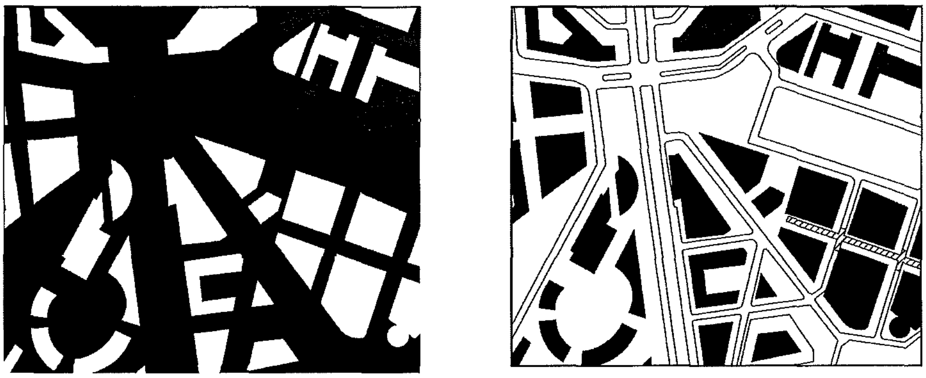


1 Street spaces in cities become readable when their areas are blacked in, because the eye understands black areas as cohesive and white areas as holes.

Design

Street spaces are formed by roads with surrounding buildings. These can easily be illustrated on black layouts, on which the roads and squares are coloured black and the buildings remain white → **1**. The spacing and height of opposing buildings have an influence on the impression made by a street space. Considering an angle of view of about 45°, the effects of street spaces can range from closed (like a ravine) to open (like a square) → **2**.

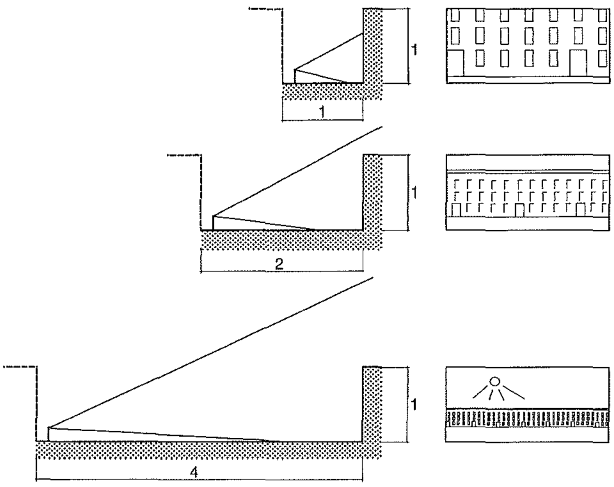
The design intentions for street spaces, in addition to the fulfilment of traffic and supply functions, are to create an identity, give orientation and provide residential quality. Identity is the result of emphasising particular local features, and relation to topography and to view axes. Distinctive places provide more ways of orientation and offer means of identification.

Apart from building façades, trees are the strongest space-building factor. They can also bind the street space upwards. Trees can direct the eye, create scale and fill in gaps → **5**.

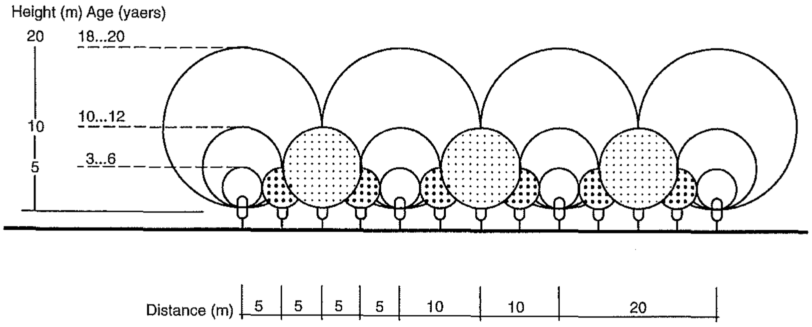
The percentage of space boundaries in the field of view determines how open or closed a street space is read as. The perception of architectural details on buildings also depends on the distance from the building → p. 40. The formula on p. 40 can be used to determine the relationship between the distance of an observer from a building and the scale of a drawing of a building. The degree of detailing at a scale can thus be matched to a certain distance of the observer.

