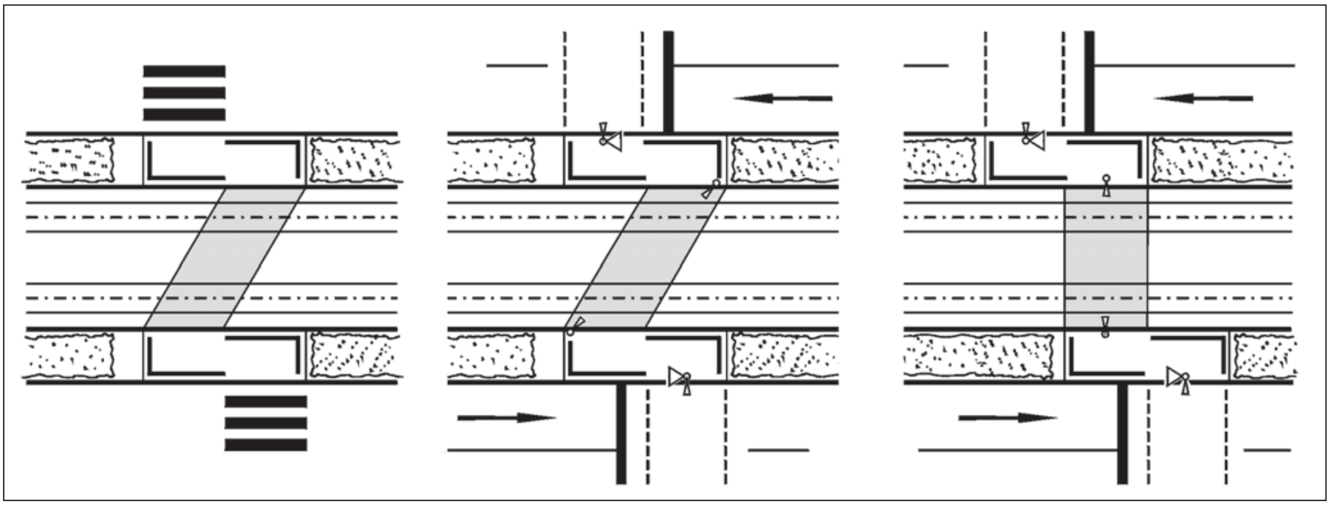

Figure 83: Examples of pedestrian crossings of separated tracks

A width of 4.00 m (minimum 3.00 m, maximum 12.00 m) is the standard for pedestrian crossings. Cycle crossings are to be at least as wide as the adjoining cycle facilities. Figure 82 shows typical dimensions and appropriate markings.

When designing crossings, it must also be noted that

- the crossing should be aligned, as far as possible, perpendicular to the carriageway;
- pedestrian and cycle crossings must be next to each other if they share signal controls;
- waiting areas for pedestrians and cyclists must be of adequate size (approximately 2 persons per m² and 1 cyclist per 2 m²);
- visibility splays must be kept clear;
- kerbs should be lowered flush on cycle crossings (see also figure 104).

6.1.8.7 Crossing separated tracks

Crossings of separated tracks may be needed on straight stretches or at junctions. At those locations, they may be combined with a stop, or be independent of it.

Crossings with waiting areas on both sides, between track and carriageway, should have a 'Z' shaped design. 2.50 m should be provided at the refuge to allow for prams and wheelchairs. Fixtures near the crossing should be sized and placed to allow adequate space to pass.

Crossings **in the track area** may be controlled by signals operated on demand from the tram. The track area should be controlled independently of the signal control of the carriageway crossings by means of dedicated signalling (flashing amber or red lit/unlit). Adequate visibility must be provided between both ends of the crossing and the public transport vehicles.

In the **carriageway** the crossings may be backed up by narrowing the carriageway, with or without traffic signals (figure 83).

If the pedestrian crossing also gives access to a public transport stop, the crossing phases should be configured so that passengers waiting at the roadside are able to cross in time to catch the approaching service.

Where crossings are also used by cyclists, a refuge width of ≥ 2.50 m is required.

6.1.8.8 Underpasses – overpasses

As a matter of policy, new under- and overpasses for pedestrians, under/over roads in built-up areas, should not be built unless they offer benefits for pedestrians due to the topography of the area. Existing underpasses should be replaced, or in the medium to long term be supplemented with at-grade crossings,. Exceptions to this policy are overpasses and underpasses on level ground in conjunction with sunken bus and rail routes or on roads which have the character an urban motorway. Because of vehicle clearance requirements, overpasses usually require pedestrians to climb a greater height than underpasses. In the usual situation 'outside', mechanical aids (escalators, lifts) to overcome the height difference are expensive and prone to failure. The following principles should be considered which play a key role in terms of acceptance:

- In view of the dangers of crime, especially at night, at-grade crossings – even if less comfortable – should always be provided as an alternative to underpasses.
- Turn-offs and the like should be built as gradual bends or conical transitions rather than at right angles. Guidance for visually impaired persons must be provided where routes do not run straight and/or turn-offs are not set at right angles.
- Underground routes should, as far as possible, correspond to the desired directions, without diversion, and should provide simple means of orientation. Niches and hidden corners should be avoided (to preserve visibility in combating the threat of crime).
- Stairways should preferably extend out in the directions of all the main footpath routes. Easily negotiated (disabled-access friendly) ramps should always be provided, in addition or be installed instead of stairways.
- The proportion of distance traveled underground should be a maximum of 85 % of the total crossing distance (including ramps), though wherever possible it should be less than 60 %. This can be achieved by keeping the entrance areas largely open, also along the route of the underpass where appropriate.

Underpasses for pedestrians and cyclists are to have a minimum clearance of 2.50 m (3.00 m is desirable) and be of a width in accordance with their function and length (table 34).

Table 34: Underpasses

Length	Clearance width (minimum width)
Short underpasses for pedestrians for pedestrians and cyclists	 3.00 m 4.00 m
Underpasses up to approximately 15 m length	5.00 m
Longer underpasses	6.00 m

The width to length ratio, independent of these measurements, should not be less than 1 : 4.

The width of overpasses varies according to their use by pedestrians and cyclists (table 35).

Table 35: Overpasses

Use	Clearance width (between railings)
Used by pedestrians only	2.50 m
Shared use by pedestrians and cyclists	4.00 m

Railings of overpasses are at least 1.00 m high. If they are used by cyclists, a railing height of 1.30 m is advisable.

If underpasses or overpasses are used jointly by cyclists and pedestrians, it is advisable to separate the two modes, such as by installing separate cyclepaths and footpaths (sign 241 StVO).

Ramps

Ramp slopes of more than 6 % should usually be avoided, to enable wheelchair users to use the ramps on underpasses and overpasses. There should be a flat intermediate landing 1.50 m in length after no more than 6.00 m. No steps leading down may be installed onwards from the ramp (DIN 18024, Barrier-free construction; new: DIN 18030)[42] (table 36).

Curved ramps may be used where appropriate to reduce the slope. The ends of the ramp should be rounded.

Table 36: Barrier-free ramps

Feature	Dimensions
Maximum longitudinal slope	6 %
Intermediate landing	At intervals of max. 6.00 m, min. 1.50 m long
Minimum width of the usable travel surface	1.20 m
Minimum usable width of platforms	1.50 m
Wheel protection on ramps and intermediate landings	10 cm high on both sides, at least 8 cm away from the wall
Handrails on ramps and intermediate landings	85 cm high on both sides, at the same distance from the wall as the wheel kerbs

Ramps and stairways should generally be provided with a grippy, anti-slip surface.

A Stairway is not a barrier-free vertical connection. Without additional ramps, stairways are last-resort solutions for underpasses and overpasses. Lifts (elevators) must then be installed in place of ramps (table 37).

If a stairway is the only possibility, due to a severe shortage of space, a suitable means of pushing prams and wheeling bicycles must be built into the stairways.

Table 37: Stairways with handrails

Stairway slope	Conditions of use
≤ 14.5 cm/34 cm	Normal slope
15 cm/33 cm or 16 cm/31 cm	Maximum difference in height approximately 4.00 m, after a maximum of 15 to 18 steps (2.50 to 3.00 m height difference) a minimum 1.35 m deep intermediate landing should be incorporated

Stairways should not be curved or spiralled, although turns may be effected on the flat by means of intermediate landings. There must be a clearance width of at least 1.50 m (preferably: 2.50 m) between the required handrails running the full length on both sides. Stairways more than 2.50 m wide should also have a centre railing. A handrail for small children, 0.40 to 0.50 m high should be installed, additionally, at least on one side.

The steps should have a visual contrast by means of markings or highlighting material. Identification zones at least 60 cm deep extending across the full stairway width should begin directly in front of the bottom step and directly after the top step.

If escalators are to be used, their on and off zones and the underpasses and overpasses themselves must be much wider. If wheelchair users only have use of a ramp, its slope must not exceed 13 %.

6.1.9 Crossing facilities for cyclists

When providing crossing facilities for cyclists over a side street junction, a distinction needs to be made between crossing from side space to side space or whether the cyclist is travelling along the carriageway.

Where cyclists are travelling straight ahead (using advisory lanes or with other traffic) or on cycle lanes, a crossing provision such as a direct left-turn with special turning lanes for cyclist is usually suitable (see section 5.4). On high-volume, fast-moving roads, if there is no means of providing a protected left-turn, then if there is enough room a signal-controlled crossing point with a short cycle bypass can be created on the side space.

For cyclists crossing from (a shared use) side space to side space, any provision for protecting pedestrians is suitable, such as

- central medians and islands;
- widened side spaces to improve visibility and shorten crossing distances;
- crossings with traffic lights and for routes carrying primary cycling links;
- priority crossings across lightly-trafficked residential streets.

The measures can also be combined and be linked with traffic calming measures.

6.1.9.1 Central islands and central medians

In addition to the specifications for central islands and central medians as a help for pedestrians crossing, greater widths are required where they are also used by cyclists. The length of bicycles with trailers must also be considered depending on the local context.

Where stopping in the middle is unavoidable, central islands and medians should be 3.00 m depth and the waiting area 4.00 m wide. The minimum width for the waiting area, where there is a possibility of stopping in the middle, is 2.50 m.

6.1.9.2 Unsignalled crossings

At unsignalled crossings cyclists are required to give way to traffic on the main road. No indication of a cycle crossing may be marked. Unsignalled crossings where waiting is mandatory should not be located adjacent to a pedes-

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[42] DIN 18024: Barrier-free building, part 1: Streets, squares, paths, public transport and green spaces; planning basis, edition 1998-01, German Standardisation Institute, Berlin 1998 and DIN 18030: Barrier-free construction – Design Principles; draft standard 2006-01, German Standardisation Institute, Berlin 2006.

trian crossing. The requirement to wait should usually be indicated by signs and where appropriate by a stop line for the cyclists.

6.1.9.3 Crossings with traffic lights

On roads where vehicles travel at high speeds and/or with high traffic volumes, it will usually be necessary to use traffic signals to ensure safety at crossings. Traffic signals are particularly necessary at locations more heavily used by especially vulnerable cyclists (such as schoolchildren), or on important cycle routes, where the signal control provides safe and attractive crossing conditions.

The following points should be considered in relation to crossings for cyclists featuring traffic signals:

- Pedestrian and cycle crossing markings should be adjacent to each other.
- Kerbs at cycle crossings should be flush.

6.1.9.4 Crossing separated tracks

See also the earlier guidance for pedestrian crossings on separated tracks, in particular that relating to waiting and queuing areas for cyclists on central islands and medians (6.1.8.7).

If bicycles with trailers are to be accommodated and if there are heavy flows of cyclists passing by each other in a constricted area, appropriate geometric design and signalling (figure 83) are also to be provided. If this is not possible, for example due to lack of space, alternative provision for cycle traffic should be considered.

6.1.10 Public transport facilities

6.1.10.1 Basic considerations

On urban roads public transport vehicles may be routed

- on the carriageway or
- on dedicated lanes/tracks.

Regarding the location of tramways, § 15 para. 6, BOStrab stipulates segregated or separate on-road tracks, as “trams only fulfil their role as a mass means of transport when they are able to run, as far as possible, unhindered by the other traffic”[43]. Variance from those requirements is possible only in justified cases, such as where the road cross-section is too narrow or in pedestrian zones. On roads with more than two lanes in each direction, the track area should be designed as a separate lane. On one-way streets with contra-flow tram traffic, the tram should have a separate lane.

Public transport lanes are usually installed on main roads. They are dedicated lanes for trams or buses, either in the middle of the road or at the roadside; they are reserved for public transport either permanently or at specific times. Bus lanes are key elements of prioritised public transport systems. As such, they serve to

- maintain regularity and punctuality of service and
- minimise external delays, in particular by motor vehicle traffic;
- reduce public transport journey times;
- emphasise the importance of public transport within the community.

Those aims can be achieved as follows:

- Permanent bus lanes/tracks with physical separation between private and public transport vehicles as defined by § 16 para. 6 BOStrab (with fixed barriers) or
- Time restrictions for segregated lanes/tracks (such as with tram tracks flush to the road) with segregation by measures such as electronic lane-control signals

Continuous (or semi-continuous) public transport lanes/tracks can be used along entire roads, on individual stretches or only at junctions. With differing likelihoods of delay, it can be useful on some stretches and junctions to use different methods of separation.

On straight stretches, and to benefit public transport

- continuous (or semi-continuous) public transport lanes/tracks with (physical separation) and/or
- priority to public transport applying only at certain times of day.

The most useful methods of separation depend on:

- the importance to the public transport network of the section being considered;
- the nature and extent of the delay caused by traffic, moving and parked;
- the service frequency;
- the available space and balancing the competing claims for use by (pedestrian and cycle traffic, moving and parked vehicles, deliveries, leisure, space for greening the environment);
- the intensity of use on and between each side of the street;
- the distance between key junctions; and
- the possibilities for prioritising public transport at those locations.

A segregated tram track, (as in §16 para. 6 BOStrab) should be provided

- where rapid tram transit (> 50 km/h) is planned;
- before ramps leading to tracks at a second level;
- where trams run contra-flow on one-way streets.

Dedicated lanes/tracks in the middle of the road offer the advantage that they are unimpeded by illegally parked vehicles (residents and deliveries). Regardless of whether the central provision is a flush track, a separate track or a guided bus lane, safe, unhindered flow on such facilities should wherever possible be free from crossing traffic (motor vehicles, cyclists, pedestrians).

When a track is located in a separate lane or at the side of the road, any conceivable delays to its free flow (such as parked vehicles) must be prevented.

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[43] See reasoning underlying “Regulation governing the construction and operation of trams” (BOStrab), Bundesrat document reference 74/87.

Where a public transport lane or track switches from the middle to the side of the road, or it rejoins the general carriageway from a segregated central lane, the transition zone requires special care in design, and should always be controlled by signals.

6.1.10.2 Street-running trams and other traffic,

Where trams and other traffic share a lane, traffic signals should be used so that possible delay from other traffic is largely avoided.

The tracks should be located in the middle of the carriageway.

For roads with more than two lanes in each direction and on one-way streets with contra-flow tram traffic, joint use should not be considered.

In areas with limited street space, where no dedicated, public transport lane or track is possible, a system of dynamic traffic signalling can be used to avoid delay for public transport from other traffic.

This will improve the journey times and punctuality of the service.

Traffic lanes shared by trams and controlled with dynamic traffic signalling can be used without traffic modelling checks, where the following conditions are met:

– The stretch of street-running tram lies between sections of track which provide a segregated bypass approaching areas of queuing traffic (placing the tram ahead of the traffic platoon) and then providing a free exit onto the next section of shared traffic lane.

– There are no major junctions along the stretch, unless they are incorporated into the signalling system.

– There are no junctions on the road with competing public transport systems.

– The frequency of public transport does not exceed approximately 12 vehicles per hour in each direction.

– The general traffic volumes are less than approximately 1,100 vehicles per hour in each direction (2 lanes) or approximately 1,700 to 2,300 vehicles per hour in each direction (4 lanes).

6.1.10.3 Tram-only lanes

Tram-only lanes can be used either at the side or in the centre of the road. For urban design and traffic control reasons, the centre of the road is usually preferable..

The design of tram lines (minimum radii, widths, widening on bends) can be derived from the basic data and the dynamic characteristics of the trams used.[44] Where the tram track is also used by buses the cross-section of the road space should be expanded accordingly.

The forms of tram track which can in principle be used on main roads are set out in table 38.

Separate tracks with sufaced track beds are finished in concrete, asphalt or paving material and segregated from adjacent lanes by kerbs. They thus provide a largely segregated provision for public transport away from other traffic; they can also be used by buses; they do not have a severance effect; and are usually easy to integrate into the overall street space. In terms of noise they are usually less favourable than unsurfaced forms of track.

Table 38: Tram tracks

Form		Markings
street-running tram track	without physical separation of the tram from the other traffic	Delineation by lines (sign 340 StVO)
	with physical separation of the tram from the other traffic	Delineation by lane markings (sign 295 StVO) or hatched area marking with solid line
Separate tram track	with surfaced track*) made of concrete, asphalt or paving	Delineation by kerbs Use by buses is possible in consultation with technical supervisory authority
	with gravelled track bed	Delineation usually by kerbs
	with greened track bed (grass track)	

*) See also "Information sheet for the implementation of running surfaces in track bed of tramways", edition 2006, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2006

Separated tracks with gravelled track bed are used where:

– integration into the street design is of lesser priority;

– mixed-use of the tram track space by buses is not necessary; and

– pedestrian and cyclist crossing of the tracks can be concentrated at certain crossing points.

This form of rail track is well suited to main roads outside urban areas, and is only suitable for built-up main roads in some sections. With these types of use, fencing, gating, chains or guardrails are not usually required, and rows of trees or hedges (not affecting visibility) can be used instead. With regard to noise a gravelled track bed is generally assessed favourably..

Separated tracks with greened track beds (such as grass on a humus covering) may be an alternative both to surfaced and gravelled track beds where design and ecological requirements of the street need to be offset. They are very favourable in terms of noise emission.

Full kerbs should be used for segregation.

6.1.10.4 Special bus lanes

Continuous bus lanes may be installed in the middle or at the side of the road (table 39).

Dedicated bus lanes in the middle of the road offer the advantage that they are not blocked by illegally parked motor vehicles (residents and delivery traffic). Traffic flow on such facilities should be unimpeded, safe, and wherever possible, not disturbed by crossing traffic (motor vehicles, cyclists, pedestrians).

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[44] See also "Directives for the routing of rail tracks in accordance with the Regulation governing the construction and operation of trams" (BOStrab routing directives), in: Verkehrsblatt (1993), volume 15, p. 571–576.

Permanent bus lanes at the nearside of the road can be used where there is no local traffic or where loading and unloading can be relocated to special loading lanes, frontage lanes, or courtyards; otherwise illegally parked motor vehicles (local access and delivery traffic) may block the bus lanes.

Alternatively, bus lanes at the nearside may operate at fixed times (see VwV-StVO administrative order pertaining to § 41 StVO, no. I 4 regarding sign 245 StVO "Scheduled bus services"). The operating period should include a buffer of 30 minutes before and after the actual period required, and should be identical for all bus lanes across the city. A permanent physical segregation is generally accepted and respected by other road users. It can be observed that bus lanes operating at fixed times suffer from frequent abuse. Only delivery traffic and taxis should be allowed access, for limited periods.

Bus lanes operating at fixed times (separating modes by time) are used to bypass queues, such as at junctions, and can offer a good-value alternative to continuous bus lanes or tracks at traffic volumes up to 1,500 vehicles per hour and with service frequencies up to 12 vehicles per hour in the length of road concerned.

The design requirements for bus lanes can be derived from the basic dimensions of the buses used. Table 40 presents an overview of applicable widths.

Bus lanes are indicated in the simplest case by road markings and signs, with sign 245 StVO ("Scheduled service buses"). Where appropriate with an additional sign (see section 6.1.10.5). A more distinct emphasis can be provided by lightening or colouring the road surface and by varying the material.

Table 39: Possible arrangements for bus lanes

Location		Mode
Roadside	on one side	Permanent, temporary
	on both sides	Permanent or temporary
Central	for one direction	One-way
	for both directions (2 lanes)	Each lane one-way
	for both directions (1 lane)	contra-flow alternately or alternating by time

Table 40: Bus lanes

Constraints	Width
Normal context	3.50 m
Restricted space	3.25 m
Greatly restricted space	3.00 m

Standard markings are shown in figures 84 and 85.

6.1.10.5 Shared use by other modes

Segregated public transport lanes are installed to speed up services. For shared-use, a distinction needs to be made between segregated lanes for trams and buses.

Taxis are not allowed on **tram tracks** (see VwV-StVO administrative order pertaining to § 41 StVO, no. III 2 regarding sign 245 StVO "Scheduled service buses").

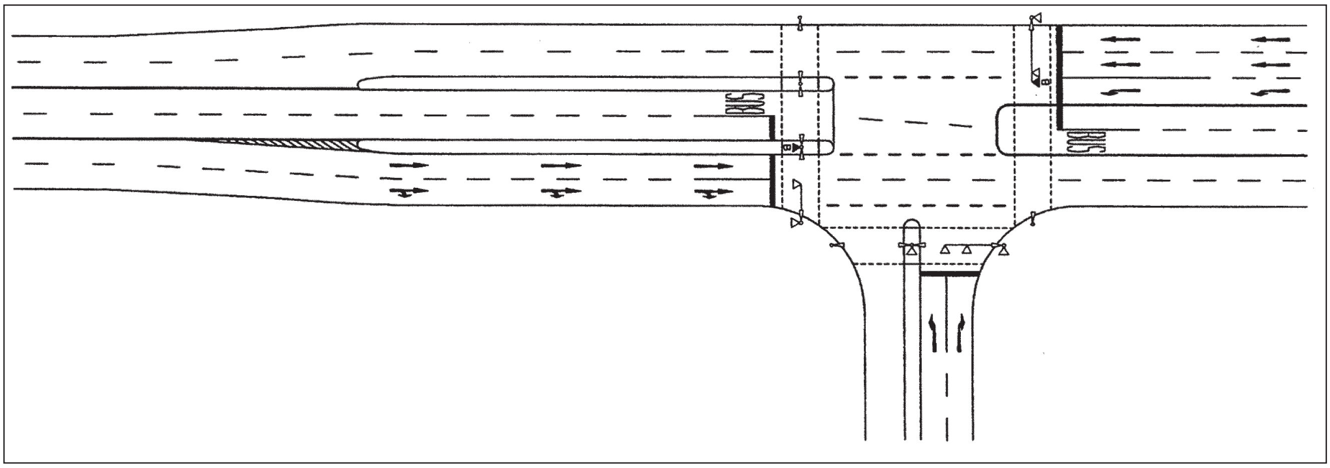

Figure 84: Example of permanent road-centre bus lanes

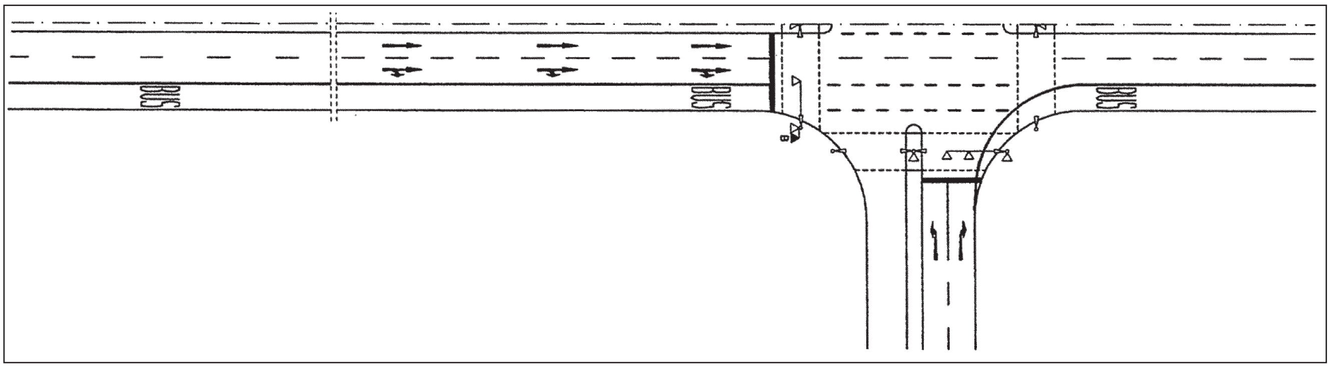

Figure 85: Example of permanent nearside bus lanes

Cyclists must be prohibited from use of segregated tracks for road safety reasons (bicycle tyres being deflected by, or being jammed in, tram tracks, particularly in wet and icy conditions, resulting in serious accidents) and be physically prevented by suitable measures.

Shared-use of **bus lanes** by other traffic can only be considered if the actual purpose of the lane is not brought into question. Particularly in the context of safeguarding and promoting environmentally friendly public transport, such shared-use may be beneficial or necessary if

– the feasibility and acceptance by motorists of lightly used bus lanes can be increased as a result;

– no other suitable solutions can be found where bus and cycle routes share the same networks, taking into account the local street context;

– accessibility for bus, cycle and essential motor vehicles, in otherwise MIV-free roads [Private Motorised Traffic] and areas is to be improved or protected, particularly in the inner city.

Making use of the possibilities offered by the StVO regulations, the standard method for marking bus lanes in conjunction with shared-use by other traffic is sign 245 StVO (“Scheduled buses”) and optionally, in some cases, adding sign 250 StVO (“No vehicles of any kind allowed”) and, also in some cases, adding sign 237 StVO (“Cyclists”). The key criteria in choice of variant are the traffic planning objectives as well as the local context.

According to StVO, joint-use of bus lanes by taxis should be allowed in principle if the bus service is not delayed as a result. This normally applies to bus lanes at the nearside of the road. At bus lane traffic volumes of up to 100 taxis and 60 buses per hour, no loss of traffic quality is to be expected. In some individual spatial arrangements higher traffic volumes are also possible without loss of quality.

Access by taxis is authorised using additional signs. In this case taxis must observe the public transport signals. It must be made certain that taxis do not stop on the bus lane to let passengers on or off.

Taxis cannot be allowed on bus lanes leading to traffic lights with a bus-activated green signal (see VwV-StVO administrative order pertaining to § 41 StVO, no. III 1 regarding sign 245 StVO “Scheduled service buses”).

If bus lanes are installed, cyclists should be separated from the buses on cycle paths.

If this is not possible, cyclists should be allowed on the bus lane, in consultation with the bus operators. This is because the cyclist cannot be safely routed between the bus and private vehicles without dedicated facilities..

The following criteria apply:

– To enable safe overtaking of cyclists by buses, a lane width of at least 4.75 m is required.

– If the volume of cyclists is less than 150 to 200 per hour, the width of the bus lane may be 3.00 to 3.50 m (with no overtaking).

– The intervals between bus stops or the lengths of lane between equally-ranked junctions should not substantially exceed 300 m.

– The permissible maximum speed is 50 km/h.

– At signalled junctions, provision is made to route cycle traffic safely and without hindering the public transport service (particularly in the case of bus lanes leading up to traffic lights with signals according to BOStrab or with a bus-activated green signal).

– If there is a lane used by motor vehicles to the right [or nearside] of the bus lane, use of the bus lane by cyclists is prohibited. This does not apply in the filtering zones of junctions.

If these use criteria cannot be met, it should be investigated whether cyclists can be permitted to use the footpath on the stretch in question.

If a road cross-section has 4.75 m width or more available for a dedicated bus lane, the layout of separate cycle provisions (such as cycle lanes) to the right [or nearside] of the bus lane should be preferred to shared-use of the widened segregated lane.

Coaches and other buses occasionally using the road can be allowed on segregated bus lanes if they do not impede the scheduled bus service. This means, in particular, that the said buses cannot be allowed on segregated lanes leading up to traffic lights with signals according to BOStrab or with a bus-activated green signal. Otherwise the same restrictions apply here as for taxis.

Parking, delivery and loading lanes adjacent to bus lanes

Parking, delivery and loading lanes along the kerb should only be allowed adjacent to segregated bus lanes if they are adequately dimensioned to permit forward entry to parking space. The width of the lane should usually not be less than 2.50 m and a minimum car parking space length of 6.50 m. Such widths are also beneficial to cycle traffic allowed in the bus lane (figure 86).

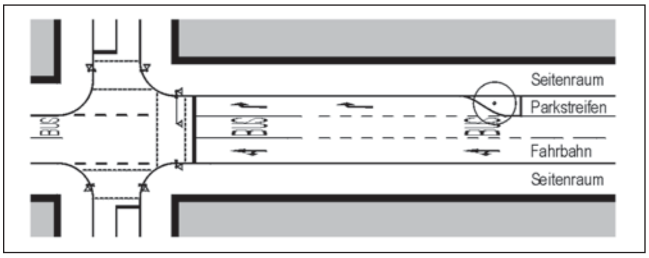

Figure 86: Example of parking, delivery and loading lanes next to a bus lane (indicative)

Echelon and perpendicular parking next to segregated bus lanes should be prohibited where vehicles emerging from parking spaces do not have sufficient space (a manoeuvring strip) adjacent to the public transport lane.

6.1.10.6 Location of stops along the road

Stops should be positioned so that passengers can reach the public transport comfortably, safely, and with a short travel distance. The same applies at interchange stops with regard to the distances between the various connecting services.

When laying out stops, particular attention should be paid to clear visibility, ensuring that all road users can see and react to the stops in good time. The visibility for all road users must be considered.

Designers must ensure good visibility for bus and tram drivers safely approaching and leaving stops, and supported where appropriate by technical or by traffic regulations.

Whether a stop is located before or after a junction can only be determined according to each specific case. Key factors in deciding this include

- accessibility for passengers and the locations of crossing points;
- the location of and potential services using the bus interchange;
- the urban context;
- if using disabled-access kerbs, are drivers able to approach the stop precisely;
- whether traffic light controls at adjacent junctions can accommodate the platoons of private and public transport;
- the amount of crossing traffic (including approaching passengers) but maintaining priority for public transport;
- the capacity of the roads approaching the junction;
- the possibility of separating out individual services from a number of lines.

Where there is absolute prioritisation of public transport at traffic lights, a stop after the junction has the advantage that the crossing traffic can be given a green signal after the vehicle has reached the stop, and that the crossing point is behind the stopped bus. This gives pedestrians a better view of traffic flowing in the same direction.

At stops in front of signalled junctions, the bus can be given a separate green light ahead of other traffic (providing them with a "head-start"). This ensures that public transport emerging from bus bays or lanes are filtered ahead of following vehicles.

Locating stops on junction approaches is also advantageous if

- the catchment area served by the stop is asymmetrical and most of the passengers walk to the stop in the direction of travel;
- a number of services on a public transport lane on side of the road are taken through a bus gate; or
- joint use of lightly-used right-turn lanes, by stopping services, is possible.

The stops need to be as close as possible to junctions for the sake of better accessibility and ease of crossing the road. However, minimum distances may result from the requirements for turning lanes as well as to prevent too much congestion after the junctions.

At interchanges between buses, and also trams and buses, the stops of both modes should be close to each other or shared. For safety, relating to the connections between any two stops, crossings of carriageways and tracks should be minimised.

Stops should be located on straights wherever possible. If they have to be located on bends, the curve radius should be sufficient to allow wheelchair access-friendly entry and exit.

6.1.10.7 Tram stops

Trams Stops can be positioned at the side of the road as

- build-outs of the side space

or in the road centre with

- side platforms,
- central platforms,
- raised tracks,
- signal-controlled 'virtual island' at the stop area (with raised track).

Tracks at stops should have no longitudinal slope. Only in exceptional cases may a slope at tram stops exceed 4 %.[45) Longitudinal slopes at bus stops should not be more than 5 %.

With **tram stops at the side of the road build-outs** are useful as trams are prioritised in the stop zone when sharing the same road space as other traffic (figure 87).

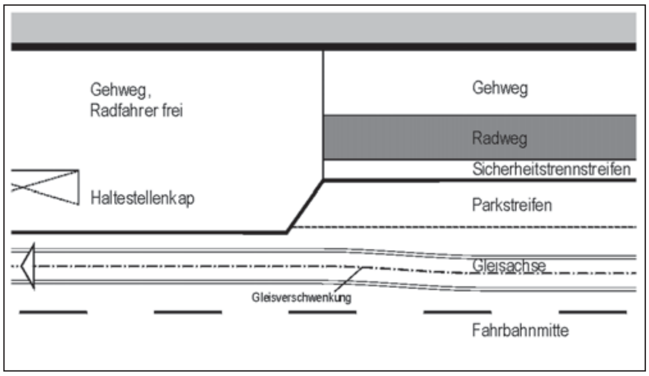

Figure 87: Example of a tram stop side space build-out

This form of stop

- places public transport at the head of vehicle queues;
- helps keep the stop zone free of parked vehicles;
- enlarges the waiting area for the passengers and creates space for the shelters, ticket machines etc;
- enhances the comfort of waiting and the ease of getting on and off the tram, as well as improving passenger safety;
- is the easiest method for persons with restricted mobility.

If constructing a build-out necessitates the tracks veering to the side of the road, then passing to the left (offside) of halted trams should be prevented for safety reasons (e.g. by making a central island).

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45) See BOStrab routing guidelines.

Stops in the middle of the road should be the preferred solution for trams. Where buses and trams are running in the middle of the road, the aim should be to route them on a dedicated lane with shared stops. Such stops are useful for improving clarity, saving space, and where passengers transfer between transport modes.

When considering whether to favour side/central platforms, signal-controlled virtual stop islands or raised tracks the following criteria apply:

- Joint-use by buses;
- whether the trams have doors on both sides;
- the floor height of the trams;
- the need the track to veer before and after the stop;
- facilities at the stop;
- passengers making connections;
- passengers‘ sense of safety;
- urban design context;
- required space.

With platforms beside tracks, in the centre of the street, it may be necessary for safety to protect the waiting area on the carriageway side. Between the barrier fence (or wall), which can be designed as a splash guard, and the carriageway a 0.50 m gap should normally be provided. This may be reduced to 0.30 m in tight spaces in urban streets.

If the track area, at island stops, is also used by scheduled buses, necessary clearances and lane width for buses must be available. The traffic and passenger areas should be segregated by physical provisions, or at least be visually distinct. If buses approach the stop using the track area, segregated from private traffic by lane markings (sign 295 StVO) or via a segregated tram track, no special marking separating it from the other traffic is required.

If there is no segregation, then sign 222 StVO (“Keep right”) with additional exemption sign 1026-32 (“free for buses”) must be installed on the island head.

Road signs must be used at the heads of island bus/tram stops and at the start of separated tracks.

The length of islands and side space build-outs at stops is derived from:

- the number of public transport vehicles scheduled to stop at the same time,
- whether it is a single or double stop,
- the vehicle lengths,
- spacing between vehicles at the stop – from 1.00 to 2.00 m,
- where appropriate the width of pedestrian crossings and
- the space required for the signs needed at the stops (such as light columns).

Island stops should be ramped downwards on the side facing a crossing point. Depending on the size of the island, this may result in a longer island and relocation of the public transport stop line.

The usable width of islands at stops should not be less than 2.50 m. Greater widths are to be recommended at interchanges, at double stops and where shelters with seating are installed.

Taking into account the needs of persons with restricted mobility (as well as wheelchair users, visually and hearing impaired persons, also persons who have difficulty walking, older people, persons pushing prams, or persons of short stature) additional requirements apply to the furniture both at the stops and in the vehicles. The design of vehicles and the stops must be coordinated, for example to minimise steps and gaps between the waiting area and the floor of the vehicle.

In **high-floor systems,** where raised platforms are used, consideration should be given to the impact on street space and to the effect of visual separation. On built-up main roads with features key to the urban design quality, raised platform stops must respond appropriately to the design requirements of the environment.

In the case of **low-floor systems,** depending on the type of vehicle used, half-raised platforms or waiting areas which are 25 to 35 cm above the top of the rail can be installed.

By **raising the carriageway** to vehicle height, near the stop, entry to low-floor vehicles can be made barrier-free (figure 88).

Signal-controlled virtual islands protect passengers entering and exiting, by temporarily keeping the car-

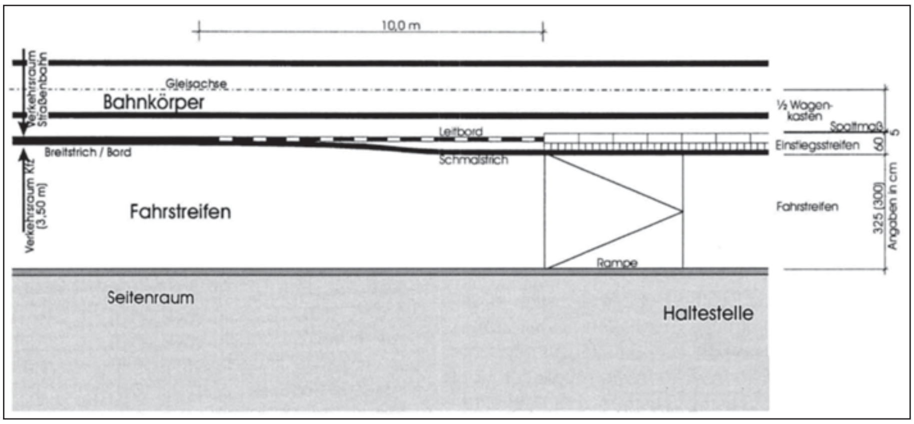

Figure 88: Principle of a raised roadway (at stops)

riageway area required for passengers to cross, free from vehicles by means of traffic signals. As the bus or tram approaches the stop, a signal stops the road traffic, preventing non-compliance with § 20 StVO (to drive past tram stops in a gentle manner). They are conveniently combined with raised roadways.

6.1.10.8 Bus stops

Bus stops may be located at the roadside or in the middle of the road.

Where bus stops are located in the **middle of the road,** the corresponding requirements imposed on tram stops apply.

Where the stops are located at the **side of the road,** to let passengers on and off, buses can stop

- at side space build-outs;
- on the carriageway; or
- in lay-bys (table 41).

Table 41: Bus stops at the side of the road

Form	Operating limits
Stops on the carriageway	Few construction measures required. Operating limits: up to 750 vehicles per hour in each direction and bus frequencies ≥ 10 minutes*)
Side space build-outs	Kerb is shaped to carriageway edge Operating limits: up to 750 vehicles per hour in each direction and bus frequencies ≥ 10 minutes*)
Bus lay-by	On major roads in case of lengthy dwell times and where the Operating limits for stops on the carriageway and Side space build-outs are exceeded

*) See Handbook for the design of road traffic installations (HBS)

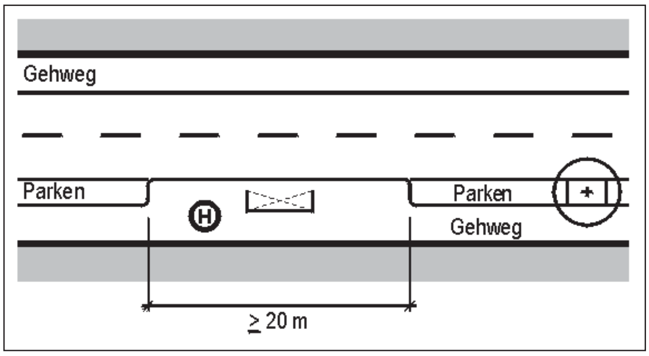

Figure 89: Example of a Side space build-out stop for articulated buses

Bus stop at side space build-out (figure 89)

- allows buses to approach the kerb in a straight line and precisely, facilitating access for persons with restricted mobility;
- enables the bus to move off and continue in a straight line along the lane it is using;
- places the bus ahead of other traffic;
- helps keep the bus stop free of parked vehicles;
- are particularly well suited to areas where there is high parking demand, as no entry and exit stretches need to be kept clear;
- requires a short length;
- are cheaper to construct than bus bays;
- compared to bus bays, they enlarge the waiting area for passengers and create space for the installation of shelters, ticket machines etc.;
- enhances passenger safety;
- simplifies the routing of cycle traffic;
- offers advantages in terms of urban design, thanks to the parallel carriageway edge and eliminates the need to widen the carriageway;
- offers advantages in terms of winter maintenance.

Side space build-outs can affect flow for the private car. The operational limits for side space-build outs are derived from the motor traffic volume, the frequency (cycle times) of public transport vehicles, and the dwell times, which are largely determined by the time taken for passengers to enter and exit.

With bus frequencies of 10 minutes and more, and with average stopping times of 16 seconds, Side space build-outs are always possible.

If stopping times are longer, or frequencies are less than 10 minutes, side space build-outs present no problems up to a traffic volume of around 650 vehicles per hour in each direction on two-lane roads. Positive results have been reported at flows up to around 750 vehicles per hour in each direction, and at frequencies ≥10 minutes.[46]

Because of their overwhelming advantages, side space build-outs should be implemented as frequently and regularly as possible on built-up main roads. Converting bus bays into build-outs can be regarded as generally improving local traffic conditions.

Bus stop areas at the roadside are made by marking no-stopping zones (figure 90). They have the advantage that they can be created with little engineering work. A disadvantage of them is that, when installed in existing streets, the waiting areas which can be provided are frequently not as wide as with a side space build-out, and obstruction by parked motor vehicles is likely. If parking at the roadside is allowed, then the length of the bus stop should be marked on the carriageway, corresponding to the dimensions of a bus bay, in order to enable a parallel approach.

It must be possible for buses to approach bus stops so that they are parallel to the kerb, at a distance of 5 cm from it, to enable convenient access for persons with restricted mobility. Bus bays therefore demand a significant length and space requirement, and are generally unsuitable within built-up areas.

Bus bays may be required in special cases due to the volume of motor vehicle traffic or for operational reasons. They are used, for example, where passengers wait for buses with long scheduled dwell times, as well as to reduce delay to other traffic while the bus is stopped.

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[46] See "Handbook for configuration of road traffic installations" (HBS).