The relationship of scale to distance according to the formula is approximately:

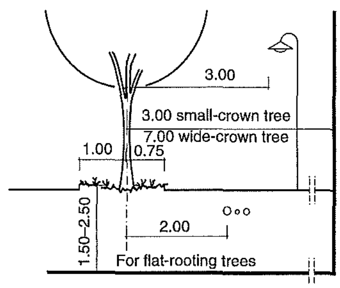
1 : 100	120–170 m
1 : 50	50–80 m
1 : 20	10–20 m



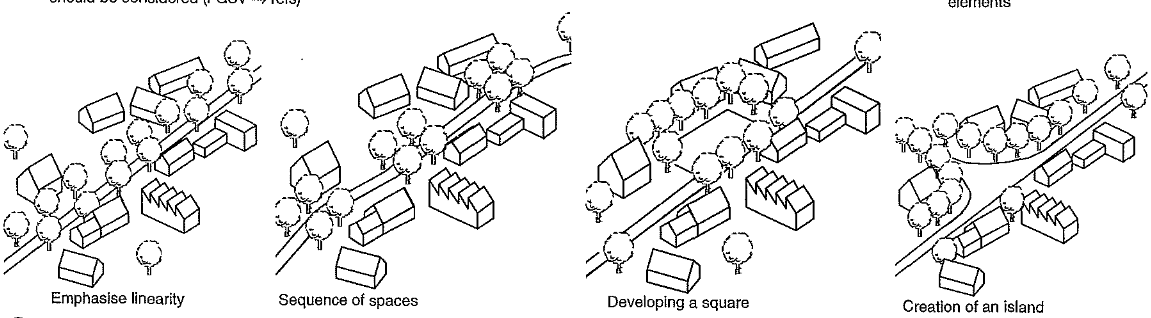
2 The relationship of width to height determines how a street space is read (FGSV → refs)



3 When choosing the positioning of trees for planting, the space that will be required by the fully grown trees should be considered (FGSV → refs)



4 Distances of trees from other street elements

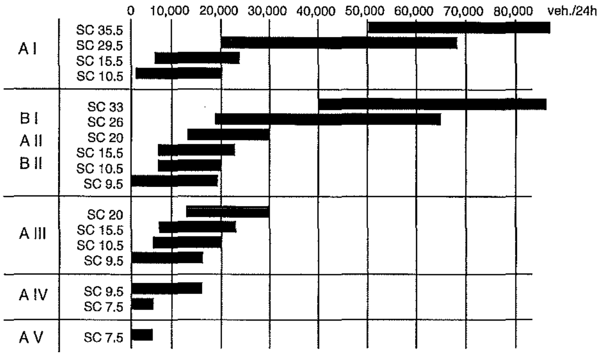


5 Structuring of a unified space with trees

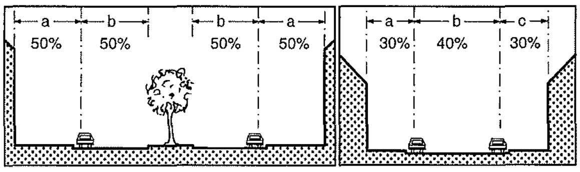
Link function level \ Category group		Not in built-up area	Inside built-up area			
		No adjacent buildings		Adjacent buildings		
		Link			Access	Stay
		A	B	C	D	E
Large–area road link	I	A I	B I	C I	D I	E I
Extra–regional road link	II	A II	B II	C II	D II	E II
Road link between towns	III	A III	B III	C III	D III	E III
Road link between residential areas	IV	A IV	B IV	C IV	D IV	E IV
Minor road link	V	A V	–	–	D V	E V
Track	VI	A VI	–	–	–	E IV