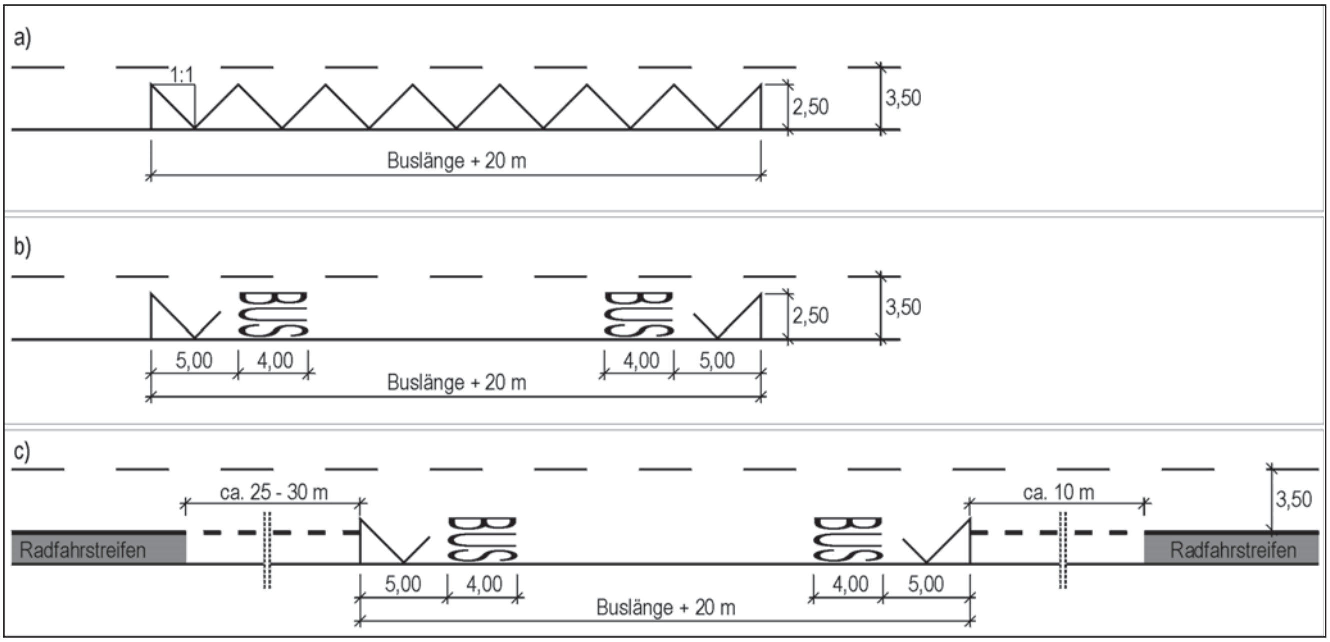


Figure 90: Examples of the layout and marking of bus stops at the roadside

Buses at stops immediately after signal-controlled junctions should not hinder the following traffic. Consequently, bus bays or widened lanes are an option for such locations.

To ensure unhindered exit from the bay, crossing traffic should be given priority until the bus moves off.

Bus bays in the queuing area before junctions should enable the bus a direct exit into the junction (figure 91). If direct exit cannot be guaranteed by bus-priority lights at signal-controlled junctions, the stop line of the adjacent lane should be set back far enough so that buses can leave the stop ahead of other traffic.

Disadvantages of bus bays are that

- buses have to rejoin the traffic flow, resulting in lost time when traffic is heavy, despite regulation § 20 para. 5 StVO, (requiring traffic to give way to departing buses).
- standing passengers and those getting up to exit the bus are subject to unpleasant sideways forces as the bus approaches and exits;
- they cannot always be approached accurately because of illegally parked vehicles at the roadside and in the bays;
- as a result, buses stop at an angle, meaning that passengers getting on and off must step down onto the carriageway. For persons with restricted mobility and wheelchair users, access and exit is rendered impossible;
- bus overhang may sweep across side space areas when entering and leaving the bay;
- the side space area is reduced by the footprint of the bays. This makes it more difficult to achieve safe and conflict-free cycling and to find space for shelters and passenger information;
- they require extra effort when winter maintenance is needed;
- their integration into the urban context is often problematic.

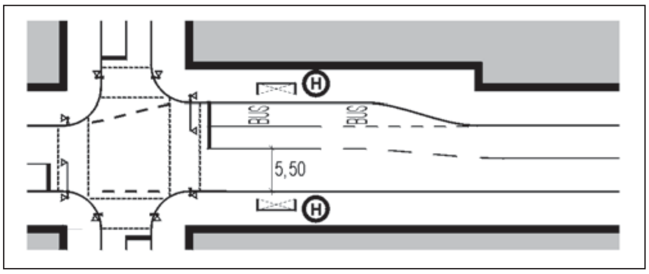


Figure 91: Example of a bus bay before the junction and a stop with a widened lane after the junction (outline sketch)

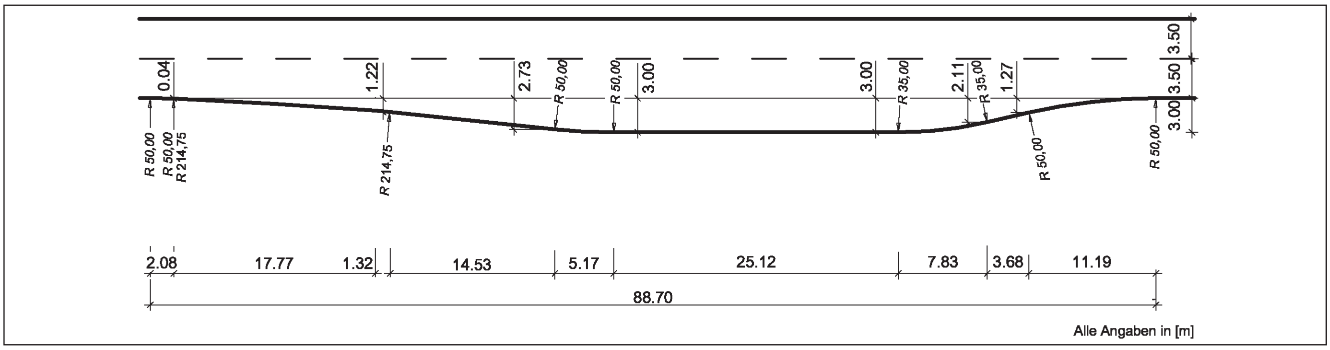
A bus bay allowing a parallel approach to the kerb, taking into account the need to accommodate low-floor buses, demands a considerable length (figure 92).

Bus bays should be designed with a depth of 3.00 m. If the width available is insufficient, a stop at the roadside must be provided.

If bus bays on bends cannot be avoided, make sure that the shape of the bay is adapted to the tracking of the buses, and conforms to the basic specifications.. The design of the bay must provide the bus driver with adequate visibility of the following traffic when moving off (at least 50 m at $V_{\text{limit}} = 50$ km/h).

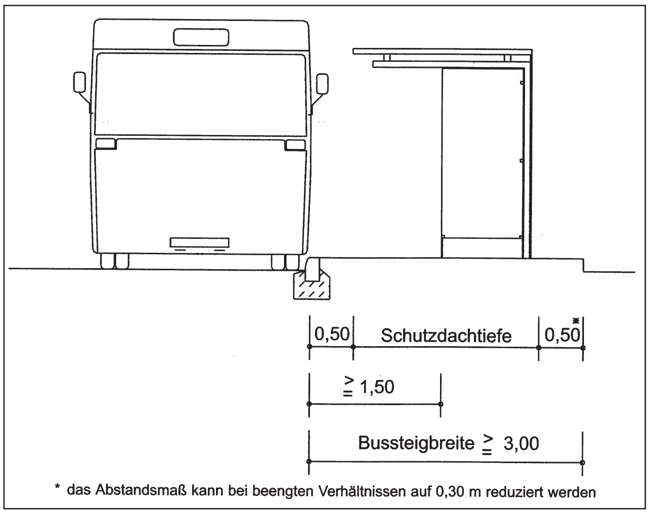
The dimensions of the **waiting areas** are derived from the dimensions of the shelter and the areas necessary for entry and exit and for parallel parking (figure 93).

The waiting area should not be more than 5 cm below the height of the bus floor, to enable entry and exit without the help of others. Height differences between 5 cm and 10 cm



Alle Angaben in [m]

Figure 92: Dimensions of a bus stop bay for standard buses allowing barrier-free entry and exit[47]



* das Abstandsmaß kann bei beengten Verhältnissen auf 0,30 m reduziert werden

Figure 93: Dimensions of bus stop waiting areas and islands with shelters (applicable where approach is virtually parallel)

are usable with difficulty or with the help of third parties; height differences greater than 10 cm should be avoided.

Waiting areas up to 16 cm above the road are easily passable by low-floor buses with their overhangs. Good empirical results have also been obtained with 18 to 20 cm high kerbs (depending on the camber of the road).

The boarding areas to public transport vehicles should be highlighted with tactile and visually contrasting paving.

6.2 Speed reduction measures

6.2.1 Physical traffic calming measures on urban streets

Physical traffic calming measures are needed wherever inappropriate speeds put road safety at risk. The main methods of speed reduction on urban streets are based on physical traffic calming elements. These are speed humps, raised plateaux and chicanes.

At suitable junctions mini-roundabouts are another option (see section 6.3.4).

On scheduled bus routes physical measures should be avoided. Where this is not possible, they should be designed to be compatible with the needs of public transport vehicles.

6.2.1.1 Speed humps and raised plateaux

Speed humps and raised plateaux cause motorists to drive more slowly.

In the case of speed humps, the carriageway is raised 8 to 10 cm and engineered with ramp slopes of 1 : 10 to 1 : 7. The minimum length should be greater than the wheelbase of the vehicles regularly using the road (see table 42). Speed humps of these types limit speeds to between 25 and 35 km/h. They should be spaced no more than 50 m apart (see figure 94).

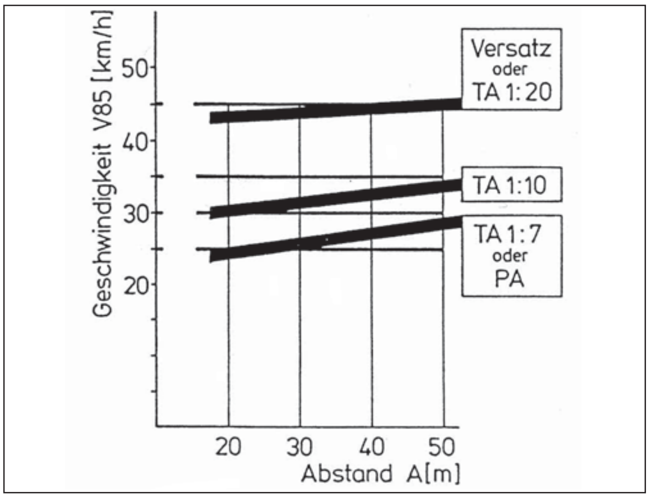


Figure 94: Speed level V_{85} dependent on method and spacing of physical measures (TA = speed hump, PA = raised plateau)

The reduced height difference between footpath and carriageway, with full width speed humps, enhances the convenience of crossing for pedestrians. However, the kerb should remain perceptible to touch, for visually impaired persons (e.g. with different material, small height difference). If a flush surface is to be provided, where pedestrians have priority over vehicles, pedestrian crossovers should be designed (such as connecting at junctions).

Speed cushions on scheduled bus routes are 5 to 8 cm high and 1.70 m wide. Where there are no bus services, they can be designed wide enough to leave a space for cyclists of 0.80 to 1.00 m on both sides. Car speeds are reduced

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[47] Drive tests and calculations: Stadtwerke Verkehrsgesellschaft Frankfurt a.M. mbH, 1997.

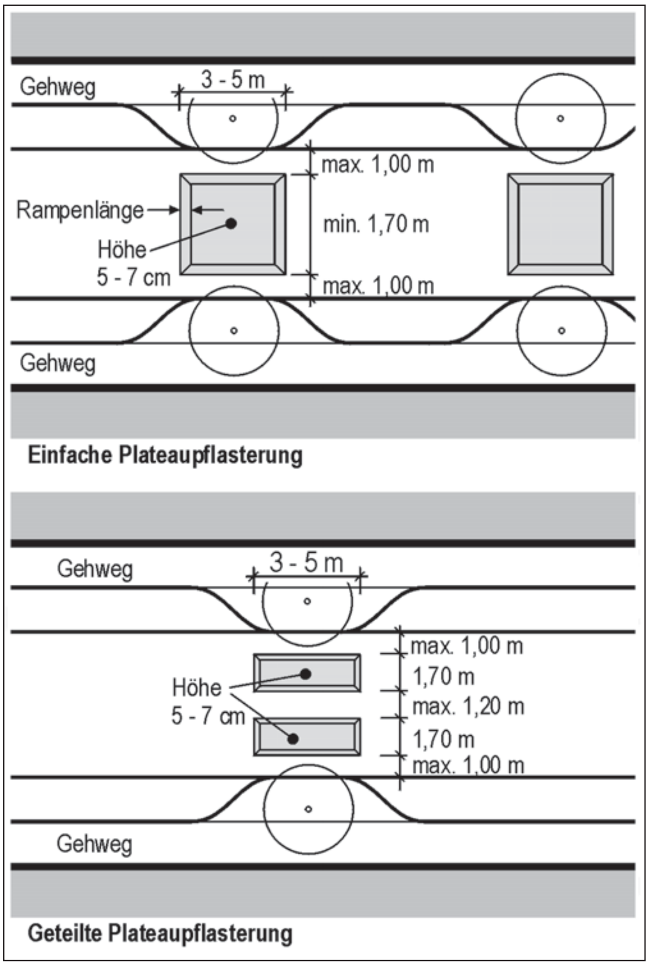


Figure 95: Dimensions of speed cushions

down to between 25 and 30 km/h. The dimensions of speed cushions are shown in figure 95.

On urban streets which are occasionally used by scheduled buses, speed cushions are the only traffic calming measures which can be considered.

Raised block-paved humps with ramp slopes of 1 : 25 to 1 : 15 are classed as having a visual impact; ramp slopes of 1 : 10 to 1 : 7 are classed as speed-attenuating humps (table 42).

Table 42: Speed humps

Applications	Ramp slope	Minimum length of horizontal area
Speed-attenuation	1 : 10 to 1 : 7	5.00 m
Negotiable by standard buses	1 : 25 and flatter	7.00 m
Negotiable by articulated buses	1 : 25 and flatter	12.00 m

The ramps of speed-attenuation humps should be made using sinusoidal ramp blocks. For plateau humps, chamfered ramp blocks are recommended. Such shaped blocks ensure that the correct dimensions are maintained even in continuous operation.

A 3 cm height difference, between the speed hump and the kerb, enables the visually impaired person to perceive the edge by touch.

Surface material options are asphalt, in varying textures or tone, as well as concrete, brick and load bearing, even-faced, natural stone.

When using rough paving, the road noise – particularly in the case of short intervals between different materials – can be perceived as a major disturbance due to the changing character of the noise (frequency range) even if the average level remains unchanged.

These materials are also unacceptable where cyclists use the carriageway.

6.2.1.2 Chicanes

Chicanes have an impact on speed if their depth is equal to or greater than the width of the driving lane. Islands can be used to increase the depth of the chicane, because only one lane of the carriageway width has to be used. On urban streets, short chicanes without islands are usually used (figure 96).

To reinforce the right-before-left rule at junctions, leftward (offside) chicanes must be used. This usually results in an odd number of chicanes on the stretches of road between junctions (figure 97).

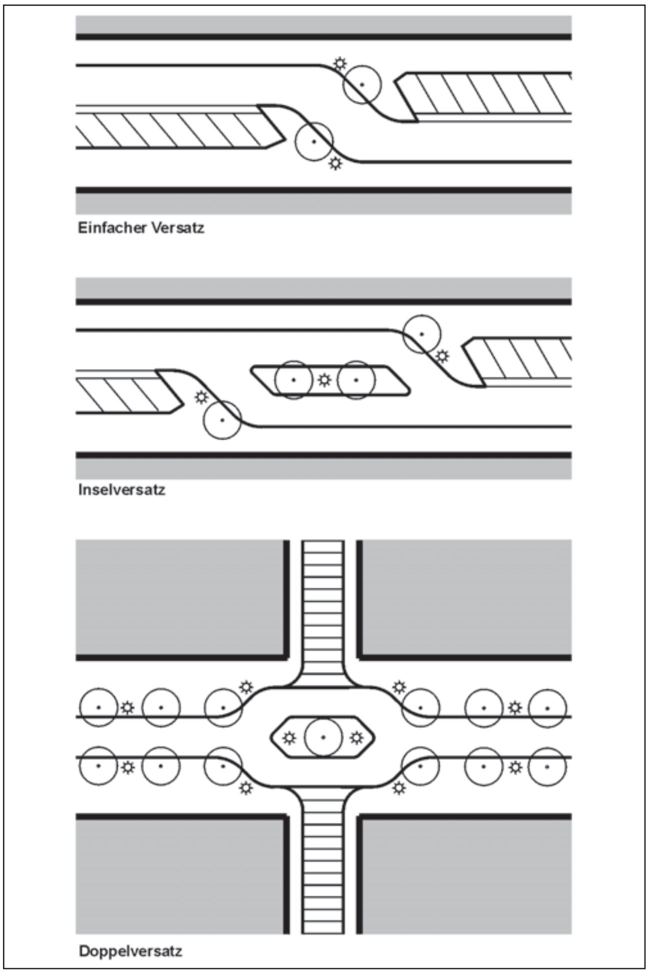


Figure 96: Examples of chicane layouts between junctions (outline sketches)

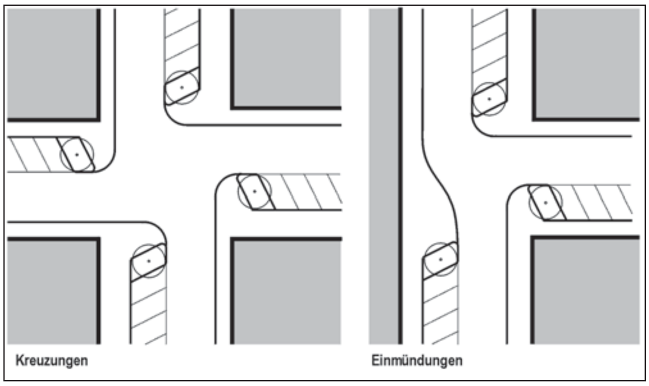


Figure 97: Layout of chicanes at crossings and junctions (outline sketch)

For cars and trucks the negotiability of a chicane is assured if the chicane length l_V is designed dependent on the chicane depth t_V and the carriageway/lane width b as shown in figure 98. For truck-trailer and semi-trailer combinations to negotiate them, the chicane length must be extended by 50 %.

The speed at which buses can manage a chicane is dependent on the chicane depth and length (set out in table 43).

Table 43: Bus speeds possible in chicanes with a carriageway width b = 3.25 m, dependent on chicane length l_v and chicane depth t_v

t_v l_v	2,00 m	2,50 m	3,00 m	3,50 m
16 m	30 km/h	–	–	–
18 m	35 km/h	30 km/h	20 km/h	–
20 m	40 km/h	35 km/h	30 km/h	–
22 m	50 km/h	40 km/h	35 km/h	15 km/h
24 m	–	50 km/h	40 km/h	25 km/h
26 m	–	–	50 km/h	30 km/h
28 m	–	–	–	35 km/h
30 m	–	–	–	40 km/h
32 m	–	–	–	50 km/h

To help pedestrians cross at chicanes, footpaths should extend forward to the carriageway/street edge at the start and end of the chicane. The path should have a minimum width of 1.50 m and have lowered kerbs (figure 98).

Where the architectural character of a building facade makes ‘winding chicanes’ an inappropriate design choice, speed humps or raised plateaux can be considered (see section 6.2.1.1).

6.2.2 Traffic calming on through-roads

6.2.2.1 Approach localities

Motorists approaching a locality must reduce their higher inter-urban speeds to the urban speed limit, 50 km/h within the built-up area. The design of the transition from the open road to the beginning of the built-up area must therefore indicate clearly to motorists where they need to adjust their driving to urban conditions. This includes clear signs (place-name sign indicating entry to a locality), where appropriate supplemented by graduated speed limits (reducing in stages to 70 km/h and 50 km/h) and a clearly identifiable start of the built-up area. The place-name sign marks the entry into the locality. It is to be positioned at the start of the built-up area (regardless of the position of the administrative “OD” marker stone).

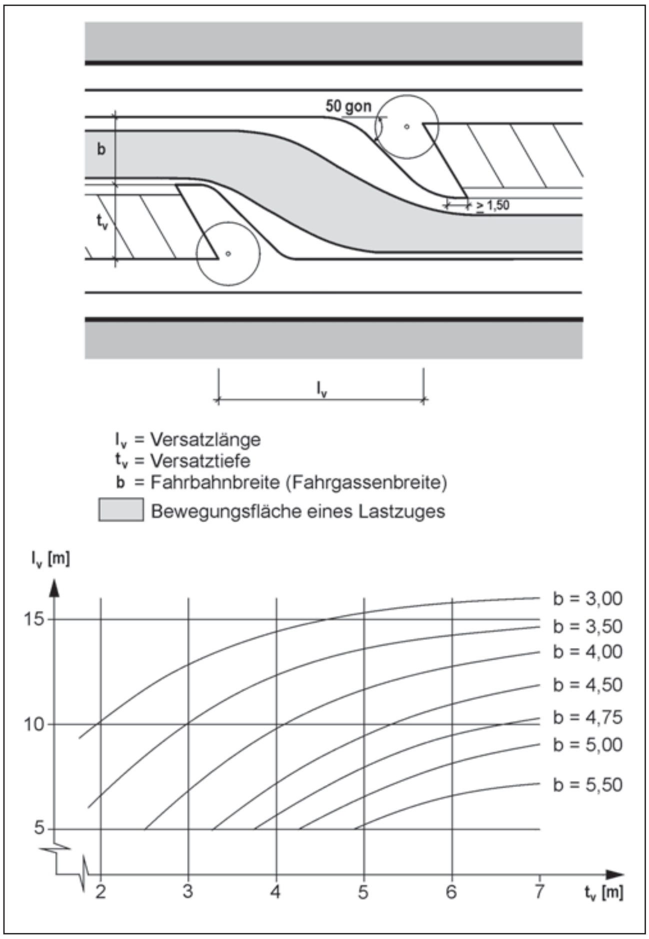


Figure 98: Dimensions of speed-impacting chicanes

Further measures to reduce speed should respond to the existing local situation. Key factors be taken into consideration are, the risk of accidents approaching the urban area and as the road continues through the town (see section 3.4).

In planning the road approaching a locality, crossings of the carriageway will be necessary where pedestrians and cyclists have been located on one side of the road and then within the built-up area there are facilities on both sides. Such traffic calming measures as are used, approaching the locality, must be clearly identifiable.

In order to impose an appropriate reduction in speed at the start of the built-up area, the following options are available:

- Central islands with a chicane on both sides; or
- a small roundabout, provided it can be integrated into the urban context, and if roads feed into the road approaching the locality which make it expedient to install a roundabout.

The best effect is achieved by central islands with a chicane on both sides. The chicane depth must be at least 1.75 m

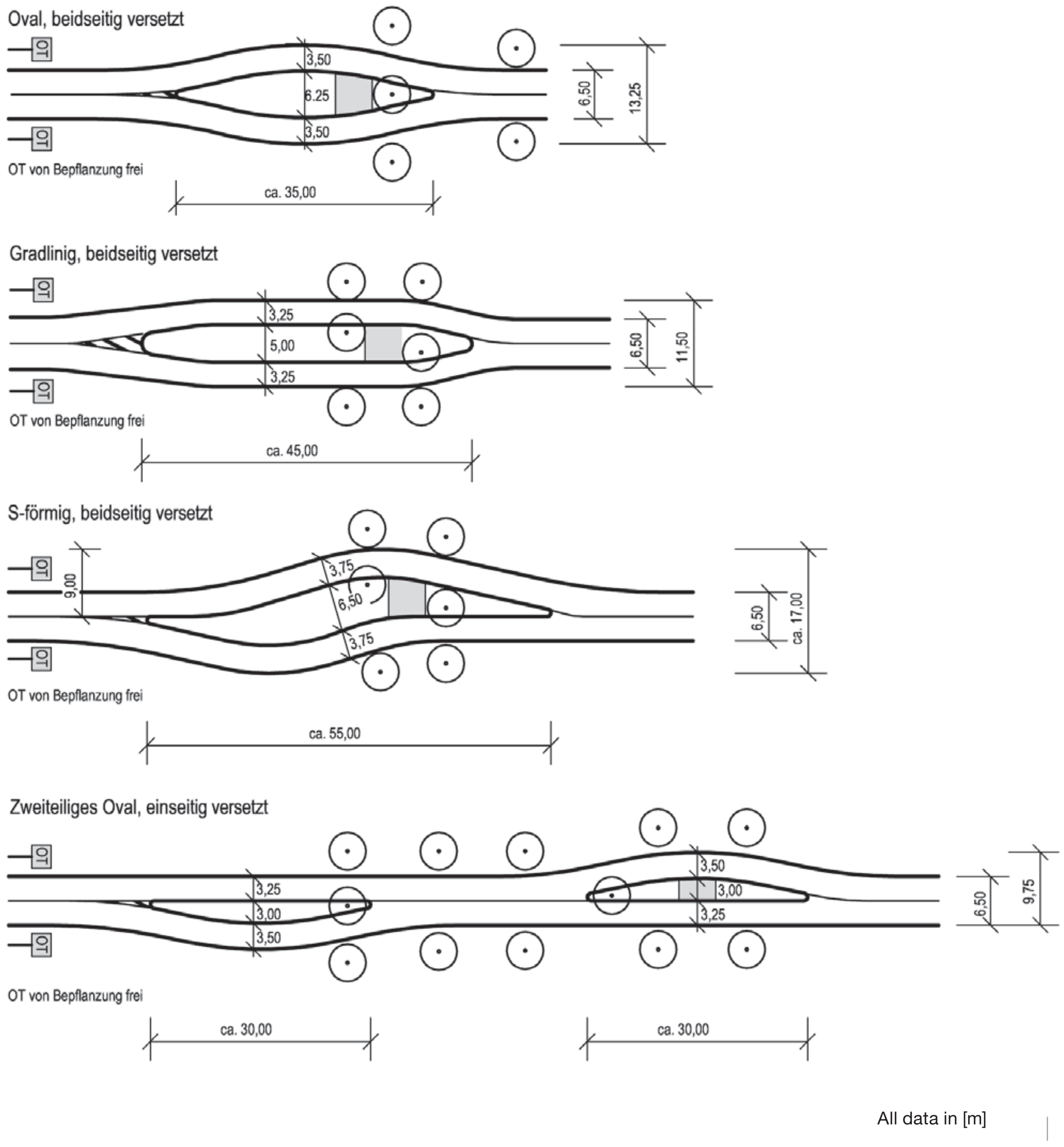


Figure 99: Basic forms of central islands with lane chicanes for traffic calming

on each side, though it is better to design the chicane depth as one lane width, because a speed of 50 km/h or lower can, largely, be guaranteed. The islands at the entry to the locality must therefore – in contrast to being purely crossing aids – be at least 3.50 m wide. The same results can be achieved with a space-saving "S-shaped island". If one of these variants is not possible due to lack of space or for other urban design reasons, two islands in sequence with chicanes on one side can also be considered. Here, too, the chicane depths must be at least 1.75 m. The chicane in the direction of the built-up area must be laid out as the first one, from the driver's point of view (figure 99). The geometric dimensions of central islands with single-lane chicanes must always be checked for negotiability by means of swept-curve analysis.

Single islands with a chicane only on one side affect only one direction and run the risk of vehicles illegally bypassing them on the wrong side of the island. They should therefore only be used in exceptional cases.

Trees on central islands enhance recognition of the island and help in framing the street space. In the case of islands at the approach to a locality, trees are possible towards the rear areas of longer islands (≥ 20 m). The island should be introduced with a speed reduction in steps, where appropriate.

The carriageways in each direction are usually 3.25 to 3.75 m wide (see section 6.1.1.6). Where there is heavy agricultural traffic with wide vehicles, the design must ensure that a 1.00 m overrun strip on the outer edges of the carriageways is kept free of any built structures.

Where trees or frontages close to the road prevent the use of central islands, the carriageway can be narrowed in order to indicate that the road is entering a built-up place. As in the case of road narrowing within the locality, the narrowing must be clearly identifiable. Consideration should be given to the fact that, depending on the dimensions and likelihood of oncoming vehicles meeting, motorists may seek to pass through the narrowing before the oncoming vehicle, and may speed up to do so. A chicane should be used in this case, over a length of 5 to 10 m. Warning signs should not be used within the locality if the narrowing is clearly identifiable.

There are a range of possible variations for routing cycle traffic, approaching a locality, depending on the cycle paths available both within and outside, such as:

- no cycle path outside of the locality and cycle paths on both sides within the locality: Cyclists must be safely taken back onto the carriageway using a marked transition point before the sign indicating the end of the urban area. Cyclists entering the locality are routed onto the cycle path at a suitable point via a lowered kerb.
- cycle path on one side outside of the locality and a cycle path/pedestrian footpath on both sides within. At the entrance to the urban area a crossing-point is made using a central island, which also serves as a traffic calming measure (figure 100). A speed reduction in steps, has proved successful, in these circumstances.
- cycle path on one side outside of the town; no cycle path within the town: Cyclists are routed across a central island, serving at the same time as a speed calming measure, to the cycle path.

For these points to be read as legitimate, they must be designed within an overall urban design context (e.g. forming part of a band of planting at the edge of the town).

Physical measures at the entrance to the locality must be clearly identifiable:

- Islands without crossings should be equipped with low-level (approximately 1 m) illumination.
- Islands that are crossings, as well as narrowing the carriageway, are to be illuminated by lights with lamp-posts of 3.50 to 4.50 m height.

Small roundabouts effectively reduce speeds at the entrance to the locality.

They are only applicable if there is a junction at that location and the physical context permits a roundabout design (see section 6.3.5).

Fixed speed-monitoring systems are particularly suitable as a means of improving road safety quickly and cheaply at accident black-spots and as preventive measures at other critical locations (such as near schools, kindergarten, nursing homes). It may be useful in terms of traffic management and/or urban design to combine them with physical measures.

6.2.2.2 Built-up areas

In order to ensure statutory speed limits on motor vehicles using streets where there are frequent pedestrian crossings and/or specific points of hazard (see section 3.4), design effort should be made to establish the road as a series of 'places' in response to the local context and with traffic calming measures (as a guide at: 100 to 150 m frequencies).

These should be installed at crossing locations, in the form of central islands, central reservations or narrowing points where there are concentrations of pedestrians, for their safety and particularly for older people and children.

At junctions and at locations which have importance in the local context and/or with regard to road safety (such as a market alongside the road), raised carriageways up to 8 to 10 cm with ramp slopes of 1 : 15 are suitable means of cutting speed. The particular concerns of scheduled bus service traffic must be considered. Raised carriageways should generally be executed in asphalt. Exceptions are possible in areas of historic architectural importance (figure 101).

Just because of their generally low frequency of use the safe design of bus stops on cross-town links is particularly important.

Buses stop at the roadside or at kerb build-outs. Bus bays should only be used where very long dwell times are expected, such as at terminals.

Bus stops should be used with long central islands, of approximately 25 m, as they provide for safe crossing

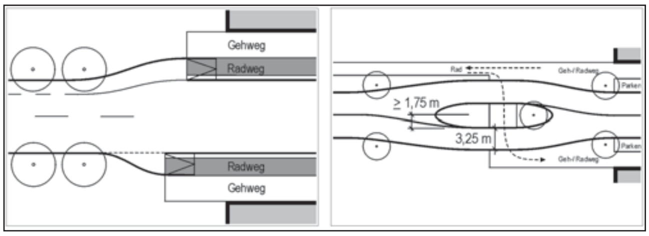


Figure 100: Examples of start/end of cycle path at entrance to locality

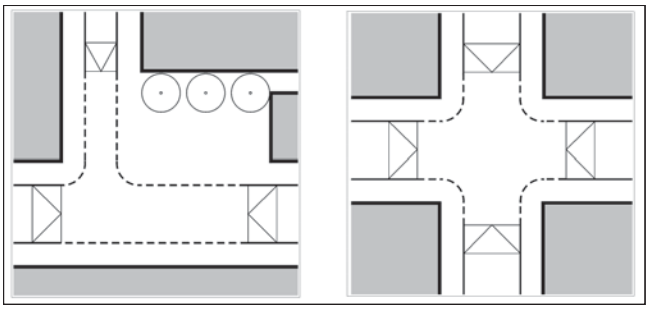


Figure 101: Examples of raised carriageway areas

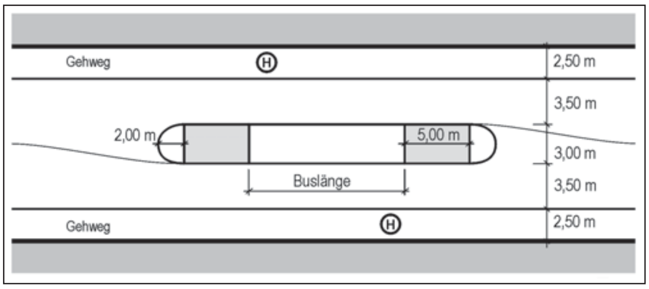


Figure 102: Bus stop with a long central island (draft sketch)

behind the stopped bus: they also prevent dangerous overtaking on two-lane roads (figure 102).

School bus stops, where a number of buses stop at the same time, should be located off the through-road (such as on side streets).

6.2.3 Traffic calming on urban main streets

The enforcement of user-friendly speeds on urban main streets is especially necessary where

- cycling in mixed traffic is to be enabled because separate facilities are not possible (due to confined space);
- there is a need for straight crossings and pedestrians can be given advantage by means of an appropriate street section design (central reservation); or
- hazards give rise to accident (with potentially serious consequences).

Additionally, providing safe routes to school and other special considerations are reasons for calming traffic.

On main streets, the primary means of calming traffic are chicanes with central islands. Where there is a need for a crossing parking lanes/bays on both sides of the road may be removed, along given sections, to create a central island.

By using perpendicular or oblique-angled parking bays, deeper chicanes are possible where asymmetric sections are varied in position along some sections of the street. In this case, the island in the chicane serves not only as an aid to crossing, but is an essential measure to avoid cutting across these chicane areas.

Where such built measures are not feasible due to lack of space or for other reasons, such as in relation to architectural/design considerations, the use of fixed speed monitoring systems should be investigated.

In traffic-calmed shopping areas where the speed limit is 30 km/h and lower, measures which are commonly applied on local streets (speed humps, raised plateaux) are suitable. With regard to geometry and use see section 6.2.1.1.

6.3 Junctions

6.3.1 Generally:

Junctions must

- be identifiable in good time from all approaches;
- be clearly understandable, to make all road users aware of the priorities, potential conflicts with other road users, and any filtering and turning options available;
- be clearly laid-out so that all waiting traffic is able to see the traffic with right-of-way in good time on approaching a hazard point;
- be easy and safe for pedestrian and vehicular traffic.

The number of lanes in the junction depends on the requirements arising from the adjoining open stretches of road, the turning traffic volumes, the desired quality of traffic flows, and specific requirements of pedestrians, cycle traffic, public transport and the surrounding environment.

The number of through-lanes in the junction should usually remain unchanged from the open stretch of road, especially at junctions without traffic light controls. A through-lane should not suddenly change into a turning lane approaching a junction.

If, in exceptional cases, a through-lane changes into a turning lane, special attention must be given to providing early and unambiguous road marking in conjunction with the relevant signs.

Additional through-lanes may be useful at junctions with traffic lights in order to align the quality of traffic flow to the quality of the adjoining open stretches of road.

Unless defined by kerbs and hatched areas, through-lanes in the area of the junction should be as wide as the lanes on the adjoining stretches of road. Where space is tight, they may be 0.25 m narrower. In the case of multi-lane roads approaching a junction, in a 50 km/h limit, the lane width may be reduced to 3.00 m where necessary; in exceptional cases the inside lanes may be reduced to 2.75 m, if this is the only way that turning lanes can be created. The turning lanes may be 0.25 m narrower than the through-lanes, but must not be less than 2.75 m – or where scheduled bus services run, not less than 3.00 m.

6.3.2 Junctions/crossings with the right-before-left rule

The “right-before-left” principle should be considered primarily for use at junctions and crossings between equally-ranked local streets which are usually in 30 km/h zones. For roads with regular bus services, application of the right-before-left rule can only be considered in exceptional cases (see also section 5.3.2).

These junctions must be readily identifiable and their rights of way clearly understandable. Highway elements such as continuous gutters along one of the streets, which may raise doubts about equal priorities, should be avoided. Also, adequate visibility must be ensured, and the design of the streets approaching the junction should be uniform. The right-before-left rule can be highlighted by (leftward) chicanes in the street or by raised junction paving. This is necessary in all cases where local streets of different ranking – that is to say, with different traffic volumes or development characteristics – use the right-before-left rule.

For pedestrians, crossing must be provided in a barrier-free style even at junctions applying the right-before-left rule. This can be done either by lowering the kerbs to 3 cm, or by corresponding raising of the carriageway using a paved table, this enhances visibility and leads to slower driving at the junction.

6.3.3 Junctions and crossings with priority-control signs

Junctions and crossings with priority control signs are normally used at junctions of streets of different importance and at junctions on two-lane main arterial roads with access roads. The engineering differs in the method of routing left-turning traffic.

Whether queuing areas or left-turn lanes are necessary depends on the volume of exiting traffic and the volume of the flow from which traffic is turning. Their provision should be balanced against the area available and should normally be used only on main roads.

There are three basic methods of routing left-turning traffic on main roads (figure 103).

The appropriate application can be derived from the volume of the main traffic flow and of left-turning traffic (table 44). A queuing zone or left-turn lane may, however, also be necessary for road safety reasons, regardless of the traffic load, if, for example, speeds above 50 km/h occur.

Left-turn lanes are composed of the offset zone lz and the queuing zone lA.

At junctions on built-up main roads, shorter offset zones lz of 10 to 20 m are usually sufficient. On open main roads, the length of the offset zone depends on the speed limit in operation and on the widening (see section 6.1.4.3).

In the case of an enclosed lead-up to a left-turn lane, the offset is measured from the point where the carriageway has widened by 1.50 m, with the offset length l_{Z1}. It is to be a maximum of 30 m long ($l_Z - \mathrm{ln} \geq l_{Z1} \leq 30$ m).

If the left-turn lane develops out of a central lane or a central island, it may be useful in design terms to have the left-turn lane begin abruptly.

The length of the queuing zone lA begins at the stop/give-way line. The demand can be calculated from the volumes of the affected traffic flows (see HBS). Without specific verification, table 45 applies.

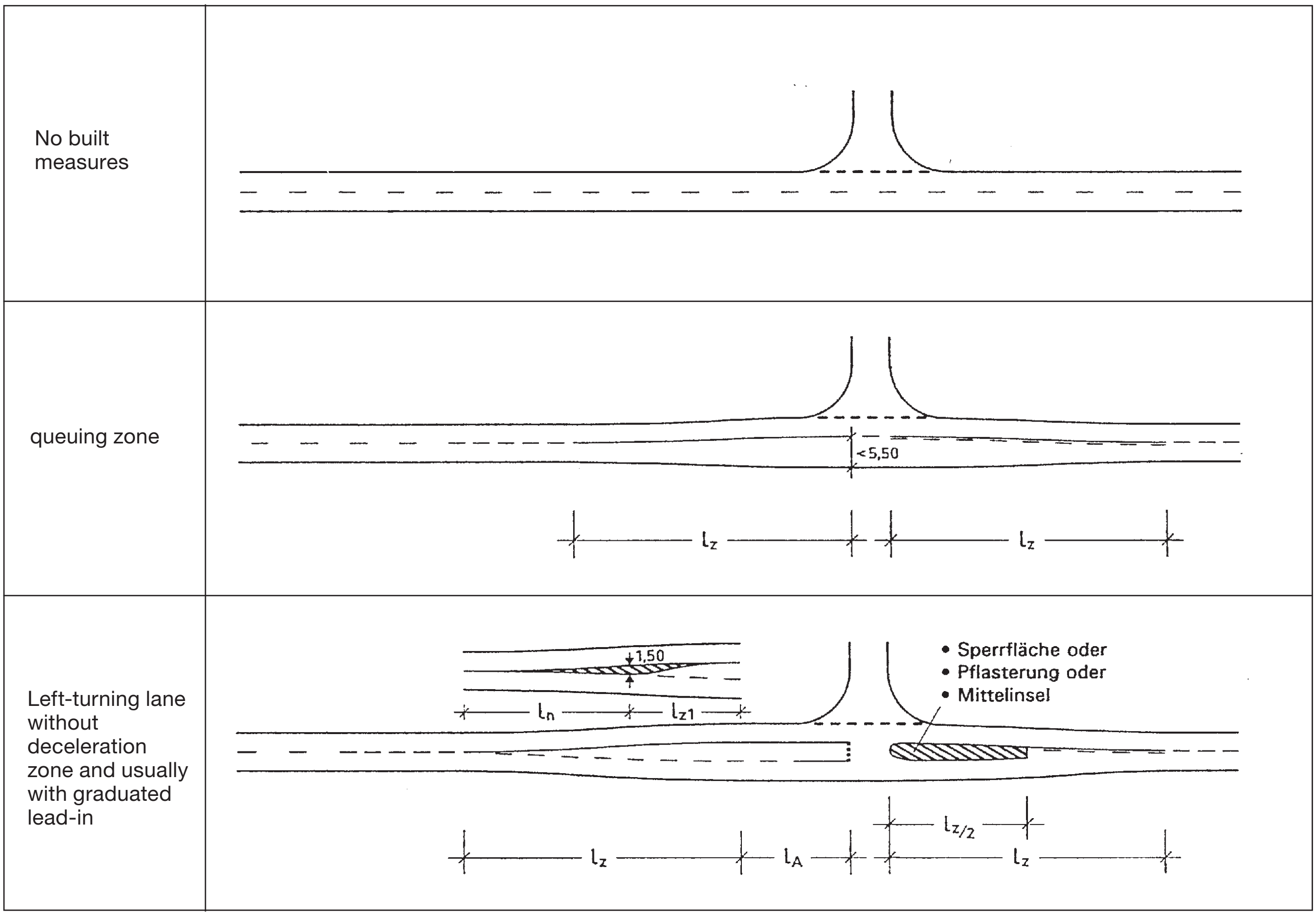
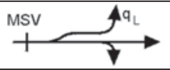


Figure 103: Methods of routing left-turning traffic on main roads

Table 44: Application matrix for left-turn lanes and queuing zones on two-lane carriageways and on carriageways with intermediate widths

	Volume of left-turning traffic q_L (veh/h)	Main traffic flow volume MSV [veh/h] 						
		100	200	300	400	500	600	> 600
Built-up main road	> 50	□	□	□	□	▨	■	■
	20 … 50	□	□	□	□	▨	▨	▨
	< 20	□	□	□	□	□	□	□
Open main road	> 50	▨	▨	■	■	■	■	■
	20 … 50	▨	▨	▨	▨	▨	▨	■
	< 20	□	□	□	□	□	□	▨

□ No built measures ▨ Queuing zone ■ Left-turn lane

Table 45: Queuing zone IA (congestion zone)

Application	Length
Standard measure	20.00 m
Minimum	10.00 m

The width of left-turn lanes and queuing zones may vary depending on the available space (table 46).

Table 46: Left-turn lanes and queuing zones dependent on available space

Element	Width
queuing zone	< 5.50 m (≥ 4.75 m)**)
Left-turn lane*)	≥ 3.00 m (≥ 2.75 m)**)

*) Maximum 0.25 m narrower than through-lane
**) With restricted space

6.3.3.1 Management of pedestrian traffic

At junctions and crossings, pedestrians should be taken across approach roads without diverting to where vehicle traffic is required to wait. If raised block-paved areas are used, they should be installed where pedestrians walk.

Pedestrians' facilities, crossing priority roads, are described in section 6.1.8.