RAS–Q, RAS–L | EAHV 1993 | EAE 1985/95

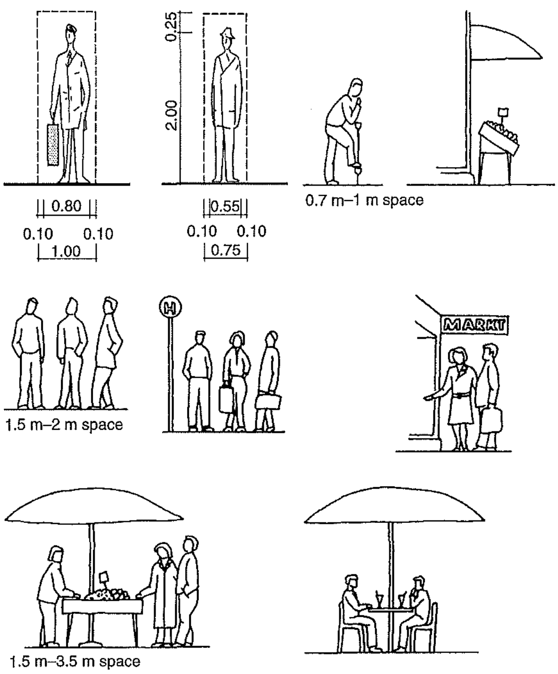
❶ Determination of road categories (FGSV → refs). RAS-L: Guidelines for Construction of Roads – Road Layout; RAS-Q: – Cross-section; EAHV: Recommendations for Construction of Main Roads; EAE: ... Access Roads.



❷ Determination of standard cross-sections for roads without adjacent building (FGSV → refs). SC: standard cross-section.



❸ Desirable width relationships between vehicle areas and pedestrian spaces (FGSV: RAS-Q 96 → refs)



❹ Basic dimensions for various uses of pedestrian areas (FGSV: EAR 05 → refs)

Classification

As part of the transport network, the layout of roads depends on their function in the network's structure. The classification of roads has to differentiate their location inside or outside a built-up area and above all their function as access for properties and buildings next to the road, leading to the important distinction between roads which are built along and those which are not.

Roads without adjacent building

These roads are almost entirely used for vehicle traffic. Their design is based on the planned average speed, the connection function level and the category group. The correct road category can be found in → ❶ and, together with the forecast number of vehicles, the cross-section of the road can be determined → p. 378 ❶.

Roads with adjacent building

These roads are part of the public space and serve a multitude of uses in addition to transport, though the predominance of motorised transport has today led to them being mostly formed by the needs of road traffic. Town and transport planning has the purpose of achieving a balanced relationship between road traffic and the other important functions of the street space. These are, for example:

communication areas	relaxation, strolling, walking, demonstrating...
play areas	cycling, roller skating, ball games, playing hide and seek
commercial use	market stalls, pavement cafés, food stands
green areas	binding dust and pollutants, oxygen production, microclimate improvement