6.3.3.2 Managing cycle

The management of cycle traffic across side roads, where vehicle traffic is required to wait, depends on the kind of cycle traffic provision on the priority road; priority for the cyclist is usually given. Left-turning cyclists can usually be routed directly.

Cyclists' facilities, crossing priority roads, are described in section 6.1.9.

6.3.4 Junctions/crossings with traffic lights

Junctions and crossings with traffic lights are used at junctions connecting local streets onto main roads and at junctions of main roads.

The number and length of queuing lanes for **motor vehicles** is derived from the traffic signalling assessment as well as the safety considerations according to the RiLSA directives.

Usually the queuing zone 1A should be designed long enough, or the signal programme modified, so that vehicles approaching in one cycle can be accommodated. The length l of the number of lanes continuing-on from the junction exit depends on local conditions, on the utilisation of the queuing lanes and on the duration of the green phase for the relevant vehicle flows. As a guide value, l [m] = 3.0 x t_{gr} [s] can be assumed. The minimum length is 50 m.

6.3.4.1 Guidance and signalling of pedestrian traffic

When designing a junction, particularly when selecting the appropriate cross-section of the traffic-lanes, the layout of central islands and the location and size of the queuing areas, the aim should be to mark the pedestrian crossings without diversion and, as far as possible, in a straight line. So as far as possible, a pedestrian crossing, in a direct line with footpath links should be provided as a matter of policy at each arm of the junction.

With regard to signalling of the crossings, refer to the RiLSA directives.

Where crossing points are sited, guttering should be at the same level as the carriageway and kerbs should be lowered. A kerb reduced to 3 cm height is a good compromise between the requirements of visually impaired persons (tactile aids), wheelchair users and the management of surface water. In order to meet the various needs of people with impaired mobility, such as those who have difficulty walking and use a rollator and visually impaired persons, a combination of various kerb heights supplemented by visual and tactile aids is suitable, as shown in figure 104, derived from DIN 18030[48].

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[48] DIN 18030: Barrier-free construction – planning bases; draft standard 2006-01, German Standardisation Institute, Berlin 2006.

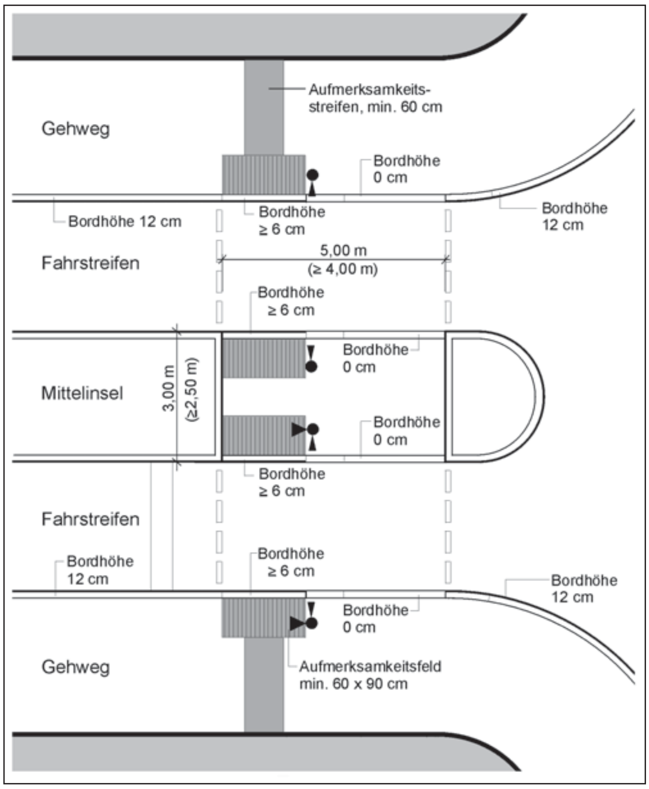

Figure 104: Example of aligned crossings with differing kerb heights

Central islands can provide aligned crossings. These islands are necessary on wide junctions where sections of the crossing, for pedestrians and cyclists, are controlled in different phases. In such cases the crossings should be at least 4.00 m wide and the islands at least 2.50 m – usually 3.00 m – wide (figure 104). For safety reasons, however, aligned crossings with differing green phases should be avoided, as it is difficult to prevent pedestrians from disobeying stop signs on individual sections of a multi-section crossing.

6.3.4.2 Routing and signalling for cyclists

Designing for cyclists at signalled junctions depends on the lane layout, the motor traffic volume and the local traffic conditions, as well as on how the cyclists can be routed before and after the junction, and on the crossing/inflowing road and for turning left, and also depends on the main travel links for cyclists.

For **cycle traffic** using cycle paths or in cycle lanes, crossing markings should be laid-out at traffic lights. The marking consists of two solid lines 0.50 m wide, with a 0.25 m gap length. Cycle crossings are usually 2.00 m wide, and at least as wide as the adjoining cycle facilities.

To enable crossing the arms of junction, **cycle paths alongside roads** and cycle lanes are not-set back (see section 5.4).

It may be advisable to use advisory lanes for cyclists on the approach to a junction if the cyclists on the open stretch of road are in normal mixed traffic. Advisory lanes can then provide cyclists with room to pass and when moving off. Widened queuing zones help cyclists turning left or continuing straight-ahead by placing them ahead of the queuing motor vehicle traffic and so within their field of view. The signalling for them is shared with the motor vehicle traffic.

For **cyclists** making **an indirect left turn**, a queuing area can be marked out at the end of the cycle crossing on the carriageway, to the right (or left) of the crossing, the function of which can be indicated by special signs.

Indirect left-turns can also be routed by bypassing cycle paths using set-back crossing areas.

The different possibilities for cyclists turning left at signalled junctions are set out in table 47.

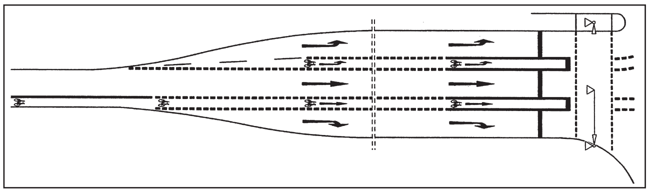

Figure 105: Example of the layout of cycle lanes at a junction with traffic lights

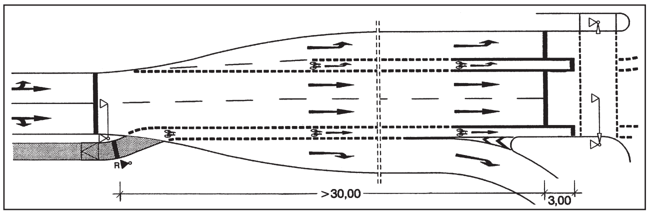

Figure 106: Example of a cycle cross-over

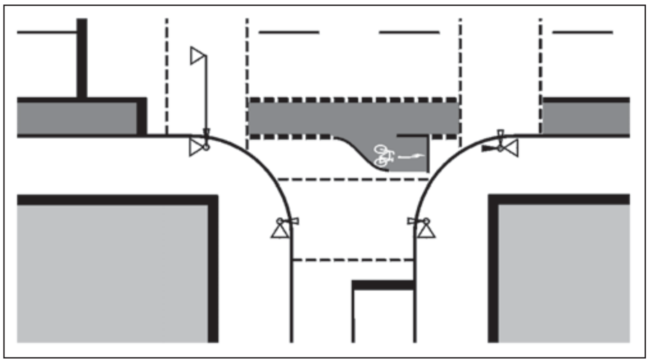

Figure 107: Example of a cycle lane at a junction with traffic lights and with an indirect route for cyclists' left-turns

Table 47: Route options for left-turning cyclists at signalled junctions

Cycle traffic route-option*)	Preconditions/applications	Marking	Signalling
Direct routing, with rider's choice of lane positioning and lane changing (figure 105)	No more than two lanes to cross Motor vehicle speed $V_{85} \leq 50$ km/h in motor vehicle traffic	The cycle lanes in the narrower junction zone are marked out as cycle crossings, i.e. by wide lines (0.25 m) with 0.50 m line and 0.20 m gap At junctions with traffic lights, queuing lanes for cyclists should wherever possible extend 3.00 m beyond the motor vehicle stop line (figures 105 and 106)	Signalling with the motor vehicle traffic
Direct routing with a cycle cross-over from cycle-path (figure 106)	The above values are exceeded Segregated cycle path along road rejoins road before junction, completely or partially (e.g. only for left-turning traffic) into cycle lane		Separate signalling for cyclists routed for onward travel from the cycle path alongside roads onto the carriageway (e.g. left-turning traffic); from there signalling along with the motor vehicle traffic
Indirect routing (figure 107)	Large proportion of unconfident and vulnerable cyclists Queuing areas for left-turning cyclists should be located so as not to hinder the straight-ahead cycle traffic (to the right or left of the cycle crossing) Also applicable in the case of a cycle path alongside road		Signalling to enter the waiting area, then according to the selected type of crossing (i.e. with motor vehicles, with pedestrians, or independently); for the second crossing – shared signalling with the pedestrians or separate cycle traffic signalling is possible

*) It is often sufficient to install a cycle lane in the junction only for left-turning cyclists

Table 48: Signalling of cycle traffic at junctions

Type of signalling	Conditions of use
Shared signalling with the motor vehicle traffic	• In mixed-traffic, on the carriageway • for cyclists using the carriageway, without mandatory usage of the footway • In the case of advisory lanes on the carriageway. • In the case of mandatory cycle lane on the carriageway or cycle paths on the side space with straight-over cycle crossings
Shared signalling with the pedestrian traffic	• On shared footways and cycle paths, on footpaths where cycling is allowed and, where appropriate, on cycle paths with no mandatory use. • In case of cycle path bordering a pedestrian crossing, if no separate signalling is provided
Separate signalling for cyclists	• At large-scale traffic junctions with long clearance zones for cyclists • For cyclists standard clearance times, or special phases, e.g. to separate the straight-ahead cycle traffic from intensive right-turning motor traffic, or on-demand phases are provided • In the case of cycle paths which are set-back by some distance • Cyclists should be enabled to cross over islands without stopping

Methods of signalling for cycle traffic[49]

There are three basic methods of signalling for cycle traffic (table 48):

- shared signalling with the pedestrian traffic;
- shared signalling with the motor traffic; and
- separate signalling for cyclists.

In the case of shared signalling with pedestrian traffic, no separate stop lines for cycle traffic are marked out.

Where there is separate signalling, and due to the generally incompatible situation where lights turn green for both driver and cyclist, they are given an advanced green signal, or a physically advanced stop-line, to gain a head start and avoid conflict with turning vehicles.

In the case of signalling along with the motor vehicle traffic, offsetting of the stop lines for the cyclist ahead of those of the motor vehicle traffic, or widened queuing areas, should be implemented to ensure that cyclists are within the motorists' field of view when the go-signal is given.

If the cyclist is in mixed-mode traffic when approaching a junction, using an advisory lane or in a bus lane with no separate bus signals, the signalling is always shared with the motor vehicle traffic. When using bus lanes with bus signals, separate signalling is provided for cyclists.

The following points should be noted when laying out crossings:

- Waiting areas for pedestrians and cyclists must be of adequate size (approximately 2 m² per cyclist).
- Visibility requirement must be kept clear.

Kerbs on cycle crossings should as close as possible to 0 cm.

If, in exceptional cases, at traffic light-controlled junctions inside towns, triangular islands are arranged with free-flowing right-turning traffic, for reasons such as the geometry of the junction, it is useful to implement direct pedestrian and cycle traffic on the higher-priority road. In the case of major curves, this also applies to the lower-priority road.

Where two-way cycle paths or small triangular islands are installed, off-line implementation may be necessary, this must be supported by additional signage and, if necessary, measures such as raised areas of paving.

6.3.4.3 Routing of public transport

Traffic signal control programmes offer extensive options for prioritising public transport: phase switching; on-demand phase changing; go-time adjustment; stop-time shortening ahead of the other traffic, etc. Full traffic-actuated signal systems allow extensive prioritisation of public transport vehicles, though they are costly.

It is often advisable to install partial public transport lanes in conjunction with such prioritisation of public transport vehicles (table 49).

Partial public transport lanes are used at junction approaches

- to bypass congestion;
- establish directional conformity; or
- to simplify entry and exit at stops.

A bus-stop bay extended to the stop line at the near-side of the carriageway or a stop in the middle of the road with an island can also be regarded as a (partial) public transport lane.

If there is no clear lane for public transport (such as where there are public transport lanes in the middle of the road and other motor traffic is turning left), then mixed-use of the public transport lane/tracks may, at low journey frequencies, also be considered. For this to be acceptable the green phase for the oncoming traffic must allow left-turning traffic to clear the junction when a public transport vehicle is approaching.

6.3.5 Roundabouts

6.3.5.1 Design principles and definition of elements

Roundabouts have a high safety level if these basic principles are followed:

Table 49: Partial public transport lanes in conjunction with traffic lights

Partial public transport lane	Controls
Ends before junction (bus filter) and goes into private motor traffic queuing space	Additional signals hold back the private motor traffic while the public transport vehicle can enter the empty queuing space
Ends shortly before junction and goes into queuing space for private motor traffic	Public transport vehicle can approach the traffic lights so closely that it can turn off in the same phase as the waiting private motor traffic
Ends at junction	Public transport vehicle can cross junction straight ahead (simple early green-phase is adequate) and when turning (dedicated public transport phase required)
Ends after junction	Public transport vehicle crosses junction straight-ahead, no additional controls required

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[49] For details refer to the "Instructions for signalling of cycle traffic" (H SRa), Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2005.

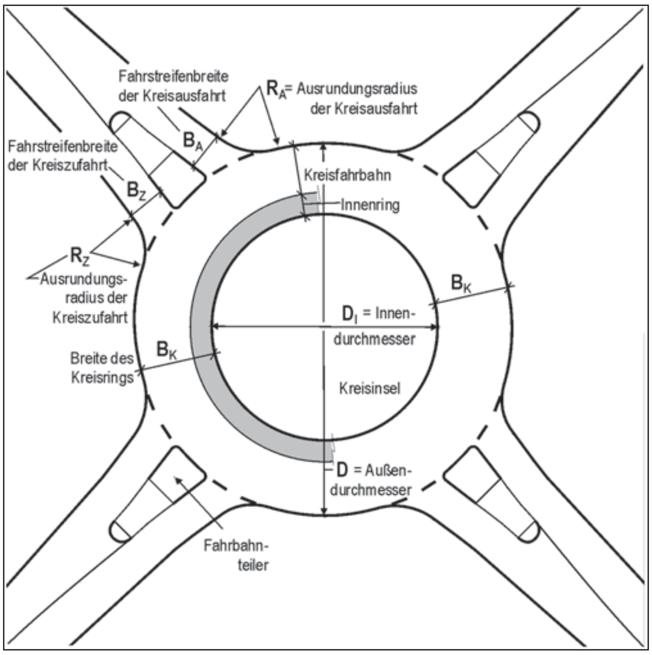


Figure 108: Definition of individual design elements and dimensions of a roundabout (diagrammatic sketch)

– as far as possible roads feeding-in should have a right-angle approach;

– a significant diversion, for vehicles travelling straight-ahead, around the central island;

– single-lane junction exit roads.

The design elements and dimensional designations of a roundabout are presented in figure 108.

6.3.5.2 Outer diameter

The outer diameter is set-out in table 50. For small roundabouts, the outer diameter must be at least 26 m if the central island is not to be driven over. Outer diameters greater than 40 m should be avoided.

On mini-roundabouts, the outer diameter should be at least 13 m, so that the central island is not too small. Larger outer diameters aid their negotiability for heavy traffic.

Table 50: Outer diameter ‘D’ of Roundabouts

Application constraints	Mini-roundabout	Small roundaboud
Minimum	13 m	26 m
Standard value	–	30 m – 35 m
Upper limit	22 m	40 m

On roundabouts with two lanes the outer diameter must be, for geometric reasons alone, a minimum of 40 m.

6.3.5.3 Roundabout, carriageway, central island

The carriageway should, for road safety reasons, be circular. Any variations can only be for compelling physical reasons; a roundabout may also be designed as two semi-circles of the same radius, linked by straight segments. The length of the straights should be greater than the radius of the semi-circles.

The width of the circular carriageway depends on the outer diameter (table 51).

Table 51: Relationship between outer diameter D and width of circular carriageway BK

Element	Mini-roundabout	Small roundabout			
Outer diameter D	13 m – 22 m	26 m	30 m	35 m	≥ 40 m
Carriage-way width BK	4.00 m – 5.00 m	9.00 m	8.00 m	7.00 m	6.50 m

The proportions of the roundabout, considering the circular carriageway to the central island, should have a minimum ratio of approximately 3 : 1. This is particularly necessary for the safety of cyclists if they are using the roundabout, and enhances the traffic calming effect based on the increased deflection of the driver’s desire line.

The central island should be designed with a transverse camber of 2.5 % or towards the outside of the circular carriageway. It should be clearly segregated from the carriageway with a kerb of 4 to 5 cm height, preventing cars from crossing it. It may be necessary to omit the kerb, for operational reasons, in which case the central island should be finished with a coarse texture. The central island, in traffic law, does not form part of the carriageway (administrative order VwV-StVO road traffic regulation § 9a StVO, clause V). It is segregated from the circular carriageway by marking a broad line (sign 295 StVO).

On mini-roundabouts a suitable width for the circular carriageway is 4.00 to 5.00 m.

The circular carriageway should have an outward transverse camber of 2.5 %. The camber should not exceed 6 % at any point. Checking the drainage using contour plans has proved a valuable tool in the design process.

6.3.5.4 Roundabout, entrances and exits

To make sure that the roundabout entrances and exits are as perpendicular as possible, the centre point of the roundabout should align with the intersection of the axes of the junction arms. Tangential or acute-angled junction entrances should be avoided for road safety reasons.

The junction exits should lead away from the roundabout at the widest possible angle. Tangential junction-exits are to be avoided if they are crossed by pedestrians or cyclists.

Roundabout exits should always be single-lane.

The lane widths of junction entrances and exits adjacent to the splitter island are indicated by table 52.

Table 52: Lane width of roundabout entrances and exits

Lane widths	Mini-roundabout	Small roundabout
Approach B_Z	3.25 m – 3.75 m	
Exit B_A	3.50 m – 4.00 m	

The arms of the junction connect to the roundabout using corners with the smallest possible radius which are usually designed as simple arcs. The layout of the road edge can also be designed using tractrix curves.

Corner radii sizes are specified in table 53. The geometry of the entry and exit areas of roundabouts must always be checked for negotiability using dynamic swept-curve programmes.

Table 53: Corner radii

Corner	Mini-roundabout	Small roundabout
Approach $\mathbf{R_Z}$	8 m – 10 m	10 m – 14 m
Exit $\mathbf{R_A}$	8 m – 10 m	12 m – 16 m

6.3.5.5 Roundabout Bypass for traffic turning right

By using a bypass, for traffic turning right outside the roundabout, capacity can be increased. The geometry of the junction may make this into a convenient option.

The safety issues of a bypass relate to the impact on pedestrians and cyclists (see also ERA). With regard to road safety, and in terms of urban design, the comments relating to triangular islands also apply (section 6.3.7.3).

Bypasses are to be physically separated from lanes on the roundabout and not just by lane delineation (sign 295 StVO). Where pedestrians and cyclists have to cross such a bypass, waiting areas should be provided, as in the case of a central reservation.

6.3.5.6 Splitter islands

On small Roundabouts and Roundabouts with two-lane circular carriageways, splitter islands should be a normal provision.

Splitter islands may be omitted only on minor junction arms or where a raised, paved area is installed. Splitter islands are also useful on mini-roundabouts.

Where space is tight, and to ensure access for heavy trucks, the use of splitter islands which are overrun-able, paint-only or slightly set-back may be considered.

The splitter islands should be designed so that their axis runs, as near as possible, perpendicular to the edge of the roundabout. They should have a minimum width of 1.60 m. For pedestrians and cyclists to use the islands as crossings a depth of at least 2.00 m for pedestrians and 2.50 m for cyclists is usually required. It should be at least 4.00 m long. It is necessary to check whether motor vehicles, travelling straight ahead and past the central island, are deflected adequately.

Central reservations with parallel edges are often useful within built-up areas. The edges of splitter islands should follow the carriageway edge in the immediate vicinity of the junction.

The edges of splitter islands should be defined by chamfered kerbs or other elements at an oblique angle.

6.3.5.7 Roundabout, central island

The central island is the key functional and design element of a roundabout.

The central island should create an adequate change of a driver's course to impose the lowest possible speeds on the roundabout. This deflection, of motor vehicles travelling straight-ahead across the central island, and where appropriate across the inner ring, should not be less than twice the lane width of the junction approach (figure 109).

On mini-roundabouts the central island helps drivers both to recognise the roundabout and to deflect vehicles. It should be built so that it cannot be crossed without significant problems by cars, or only rarely, and for trucks and buses can only be crossed at low speed.

The diameter (Di) of the central island on mini-roundabouts should be at least 4 m. It may be made of different materials, paving, asphalt and concrete structures have proved effective.

On mini-roundabouts, the central island should be enclosed by a kerb approximately 4 to 5 cm high which raises the central island markedly from the asphalt carriageway of the roundabout. The central island should also be marked with lane boundary markings: sign 295 StVO.

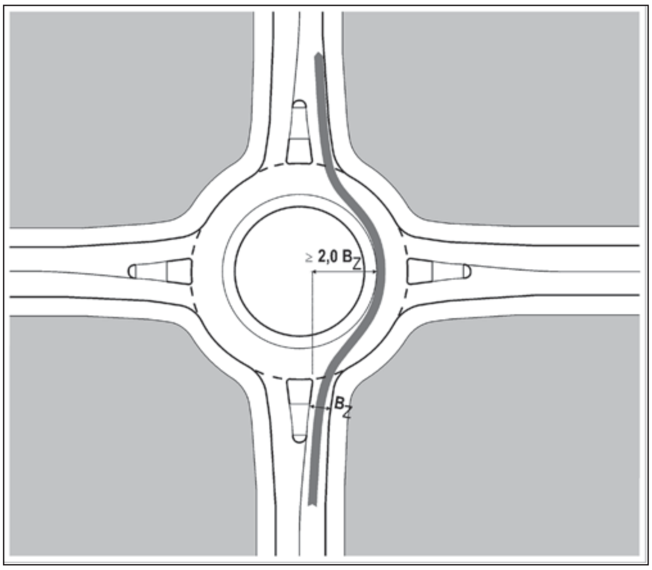


Figure 109: Deflection of motor vehicles travelling straight-ahead across the central island and where appropriate across the inner ring

6.3.5.8 Provision for pedestrians at roundabouts

In built-up areas, splitter islands with crossing facilities for pedestrians should be provided, at all arms of a junction. The following points should be noted:

- Crossing points close to the roundabout and usually set back not more than about 4.00 to 5.00 m, measured along the axis of the splitter island.
- Maximum setback of 7.00 to 8.00 m only where there is a similarly set-back cycle route in front of it.
- Crossing points designed as pedestrian crossings and where appropriate, with tactile paving for visually impaired pedestrians.

- Clear visibility for motorists of the pedestrian waiting at the roadside and on the splitter island.
- If the junction arm is narrow and with a light traffic load, or where there are raised crossovers, splitter islands can be omitted.
- Raised, paved crossovers can enhance the traffic calming effect.

Where particular pedestrian and cycle traffic flows – such as on school routes – need increased protection in crossing a junction arm, a signalled crossing may be considered, clearly set back from the roundabout. The distance by which it is set back depends primarily on visibility criteria, legibility, as well as avoiding traffic backing-up onto the roundabout.

6.3.5.9 Cycling at roundabouts

In principle two basic solutions apply:

- routing cycle traffic on the roundabout;
- routing of cycle traffic around, on cycle paths.

Cycle lanes must not be installed on the roundabout, either mandatory or advisory, for safety reasons.

How cycling is provided for on the arms of the junction and on the roundabout itself does not have to be the same.

On small single-lane roundabouts, cycling on the carriageway is a safe solution up to a traffic volume of 1,500 vehicles per hour (total flow on all incoming roads). At higher volumes, consideration should be given to whether it is reasonable to allow cyclists to share the footway or, to install cycle paths. In this case a safe transition should be made, between carriageway and footway, on junction approaches and exits.

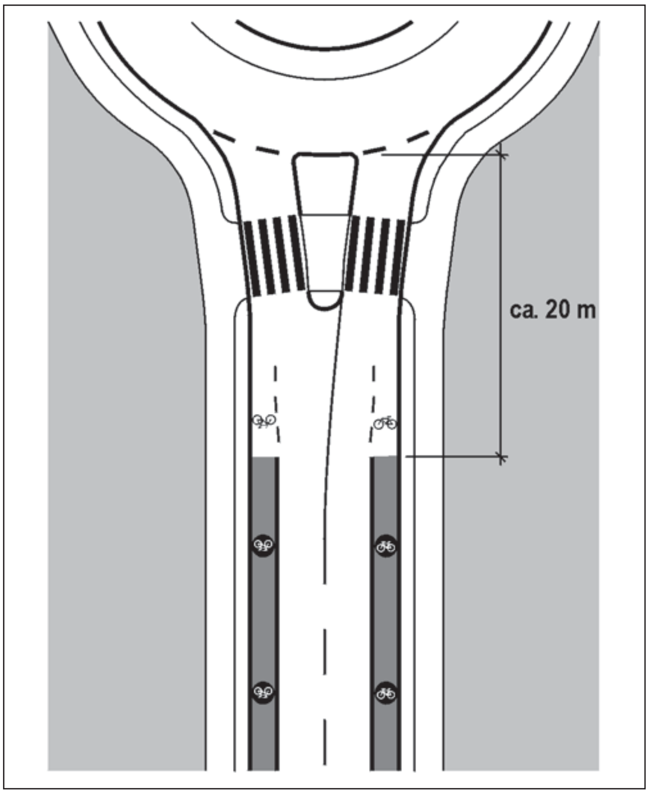


Figure 110: Arrangement of cycle lanes at a roundabout in a built-up area

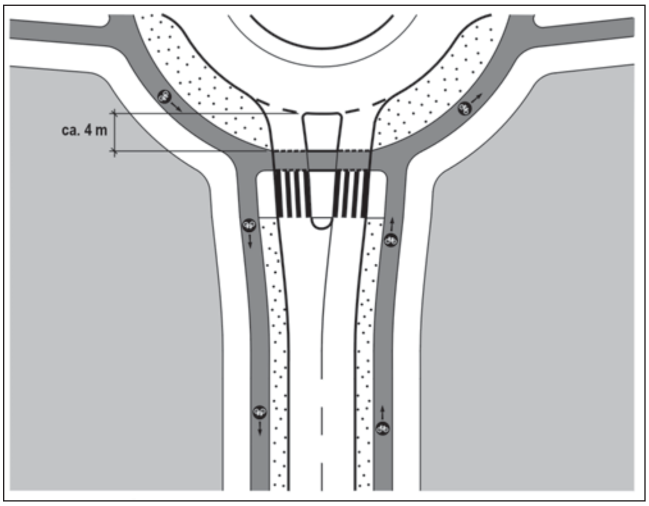


Figure 111: Arrangement of cycle paths alongside the road, at a roundabout, in a built-up area

A central island which has a kerb (see section 6.3.5.3) ensures that motor vehicles on the roundabout are largely prevented from overtaking cyclists. The roadway beside the splitter islands should be as narrow as possible, so that overtaking a cyclist, immediately before or after the roundabout, is impossible for trucks and difficult for cars.

If cyclists are to be routed from a mandatory lane, approaching the junction onto the roundabout, the following points should be noted:

- Mandatory cycle lanes should end approximately 20 m before the roundabout and be continued as short advisory lanes, in order to prevent motor vehicles and cyclists from travelling alongside each other adjacent to the splitter island (figure 110). On the roundabout exits, mandatory cycle lanes begin approximately 10 m after the splitter island.
- Cycle paths alongside the road are brought onto the carriageway as far back as the junction approaches. This requires a protected end to the cycle path, followed by a short advisory cycle lane.
- If there are cycle paths before the roundabout, and which continue after, consideration should be given to how reasonable it would be to allow cyclists to share the footway (sign 239 StVO with additional sign 1022-10 StVO).

On a roundabout with two-lane traffic, it is not acceptable to route cyclists on the carriageway.

On mini-roundabouts, it is normal for cyclists to use the carriageway.

Where a number of the roads approaching a junction have cycle paths, continuing the cycle paths around the periphery of the roundabout is a safe solution, accepted by the overwhelming majority of cyclists. In terms of road safety the disadvantage is the number of cyclists frequently travelling in the wrong direction.

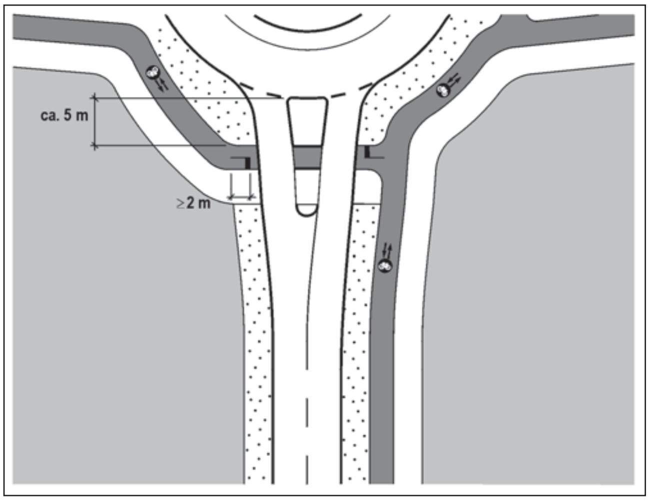


Figure 112: Arrangement of two-way cycle paths (without priority) approaching built-up areas

Only in very exceptional cases is installing cycle paths around mini-roundabouts, an option.

Cycle paths should run approximately 4.00 m from the edge of the roundabout and be adjacent to pedestrian crossings. They are usually given priority over the road approaches to the roundabout (figure 111). If pedestrians are given priority with sign 293 StVO ("Pedestrians crossing"), cyclists must also be given priority. The path should not be less than 2 m from the roundabout, for safety reasons, nor greater than 5 m.

On two-lane roundabout approaches cyclists must give-way, though two-lane roundabout approaches should be avoided where there are significant cyclist volumes.

Two-way cycle paths at roundabouts must be made particularly clear by signs, directional arrows and by the construction of the cycle path itself. If cyclists are to be given priority, motorists must be clearly advised of this situation with additional sign 1000-32 ("Cyclists crossing from right and left") to sign 205 StVO ("Give way!"). If necessary pictograms must be supplemented with arrows on the cyclist's crossing. To improve road safety a raised crossover or coloured highlighting may be appropriate at the junction arm in question.

If cyclists are on a two-way cycle path approaching a roundabout at the beginning of a built-up area (such as passing through retail areas/industrial estates), motor traffic should be made to give way for road safety reasons. Crossings should be set back 5.00 m from the roundabout and the cycle path should approach the carriageway edge at a right-angle, for at least 2.00 m (figure 112).

6.3.5.10 Public transport at Roundabouts

Roundabouts of standard dimensions are generally acceptable in use for normal scheduled services. With regard to the suitability of roundabouts see section 5.3.2. The need for a built inner-island should be investigated where there is a regular scheduled bus service, taking into consideration the position of the cyclist at the roundabout (see section 6.3.5.3).

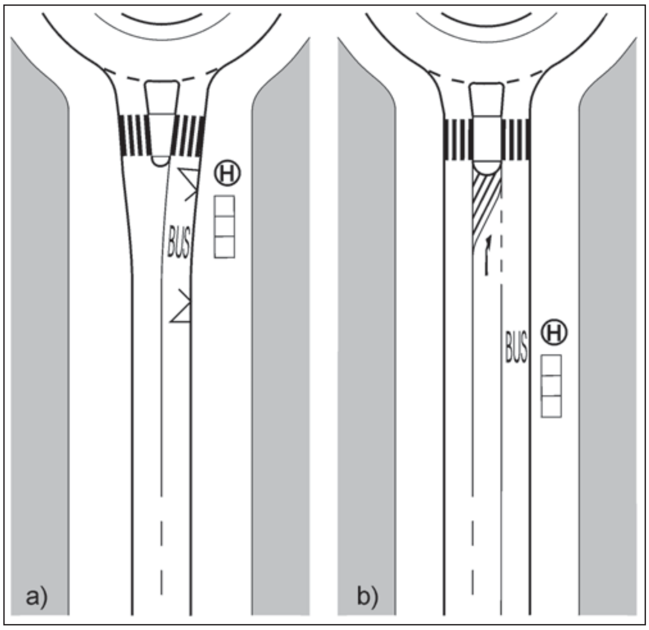


Figure 113: Stop location and lane configuration at the roundabout
a) Stop at the kerb (or kerb build-out)
b) Stop with passing lane for motor traffic before merging into the bus lane

The bus lane should usually be merged with the motor vehicle lane before the roundabout, in order to avoid a two-lane junction approach (figure 113 b).

Stops for scheduled bus services can be either immediately before or after the roundabout.

When positioned before the roundabout, on single-lane roundabout approaches, stops are possible at the roadside, on bus lane or in bus bays (figure 113).

To protect passengers entering and exiting, it makes sense for the stop to be close to the crossing over the splitter island.

When positioned immediately after the roundabout, a bus bay is usually required, otherwise the roundabout would become congested on a regular basis.

The routing of **trams** across the centre of the roundabout requires a demand-controlled signal system blocking off all roundabout approaches (the standard solution) or on the circular carriageway.

It is not permissible to route trams across mini-roundabouts.

6.3.5.11 Large signalled roundabouts

Large roundabouts should be designed with traffic lights for road safety reasons.

Their capacity depends on the overall geometry, the distribution of the traffic flows and therefore on possible signal programme control strategies. The capacity of the overall installation is derived from the capacity of the roundabout approaches, and should be calculated for each individual case (see HBS).

The roundabout should be circular, in order to avoid varying radii when travelling around. The outer diameter should not be less than 50 m, as otherwise the inner space for turning traffic will be too small and even a few vehicles making a turn will cause congestion of the junction.

Provision for pedestrians and cyclists are usually made using paths around the outside. Where the topography is favourable, in specific cases it should be checked if a grade-separated arrangement may be beneficial, or whether taking pedestrians and cyclists across the central island will help improve their journey quality. This is particularly the case with large outer diameters, with many junction arms, when the sum of the waiting times at the crossings may be considerable. The location of crossings, of the arms entering, or across the roundabout, can be designed so as not to impact on motor vehicle capacity. As the flows of motor traffic, at signalled roundabouts, allow for compatible use by pedestrian and cyclist their level of safety is comparatively high, even with two-way traffic.

6.3.6 Partially grade-separated junction

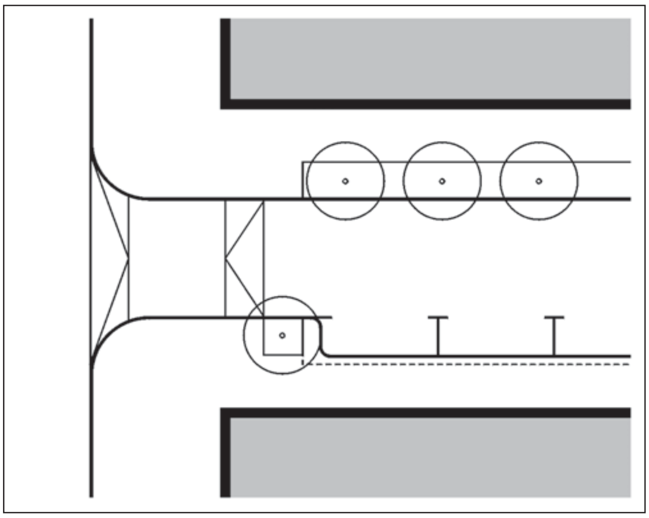


Figure 114: Example of a raised, paved hump crossover at a junction with a higher priority road

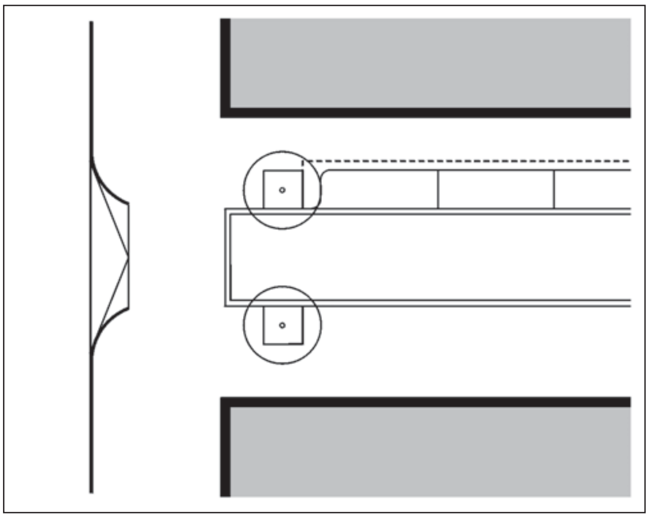


Figure 115: Footpath crossover on a junction on a higher priority road

A partially grade-separated junction is where through-lanes are carried on a structure at a different level, and vehicles joining or exiting are linked by curving ramps. Where the ramps join the through-lanes the junctions are usually merging-left turns, and are configured as normal junctions.

Owing to the bridge structure and the additional connecting ramps, partially grade-separated intersections are more costly and take up more space than at-grade crossings. The choice of this type must be justified by topography, planning and safety considerations, and because of the quality of the traffic flows.

6.3.7 Other junction types

6.3.7.1 Junctions of roads with residential streets, and property accesses

Junctions of residential streets and property accesses, with higher-ranked local streets and major roads are made mainly using either a speed hump with ramp slopes of 1 : 10 to 1 : 7 (figure 114) or by a crossover cycle path/pedestrian footway (figure 115). They both act as traffic calming measures and enable people with impaired-mobility to cross comfortably at such 'T' junctions. Pedestrian crossovers visually emphasise a changed design principle which gives priority to cycle and pedestrian traffic using cycle paths and footways along the road.

Property driveways are usually connected across cycle/pedestrian paths to local streets and main roads (table 54).

Use of special pre-formed blocks, for ramps and dropped kerbs, are appropriate at crossovers for cyclists and pedestrians, at T junctions with local streets and driveways, (table 55).

Slopes should usually be implemented in the area between the kerb and a path, a 'safety separation' area (figure 116a) considering the road safety benefits for pedestrians and cyclists, and ride comfort for cyclists, and in terms of ease of construction. The priority of cycle traffic over vehicles entering and exiting must be emphasised by the continuity of the surface of the cycle path.

The key factors in the design are the geometry of the standard vehicle when cornering and the relative height differences between the carriageway of the major road and the local street or property access.

The negotiability can be determined with tractrix curve templates.

6.3.7.2 Junctions with short chicanes

Short chicanes at the junctions of local streets serve as a means of traffic calming and emphasise the right-before-left rule. They have an impact on speed and can be combined with traffic humps.

The negotiability of the chicane can be verified as set out in section 6.2.1.2.

Table 54: Connection to main roads

Connection	Implementation
Local streets	Mainly implemented using speed humps on the desire-line of the crossing (ramp slope 1 : 10 to 1 : 7), alternatively as a shared/joint cycle/pedestrian path crossover. The width of the kerb lowering is derived from the tractrix curve for the standard vehicle, it is at least 3.00 m and not less than the width of the route through
Driveways	The adjoining footway area can be protected by bollards Cycle paths should be provided with clearly marked edges and/or be emphasised by materials Lowered kerbs and ramps should be located up to the edge of the footway If necessary parking must be restricted to meet the visibility requirements The width of the kerb lowering is derived from the tractrix curve for the standard vehicle, and is at least 3.00 m

Table 55: Kerb lowering at crossovers for cycle/pedestrian paths

Method of lowering	Applications	Implementation
Slope – positioned outside the paths – in the area of safety separation (figure 116 a)	This is useful particularly where cycle and/or pedestrian paths are on a severe gradient: ‘s’.	The pedestrian and cycle paths are kept slope-free, Permissible maximum slope p = 6 % is exceeded in the area at the carriageway side of the path, Use of pre-formed straight or sinusoidal ramp blocks, is advantageous
Ramping the whole footway (figure 116 b)	Where footway width is sufficient to keep within maximum camber p = 6 %	Length of l_2 = 1.00 m usually sufficient Length of $l_2 \geq$ 2.00 m should be the target
Lowering of footway across its full width (figure 116 c)	Footway width is not sufficient to keep within maximum camber p = 6 %	Length of $l_2 \geq$ 2.00 m should be the target
Lowering using only a sloped kerb (figure 116 d)	Infrequently used property driveways	Simplest form, has a major impact on speed

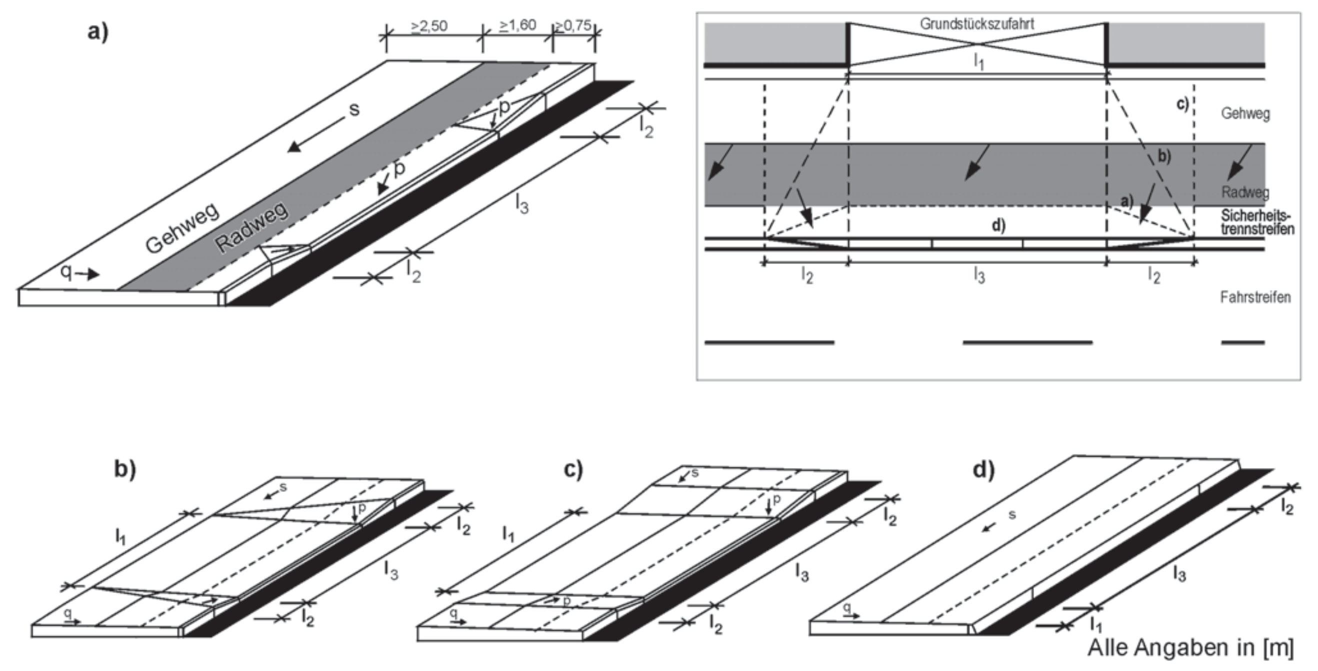


Figure 116: Forms of kerb lowering when crossing cycle/pedestrian paths

6.3.7.3 Widened junctions

Widened junctions and crossings occur when at least one of the merging roads has a wide central reservation (e.g. as in the case of an avenue) or when queuing areas for traffic turning left off and left onto the junction are created on the nearside by splaying the straight-ahead lanes by more than a vehicle length. This facilitates two-lane roads crossing over major roads with up to four lanes.