Elements of road cross-section

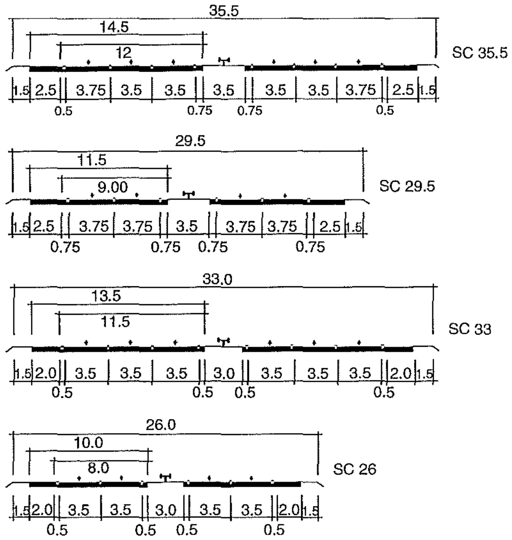
The publications of the Research Company for Roads and Traffic (FGSV) give basic dimensions for the various uses of street spaces. The traffic space is measured from the width required by the traffic participant plus a margin for movement, dependent on the speed. Together with the safety distance from solid obstacles, which has to be kept free, this gives the clear space required for traffic → p. 379. To determine the profile of the street space, the recommendations in the Appendix for Main Roads and the Recommendations for the Construction of Access Roads state a number of criteria which enable a differentiated adaptation of the available space for various needs. The most important decision criteria are:

1. Zones, divided into town centre zones, areas of old buildings near to the town centre, residential areas, industrial and commercial areas and village areas.
2. Type of connection road: main road, main feeder road, residential street and residential side street.
3. Requirement for park and green areas.
4. Type and frequency of public transport.
5. Type of use of the pedestrian areas. In addition to pedestrian routes, these offer opportunities for the social and communications functions of street spaces.

After these factors have been evaluated, a decision is made as to which size of vehicles will be allowed to travel on the road and at what speed. The required carriageway width is then derived from considering possible encounters → p. 379.

Transport

ROADS
Street spaces
Types of road
Motorways
Traffic space
Inter-urban roads
Cross-sections
Intersections
Footpaths and cycle ways
Bicycle traffic/ storage
Traffic calming
Noise protection



❶ Standard cross-sections (SC) for motorways (FGSV: RAS-Q 96 → refs).

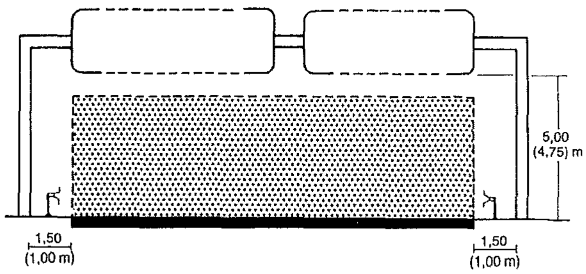
Motorways are roads without adjacent building, designed for high-speed vehicles and express transport. The two carriageways, one in each direction, are separated by a central reservation. Each carriageway consists of two or more lanes and normally a hard shoulder → ❶.

Motorways are linked to each other by grade-separated (→ p. 381) intersections. These can be three-directional → ❽ – ❿ or four-directional intersections → ❹ – ❻ and specialised junctions for joining and leaving the motorway → ❼ + ⓫.

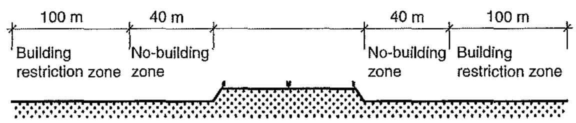
Motorways are the safest roads and have the highest capacity. The most important factor in the design and construction of new motorways is environmental impact.

Route signage → ❷: the location of the sign for junctions is at 1000 m, and for intersections 2000 m before the turn-off.

In order that built infrastructure next to the motorway does not negatively affect traffic (obstruction of view and reduction of concentration), legislators have identified adjacent zones where building is either forbidden or restricted → ❸. Building restriction: the erection or significant alteration of buildings and facilities at a distance 40–100 m from the outer edge of the carriageway of motorways is subject to a special application. Buildings of all types are forbidden up to 40 m from the outer edge of the carriageway of motorways.