High capacities can be achieved using traffic signalling with widened junctions and crossings.

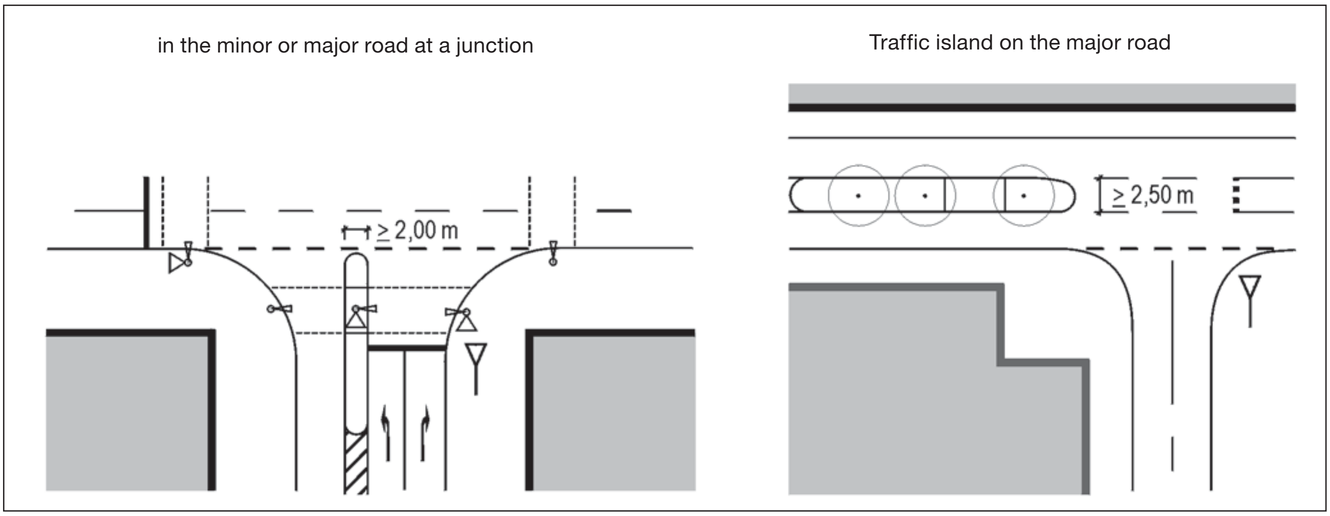
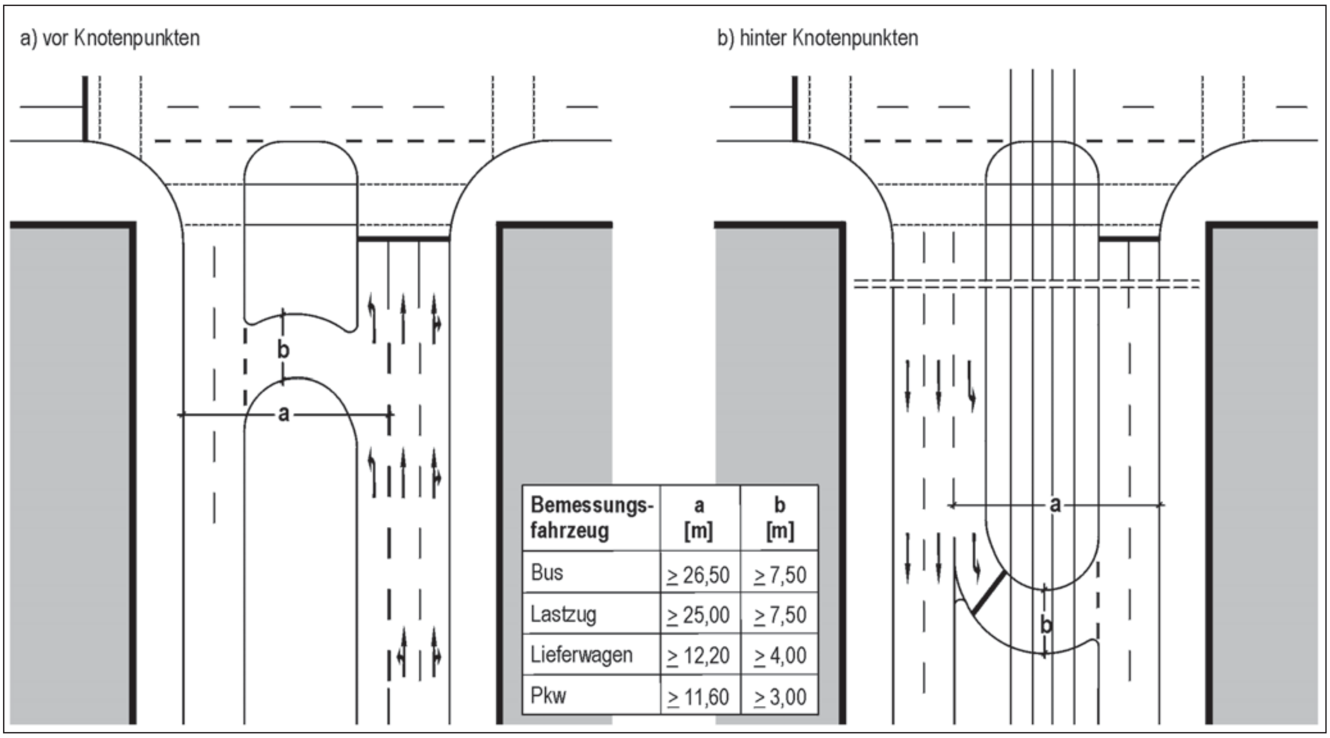


Figure 117: Examples of traffic islands at signalled and priority-controlled junctions



Bemessungs-fahrzeug	a [m]	b [m]
Bus	≥ 26,50	≥ 7,50
Lastzug	≥ 25,00	≥ 7,50
Lieferwagen	≥ 12,20	≥ 4,00
Pkw	≥ 11,60	≥ 3,00

Figure 118: Examples of U-turns a) before a junction; b) after a junction

6.3.8 Other design elements for junctions

6.3.8.1 Traffic islands

Traffic islands can be used depending on the junction type on both major and minor arms of the junction (figure 117). At T junctions, normally there is a traffic island on the major road segregating it from a left-turn lane.

Traffic islands used at crossings on minor streets make the crossing more noticeable and emphasise the need to wait. Islands used at the arms of a junction enable crossing for pedestrians and for cyclists using the footway. On the other hand, where space is tight, traffic islands must be avoided if the consequence would be that heavy traffic encroaches into the pedestrian area.

The standard vehicle must be able to negotiate the junction without difficulty. Simultaneous manoeuvres off and onto the junction must be possible. The dimensions of the required movement areas depend on the location and design of the traffic island (or splitter island) and can only be determined with swept-curve analysis.

6.3.8.2 Triangular islands

On built-up main roads, triangular islands with right-turning carriageways or right-turn lanes, should only be used without signalling for pedestrians and cyclists in exceptional situations, such as if necessary for traffic geometry reasons.

If right-turn lanes are required, where there are footways, raised paved crossovers combined with speed monitoring systems should be used in order to enable pedestrians to impose their priority over motor traffic and to enhance their safety.

Unsignalled right-turn lanes should be built as a single-lane. Bend radius should be kept small. If the swept-path curves of large vehicles require more space, then rough paved areas which can be traversed by trucks and buses can be used, but only outside the areas used for crossing by pedestrians and cyclists. Turning vehicles are then concentrated in the centre of the right-turn lane.

The main arc radius for bends with triangular islands should be selected according to table 57.

The edges of triangular islands can usually be straight, provided they are short. They should not be less than 5.00 m.

If cycle paths or pedestrian crossings use the triangular island, the remaining edges of the island adjacent to the crossings should still be at least 1.50 m long.

6.3.8.3 U-turns

As an alternative route for traffic making a left turn, U-turns can be provided before or after a junction (figures 118a & 118b). The special left-turning opportunity should be indicated in good time by sign 468 StVO ("Complex traffic routing (bypass)").

U-turns should be designed to accommodate the largest vehicle regularly making the turn. If U-turns are designed for a smaller standard vehicle, turning must be prohibited by sign 272 StVO ("No U-turns") with an additional sign for particular types of vehicle.

Traffic signals for U-turning traffic are required if

- there are not enough gaps in the oncoming traffic for the U-turning traffic;
- the view of the oncoming traffic is inadequate;
- there is inadequate queuing space for U-turning traffic.

U-turns can be integrated into the design of central reservations.

If there are pedestrian and cycle paths, tram tracks or bus lanes in the middle of the road, crossing of those traffic routes must be protected by signs or traffic signals.

6.3.9 Negotiability and visibility

6.3.9.1 Negotiability

The largest vehicle permissible under road traffic regulations – if not the standard design vehicle, or if the occurrence of the said vehicle cannot be excluded – must be able to drive through the junction in all permitted directions at least at low speed, and where necessary using oncoming traffic lanes (StVZO).

Roundabouts should also be negotiable by abnormal loads or military vehicles (see RABS), at least at low speed.

Junction and crossing geometry should be checked using tractrix curves for the key standard vehicles [50]. The entry and exit areas of roundabouts should always be checked for negotiability using vehicle tracking software.

The extent to which any use of oncoming traffic lanes is acceptable, when turning on and off, depends on the frequency and degree of the impediment it causes. Public transport should be not be impeded, nor should the space needed by cyclists, or motor vehicles, making right turns be used.

On junctions between major roads the use of oncoming traffic lanes by truck-trailer combinations and buses should generally be avoided.

Two-axle refuse collection vehicles should be able to use junctions of local streets with major roads without having to use oncoming traffic lanes, whereas three-axle refuse vehicles – and where appropriate buses – can use the oncoming traffic lane on the minor road.

Give way and stop lines should be set back accordingly where lanes need to be used by oncoming traffic.

The use of oncoming traffic lanes by abnormal loads can be implemented safely.

6.3.9.2 Corner radii

When designing corner radii, it should be noted that a standard vehicle, depending on the situation, can drive around the corner quickly.

Generally either a simple arc is used or a three-part (ellipsoidal) arc sequence (figure 119). The three-part arc offers advantages, particularly at junctions of major roads subject to heavy traffic loads, as it is better suited to the swept paths of motor vehicles than the simple arc.

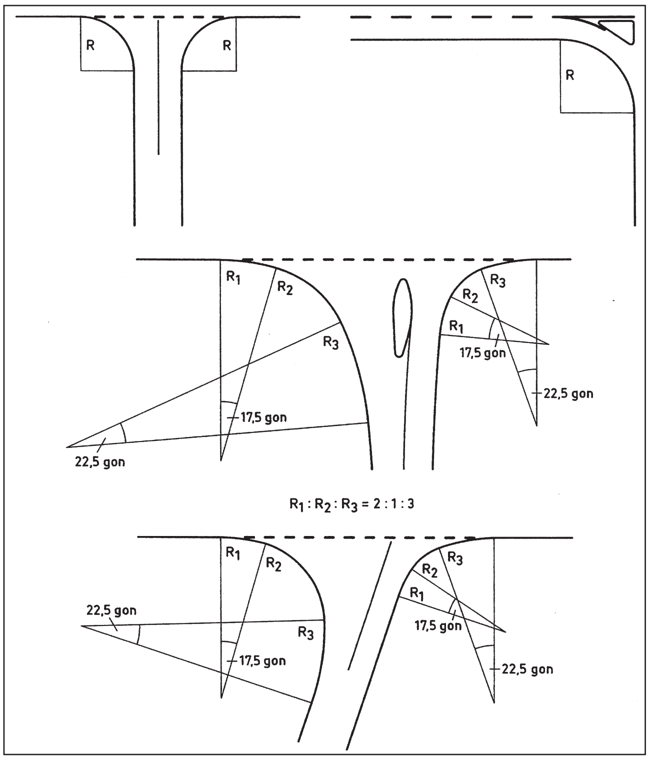


Figure 119: Different forms of corner radii at junctions and footpath crossings

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[50] "Standard vehicles and tractrix curves for verification of negotiability of traffic areas", edition 2001, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2001.

Table 56: Primary arc radii for bends without triangular island

Change of direction angle	Primary arc radius R for	
	Incoming right-turning traffic	Outgoing right-turning traffic
80 gon	8.00 m	12.00 m
100 gon	8.00 m	12.00 m (15.00 m)*)
120 gon	8.00 m	8.00 m
Intermediate values can be applied Lower values than R_2 = 7.00 m must not be used		

*) R_2 = 15.00 m only if pedestrian refuge is installed

Table 57: Primary arc radii for bends adjacent to triangular island

Change of direction angle	Primary arc radius R
80 gon	20.00 m
100 gon	25.00 m
120 gon	25.00 m
Intermediate values can be applied The dimensions produce a minimum size for the triangular island	

The simple arc has the advantage – apart from design aspects – of the shorter tangent length between corners, particularly important at pedestrian crossovers where the junction is with residential streets (control radius).

For main road junctions, out of the urban area, the size of the primary arc radius R2, should be used for corners without a turning lane or exit filter. It should be noted that the corner radius for traffic joining from the right should be made as small as possible. This emphasises the need to wait and improves visibility to the left, with due consideration to traffic geometry requirements. If heavy trucks do not frequently use the junction, some occasional corner overrunning is usually acceptable as the tightness increases visibility for car drivers who are waiting to turn (no straining to look!).

If a right-turning carriageway with right-turn lane or exit filter is required, a primary arc radius R as per table 57 (without transitional arc) should be selected.

6.3.9.3 Visibility requirements

At junctions, crossings over cycle/pedestrian paths and at crossing points, for waiting motorists, cyclists and pedestrians a minimum visibility requirement between 0.80 and 2.50 m height must be kept free of permanent obstacles, parked motor vehicles and shrubbery which blocks visibility.

Trees, lamp-posts, traffic signals and similar items may be positioned within the visibility splay. They must not, however, obstruct the view of drivers waiting to turn in, or setting off from a stop line, or non-motorised road users.

When checking visibility, the eye level of a car driver should be assumed as being at 1.00 m above the carriageway, that of a truck driver at 2.00 m, and that of the particular vehicle being observed at 1.00 m.

Visibility requirements must be verified

– for stopping;

– for approaching (X distance in UK);

– at crossings.

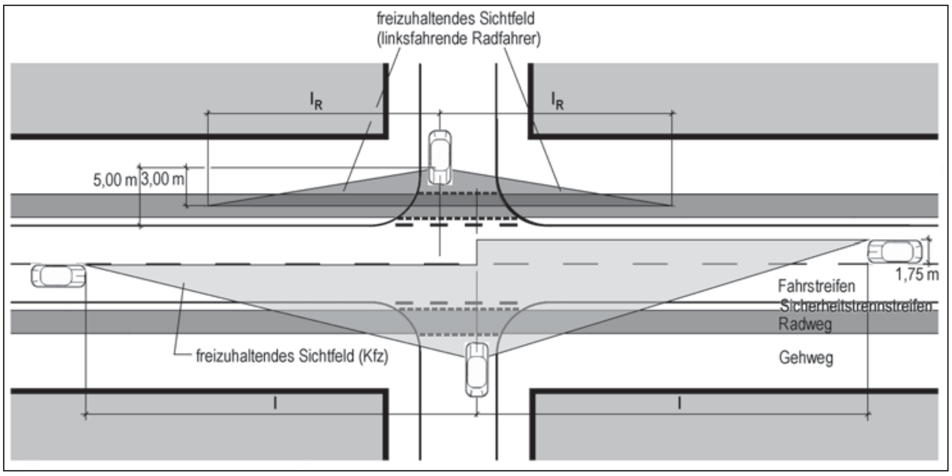

Figure 120: Visibility requirement at junctions, of vehicles and cyclists on the major road

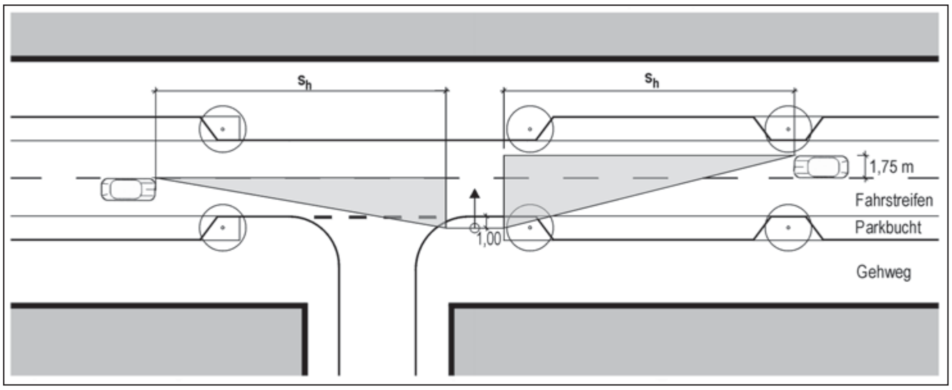

Figure 121: Visibility requirements at crossings

Within these requirements, the visibility of children, and children's sight of vehicles, must not be obstructed.

Stopping sight distance

Drivers can stop within the ranges S_h found in table 58.

On roads with trams, the stopping distances of rail vehicles must also be taken into account.

Table 58: Required stopping sight distance S_h

Road categories	V_{limit}	Longitudinal gradient 's'				
		– 8 %	– 4 %	0 %	+ 4 %	+ 8 %
Local streets, built-up main roads	30 km/h	–	–	22 m	–	–
	40 km/h	–	–	33 m	–	–
	50 km/h	–	–	47 m	–	–
Open main roads	50 km/h	54 m	50 m	47 m	44 m	42 m
	60 km/h	73 m	67 m	63 m	59 m	56 m
	70 km/h	94 m	86 m	80 m	75 m	71 m

Table 59: Distance l, visibility requirement along major road
(Y distance in UK)

V_{limit}	visibility requirement distance 'l'
30 km/h	30 m
40 km/h	50 m
50 km/h	70 m
60 km/h	85 m
70 km/h	110 m

Approach visibility (X distance in UK);

The approach visibility (X distance in UK) is the view which a motorist must have waiting at the carriageway edge. It is measured 3.00 m back along the minor arm, from the edge of the major road, to the eye of the motorist.

Where visibility distance along the major road 'l' (Y distance in UK) is available, motorists can turn onto the major road without obstructing other vehicles, see table 59

Where segregated cycle-paths cross the minor road, the distance back from the carriageway edge should be increased from 3.00 to 5.00 m so that the waiting motor vehicles can be kept-off the cycle crossings.

The visibility distance 'l' (Y distance in UK) for cyclists on the major road should be l_R = 30 m; in tight space l_R = 20 m (figure 120).

If the required distance for the approach visibility (X distance in UK) cannot be achieved, other measures (such as no-stopping, speed restrictions, traffic lights or specific turn prohibitions) should be considered.

Visibility requirements at crossings

At crossings and where pedestrians and cyclists are waiting, visibility distance 'l' (Y distance in UK) should be measured perpendicular to the direction of travel as shown in figure 121, with a stopping sight distance along the major road as in table 58.

In the case of crossings at junctions, the visibility requirement for pedestrians and cyclists are usually less than those of the approaching motor vehicle traffic.

7 Street furniture, lighting and greenery in the street space

7.1 Lighting

Lighting of an appropriate quality should always be provided on streets in built-up areas, both for public order and safety, and to improve road safety.

On **main roads with high traffic loads (> 1,500 vehicles per hour)**, the quality of lighting [51] is of great importance in terms of intensity and illuminance of the surface, uniformity and limitation of glare.

Junctions and crossings, and other special features, can be emphasised by higher levels of lighting and illuminance level, by varying the lighting layout, its form and light colour, as well as in terms of design.

The lights should be laid out so that

1. lamp-posts do not pose any additional hazards; and
2. traffic areas are uniformly lit in spite of existing trees.

High lighting positions (greater than carriageway width) should be avoided if possible on built-up main roads with intensive adjoining uses. Lights with a symmetric light distribution pattern also are often found to be disturbing in residential areas.

On **main roads with low traffic loads (< 800 vehicles per hour)**, on **local streets** and in **footway areas,** design aspects [52] are also of particular importance. The location, height, form and size of the lights, their illuminance level/carriageway luminance and light colour should respond to the built frontage and the character of the street.

Medium mounting heights (3.50 to 4.00 m) and top luminaires are usually an acceptable compromise between traffic and design requirements. Mounting heights of 4.00 m do, however, require a distance of 5.00 to 7.00 m between lights and trees.

The lighting concept should be integrated with building frontages. This can be helped by installing additional footway lighting with lower mounting heights and by choosing the same lights for public and private areas.

7.2 Signs and markings

Typical design elements usually require no additional signs. On central islands, in consultation with the Highway Authority the ‘pass-this-side’ arrow can often be omitted in favour of other vertical elements (Trees, lights).

Direction signs should be designed according to the principles and basic regulations laid out in the “Directives for route-indicating signage away from motorways” (RWB)[53] so that they are readily identifiable both in daylight and in darkness. Considering signing for cyclists, refer to the “Fact sheet for route-indicating signs for cyclists”[54].

On main roads the farthest reasonable destinations should be signed (such as “All directions”, “Districts”) in consultation with the Highway Authority, in order to have small local-signs on simple posts next to the carriageway (no gantries).

Advanced signs are usually required leading up to major traffic junctions, where there are filter lanes approaching the junction.

Local signs are used in the immediate vicinity of the junction. If prior guidance is provided, these signs serve merely to reaffirm the chosen destination. They can then be correspondingly small.

Street name signs should usually be used at all junctions in urban areas.

The use of solid lines, lane markings, no-entry zones and kerb markings should be restricted to the essential minimum.

The key dimensions are contained in the RMS[55].

Markings can be omitted if the policy objectives, management and control of traffic can be achieved by other means (e.g. areas differentiated by colour or material, or paved strips instead of edge markings at side roads). Positive empirical results have been achieved by omitting longitudinal markings with traffic volumes up to around 1200 vehicles per hour. These measures do not have the same legal significance as the markings stipulated by StVO.

Lanes with widths of less than 2.75 m should not be marked out.

7.3 Greenery in the street space[56]

7.3.1 Basic considerations

Planting in street spaces comprise

- trees (in rows or groups);
- hedges and shrubs;
- ground cover and grass lawns;
- greening of facades; and
- private planting.

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[51] DIN 5044: Stationary lighting for traffic areas, part 1: Lighting of roads for motor vehicle traffic; general lighting requirements and layout; edition 1981-09, part 2: Lighting of roads for motor vehicle traffic; calculation and configuration; edition 1982-08; German Standardisation Institute, Berlin 1981/1982, and DIN EN 13201: Road lighting, edition 2004-04, German Standardisation Institute, Berlin 2004.

[52] See ESG.

[53] “Directives for route-indicating signs away from motorways” (RWB), edition 2000, Federal Ministry of Transport, Construction and Housing, Bonn 2000.

[54] “Fact sheet for route-indicating signs for cycle traffic”, edition 1998, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1998.

[55] “Directives for the marking of roads” (RMS), part 1: Dimensions and geometry of markings, edition 1993, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1993.

[56] See “Instructions for roadside planting in built-up areas”, edition 2006, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 2006.

Trees and shrubs are a key element of the urban street. The co-ordination of the planting refers both to the greening of the road itself and to the planting of adjoining areas.

As well as having ecological benefit and social value, planting performs a key function in terms of street space design. The framing of space and structuring qualities help in focussing and emphasising the specific street function. In architectural terms, such as in historic townscapes, it may be the case that no trees or shrubs are appropriate in a given street space.

When planting bushes and hedges, as well as any issues of road safety, attention should also be paid to the social safety and security of pedestrians using the footway.

When selecting planting, it is important above all to ensure that no hazards are created for road users and, for neighbouring properties, that no avoidable constraints are imposed.

Trees and bushes can only ‘perform’ their functions properly, however, if the optimum conditions for healthy growth are established.

This requires a site-specific selection of plants, adequate space for them to develop both above and below ground, and appropriate growing conditions. If necessary, suitable protective measures must be undertaken.

To cope with the requirements of all the vegetation, planting plans should be drawn up, integrated into or alongside the street, detailing the type and scope of planting and the necessary measures for site preparation and improvement. This must take into account street furniture and equipment such as lighting, pipes and cables, traffic signals, signs and visibility requirements (see section 6.3.7.5). Existing planting should be incorporated into the street space as far as possible.

7.3.2 Trees

Trees have a high ecological value and can be used in the street individually, in rows and avenues, as ‘gates’ and in groups. Trees serve

- to frame the street space;
- to structure the space;
- to break up parking lanes;
- to form ‘gateways’
  - on the approaches to localities,
  - as transitional zones to create different sections of (a long) street
  - and on entering particular neighbourhoods;
- to vertically emphasise footway build-outs, road narrowings, central islands and roundabouts;
- as features which enhance the memorability of roads and squares, either individually or in clusters; and
- in clusters to emphasise distinct areas beside the street (small squares).

The selection of tree species depends on the specific site conditions, site requirements (soil, climate, exposition, water requirement) and growth characteristics, as well as on design purpose. For a given place only trees suitable for use in the street, in terms of their specific growth characteristics, and taking account of the amount of care and attention they need (such as frequency of pruning) should be selected.

Species which are not adapted to the location and which are only able to grow with the aid of technical interventions (such as irrigation systems) should not be used.

Specific guidance regarding the selection of suitable species is given in the latest version of the street trees list issued by the ‘Standing Conference of Directors of Parks and Gardens of the German Association of Cities’.

The space between planting and the edge of the carriageway is determined by the need to maintain specified clearances. This width is the clear space in the road cross-section which must be kept free of fixed obstacles (see section 4.1). The required clearance height for motor vehicles is 4.50 m, and for pedestrian and cycle paths normally 2.50 m (see sections 4.2, 4.3, 4.6 and 4.7).

When laying out rows or avenues of trees, consideration must be given to the size, form and species of the trees planted. This results in specifications for the spacing needed between trees.

No trees should be planted in very tight spaces and under highly unfavourable site conditions, in view of the high technical commitment required to plant and maintain them. Small fragments of land, splitter islands, traffic islands and areas adjacent to tram tracks near overhead lines are not approved for tree planting.

The vitality of a tree is directly related to the unrestricted development of its foliage and on healthy, active roots. It is crucially influenced by the aeration and moisture of the soil and the supply of nutrients. If these factors are not adequately present, suitable measures must be undertaken to improve the ground at the location.

Artificial watering of trees is not usually necessary, except when planting young trees in dry weather. Otherwise, where regular watering would be required, trees should not be planted.

When planting trees, the local utilities’ safety regulations for existing pipe and cable runs must be taken into account (figure 122).

To prevent ingress of tree roots into the space where the utility installations are, effective protection can only be achieved if suitable measures have been taken, right from the planning phase of the pipes and cables. Roots will only penetrate into these utility zones if they find favourable conditions there for growth. This is particularly the case where the ratio between air and water carrying pores is favourable (poor compaction beneath the pipes and cables, condensation forming at some points).

New pipes and cables should wherever possible be laid away from the tree canopy drip-line. If they are laid closer, special attention will be needed (including work by hand) when carrying out subsequent works on the installations. The requirements of the RAS-LP57) must be followed.

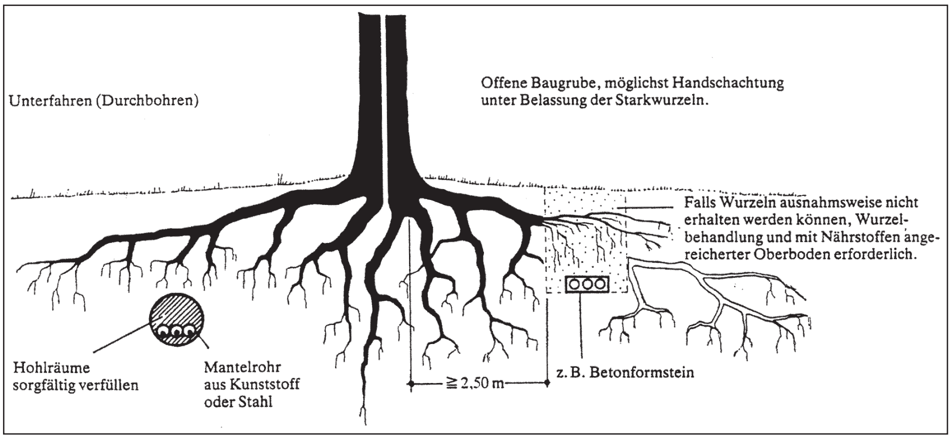

Figure 122: Examples of protecting underground pipes and cables in tree root zones

All traffic signs and installations, such as traffic signals, must be readily identifiable to vehicles travelling at the relevant speed limit. They must therefore not be hidden by trees or bushes. Visual contact between road users at crossings, junctions and pedestrian cross-walks must also be ensured. This should be considered right from the planning stage. Regular pruning may be required. In many cases, traffic installations can be relocated in favour of existing trees.

7.3.3 Hedges and bushes

Bushes which are freely-growing and dense shrubbery which blocks the view should only be used in exceptional cases in built-up areas, primarily for reasons of city design and safety. As a rule, only types which do not grow too large, too rampantly and which require little pruning should be used.

To estimate expected mature size, these distinctions are made

– normal bush: height > 1.50 m;

– small bush: height > 0.50 m;

– dwarf bush: height > 0.10 m;

Taking into account different growth patterns, the space needed for freely-growing bushes and hedges are described as follows:

– normal bush approximately 3 m³;

– small bush approximately 1 m³; and

– dwarf bush < 1 m³.

The guidance specific to use in the highway and in relation to private properties must also be taken into account.

If the required above-ground space in the street is not available, smaller types of bush should be selected. If there is insufficient space even for them, no bushes of any kind should be planted.

Ground-cover shrubs mean low bushes up to about 1.00 m height. The heights of many species and types are, however, heavily dependent on the growing environment. Wide-spreading species and types should only be used where there is adequate width, in order to avoid major care and maintenance costs

Strips of greenery with low ground coverage (shrubbery) or large planting beds can play a major role in creating a balanced relationship between the carriageway and footway areas, as well as giving protection to activities within the footway. Continuous planting with a protective and a screening effect (such as in raised beds) and with defined breaks for crossing are only advisable as a means to make clear a separation at the sides of high-volume, high-speed main roads and any lane separating islands.

When planting hedges and bushes, care must be given to aspects of both social and road safety. Adequate visibility must be maintained at entry and exit points as well as at junctions and crossings. Visual contact between motorists, cyclists and pedestrians should be possible everywhere in the sense of social control. This can best be achieved by planting low (< 80 cm, see section 6.3.9.3) ground-covering shrubbery or by using grass.

7.3.4 Shrubbery and grass areas[58]

Shrubbery and grass areas can be used beneath and alongside trees or as separate planting.

The choice of shrubbery depends on existing site conditions, the habitat requirements and the growth characteristics of the plants, as well as on design requirements.

Shrubbery usually requires a higher level of care and maintenance.

7.3.5 Greening of building facades

Creepers and climbing plants can be trained up the facades of buildings, unless design considerations demand otherwise.

On smooth surfaces, most creepers and climbers need a trellis or support of some sort. The planting of self-climbers depends on the suitability and condition of the build-

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[57] "Directives for the layout of roads, part: Landscape care" (RAS-LP), section 4: Protection of trees, vegetation stocks and animals when carrying out construction works, edition 1999, Forschungsgesellschaft für Straßen- und Verkehrswesen, Cologne 1999.

[58] Advice grass-seed selection, applications and appropriate blends specific to site conditions are contained in "Standard seed mixes for lawns" (RSM), edition 2006, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (Landscape development and construction research society), Bonn 2006.

ing facade. Existing structural damage can lead to further problems.

In selecting creepers and climbing plants, as well as the site-specific needs of the plants particular consideration must be given to their growth properties. Fast-growing plants may cause damage to the building structure if not used appropriately.

7.3.6 Private gardens

The quality of the local street environment is also affected by resident's choice of vegetation fronting the street, such as front gardens and boundary trees, as well as facades, window boxes and balconies decorated with flowers,. Streetscape design can make use of such areas of greenery. The introduction of planting, in traffic space which is often very limited, may be reduced as a result, or in some cases may even be omitted altogether (such as on streets with large front gardens).

7.4 Street furniture

7.4.1 Barriers

These include bollards, posts, chains, grilles, railings, hedges, raised kerbs, double steps, concrete thresholds, walls, steps, fences and planting beds.

Barriers should only be used where they will not create major disadvantages for pedestrians, cyclists and areas of planting and where the minimum visibility requirements and necessary minimum clearances of the footway are not restricted (see width allowances set out in Chapter 4). Bollards may be installed in the same way as parking meters at a distance of 0.25 m from the carriageway edge, provided they are at least 0.90 m high.

On cycle paths beside the road, bollards can pose a major hazard to cyclists if safety clearances are inadequate.

If barriers are installed between parking bays and footway, the parking bay depth should be lengthened by the amount of overhang (0.70 m).

The design of barriers should respond to the local style and character, in terms of form and material.

7.4.2 Civil engineering equipment

Civil engineering equipment is located in the street according to the functional requirements of the transport and utilities infrastructure (hydrants, manhole covers, electrical substations, junction boxes, public telephones, overhead cables, overhead cable pylons, litter bins, and bins for road-grit, bays for large refuse bins, recycling containers). The locations of these installations are often predetermined (such as in the case of traffic lights or street lamps) and cannot always be aligned with the objectives of street space design. This often results in an unacceptable compromise for street appearance, in part due to a lack of coordinated planning between the utilities involved and a failure to harmonise forms, proportions, sizes and materials of above-ground installations for water supply, sewerage, gas and electricity supply and telecommunications.

Consequently, when preparing designs for street space and related facilities, the designer must consider whether:

- the required installations impair the safety of cyclists, pedestrians and disabled persons;
- the installations are absolutely essential;
- they can be integrated into other existing or newly installed facilities;
- they can be combined with other installations;
- they can be positioned so that the surrounding street space remains undisturbed as far as possible; and
- their design can be improved.

7.4.3 Installations for particular purposes

Installations such as pavilions, sales kiosks, shelters for passengers, bicycle racks, mailboxes, clocks, public toilets, information points, display cases and advertising signs usually perform non-essential functions and so specific requirements can be imposed in terms of their siting and design.

The conspicuousness they need for their function is often at variance with the design principle of discreet integration into the street space.

Different locations for these installations may be useful for their different users (such as pedestrians and motorists).

On the other hand, their locations are less affected by operational necessity and so they may more easily be made compatible with design objectives than those of many technical installations. In all cases it is essential that visibility requirements should be kept clear (see section 6.3.9.3).

7.4.3 Installations with multi-functional uses

Other public installations include water features, sculptures, monuments, walls, steps, plinths, stairways to buildings, ramps, pergolas, structures to support planting, trees, stands of trees and areas of grass (see section 7.3).

These installations have multi-functional uses, and are open to a wide range of activities. They are key elements of street space in terms of legibility, identity and allowing appropriation by different users. Fountains, for example, not only serve as water taps or aesthetic objects but also as meeting points or as paddling pools and as a focus of play for children. Stairways and low walls are also multifunctional; they serve both to overcome height differences and to segregate different spaces while at the same time providing a linking element, offering a place to sit, and a place to play.

Appendix 1

Technical regulations

DIN[1]	DIN 1998	Location of pipes and cables and installations in public areas; directives for planning
	DIN 14090	Areas for the fire service on properties
	DIN 18024	Barrier-free construction, part 1: Streets, squares, pathways, public transport installations and greenery and play areas; planning basis
	DIN 18030	Barrier-free construction – planning bases (draft)
	DIN 5044-1	Stationary lighting; lighting of roads for motor vehicle traffic; general quality characteristics and guide values *(DIN 5044-1 has been partially replaced by DIN EN 13201-1 and DIN EN 13201-2. Sections 5.5, 5.6, 5.8, 7 and 8 were not replaced.)*
	DIN 5044-2	Lighting of roads for motor vehicle traffic; calculation and configuration *(DIN 5044-2 has been replaced by DIN EN 13201-1 to -4.)*
	DIN EN 13201-1	Street lighting; selection of street lighting classes
	DIN EN 13201-2	Street lighting; quality characteristics
	DIN EN 13201-3	Street lighting; calculation of quality characteristics
	DIN EN 13201-4	Street lighting; methods of measuring the quality characteristics of street lighting installations
FGSV[2]		Standard vehicles and tractrix curves for checking of the negotiability of traffic areas (FGSV 287)
	EAE	Recommendations for the layout of access roads (FGSV 285) *(The EAE have been replaced by FGSV 200: RASt 06.)*
	EAHV	Recommendations for the layout of main arterial roads (FGSV 286) *(The EAHV have been replaced by FGSV 200: RASt 06.)*
	EAR	Recommendations for resting traffic installations (FGSV 283)
	EFA	Recommendations for pedestrian traffic installations (FGSV 288)
	ERA	Recommendations for cycle traffic installations (FGSV 284)
	ESAS	Recommendations for safety auditing of roads (FGSV 298)
	ESG	Recommendations for street space design in built-up areas (FGSV 230)
	ESN	Recommendations for safety analysis of road networks (FGSV 383)
	EWS	Recommendations for cost/benefit studies in relation to roads (EWS) – update to RAS-W 86 (FGSV 132)
	HBS	Handbook for configuration of road traffic installations (FGSV 299)
		Instructions for roadside planting in built-up areas (FGSV 232)
	H BVA	Instructions for the design of barrier-free traffic installations
		Instructions for bicycle parking (FGSV 239)
	HSRa	Instructions for signalling of cycle traffic (FGSV 256)
		Information sheet for the layout of roundabouts (FGSV 242)
		Information sheet for evaluation of road traffic accidents, part 1: Compilation and evaluation of accident type charts (FGSV 316/1)
		Information sheet for the execution of traffic surfaces in track areas of trams (FGSV 940)
		Information sheet for route-indicating signage for cycle traffic (FGSV 245)
	RABS	Directives for the layout and construction of roads for heavy-duty military vehicles (FGSV 931)
	RAS-LP	Directives for the layout of roads, part: Landscape care, section 4: Protection of trees, vegetation stocks and animals when carrying out construction works (FGSV 293/4)
	R-FGÜ	Directives for the layout and component elements of pedestrian crossings (FGSV 252)
	RiLSA	Directives for traffic light installations (FGSV 321) and "Beispielsammlung"
	RIN	Directives for integrated network design
	RMS	Directives for the marking of roads, part 1: Dimensions and geometry of markings (FGSV 330/1)
	RWB	Directives for route-indicating signage away from motorways (FGSV 329)
		Sustainability analyses in local traffic planning (FGSV AP 41)

FLL[3]	 RSM	Recommendations for tree planting, part 2: Preparing locations for new planting, ditches and root chamber extensions, construction methods and substrates Standard seeding blends for lawns
VDV[4]	BOStrab clearance directives BOStrab routing directives	Provisional directives for measurement of the clearance of rail vehicles according to the Regulation governing the construction and operation of trams; Tram construction and operating regulations Directives for the routing of rail tracks in accordance with the Regulation governing the construction and operation of trams

Reference sources

[1] **Beuth Verlag GmbH**
Address: Burggrafenstr. 6, D-10787 Berlin
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[2] **FGSV Verlag GmbH**
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E-mail: info@fgsv-verlag.de, Internet: www.fgsv-verlag.de

[3] **Forschungsgesellschaft Landesentwicklung Landschaftsbau e.V., FLL**
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E-mail: info@fll.de, Internet: www.fll.de

[4] **beka – Einkaufsund Wirtschaftsgesellschaft für Verkehrsunternehmen GmbH**
Address: Bismarckstraße 11–13, D-50672 Cologne
Tel.: +49 (0) 221 / 95 14 49-0, Fax: +49 (0) 221 / 95 14 49-20
E-mail: info@beka.de, Internet: www.beka.de

Laws and regulations

BGG – Disability Rights Act – Law relating to the equality of disabled persons (BGBl I), www.bundesgesetzblatt.de, www.bundesrecht.juris.de

PBefG – Public Transport Act, www.bundesgesetzblatt.de, www.bundesrecht.juris.de

UVV – Accident prevention regulations – Employer‘s liability insurance association regulations relating to health and safety at work (BGV), Carl Heymanns Verlag, Cologne, www.arbeitssicherheit.de, www.bundesrecht.juris.de

StVO – Road traffic regulations, www.bundesgesetzblatt.de, www.bmvbs.de

StVZO – Road use and licensing regulations, www.bundesgesetzblatt.de, www.bundesrecht.juris.de

VwV-StVO – General administrative order pertaining to road traffic regulations, www.bundesanzeiger.de

Literature

User-friendly and access-friendly design of the street space, improving traffic in local communities; ‘direkt’ volume 54, Federal Ministry of Transport, Construction and Housing, Bonn 2000. www.nw-verlag.de

Handbook for the assessment of road safety, FA 3.389 on behalf of Federal Ministry of Transport, Construction and Urban Development, in work.

Communal safety in the street space – Guide to auditing of the public space in remodelling of existing installations, new design and planning; Recommendation of the Traffic Engineering Institute of the Federation of German insurers, www.verkehrstechnisches-institut.de/content/download_brosch.htm

Drive tests and calculations: Stadtwerke Verkehrsgesellschaft Frankfurt a.M. mbH, 1997

Appendix 2

Index

Remarks on the system of technical publications of the FGSV

R stands for regulations:

These publications either specify the technical design or realization (R1) or give recommendations on the technical design or realization (R2).

W stands for information documents:

These publications represent the current state-of-the-art knowledge and define how a technical issue shall be practicably dealt with or has already been successfully dealt with.

Category R1 indicates 1st category regulations:

R1-publications contain the contractual basis (Additional Technical Conditions of Contract and Guidelines, Technical Conditions of Delivery and Technical Test Specifications) as well as guidelines. They are always coordinated within the FGSV. R1-publications – in particular if agreed on as integral part of the contract – have a high binding force.

Category R2 indicates 2nd category regulations:

R2-publications contain information sheets and recommendations. They are always coordinated within the FGSV. Their application as state-of-the-art technology is recommended by the FGSV.

Category W1 indicates 1st category documents of knowledge:

W1-publications contain references. They are always coordinated within the FGSV but not with external parties. They represent current state-of-the-art knowledge within the respective responsible boards of the FGSV.

Category W2 indicates 2nd category documents of knowledge:

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