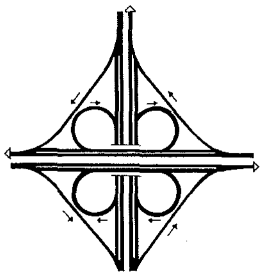


❷ Sign bridge over motorway

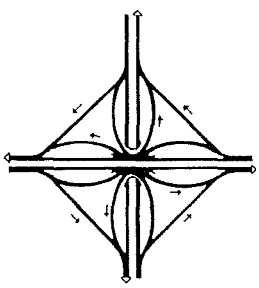


❸ Building ban/restriction zones near motorways

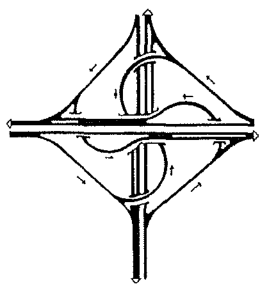
Motorway junctions (four-way)



❹ Clover leaf

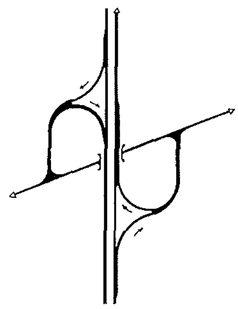


❺ Maltese cross



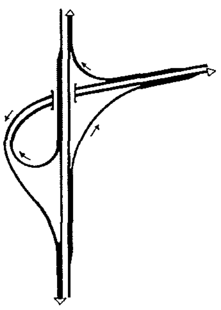
❻ Windmill

Motorway interchanges (four-way)

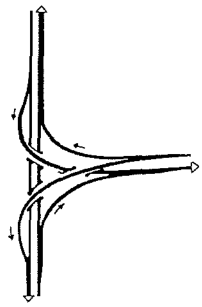


❼ Half clover leaf

Motorway junctions (three-way)

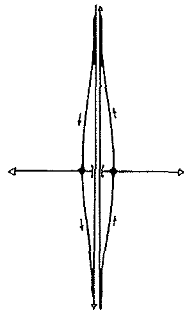


❽ Trumpet



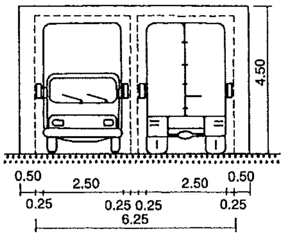
❾ Triangle

❿ Fork

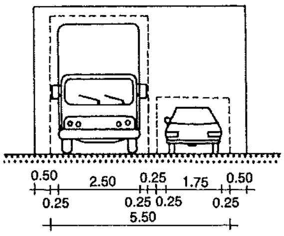


⓫ Diamond

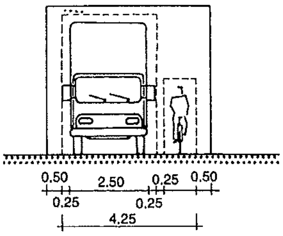
Space required at full speed (≧50 km/h)
General dimensions for traffic spaces and clear spaces for the stated encounter type with full and reduced speed



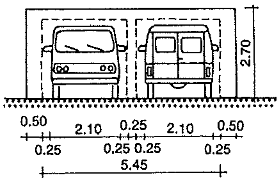
❶ Truck/truck



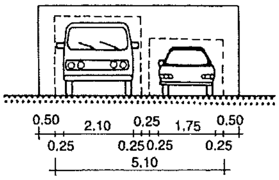
❷ Truck/car



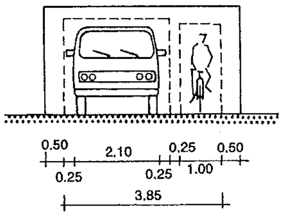
❸ Truck/bicycle



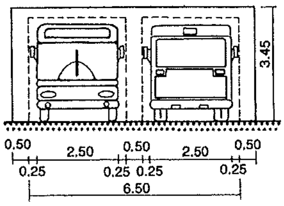
❹ Van/van



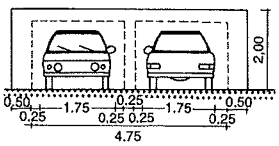
❺ Van/car



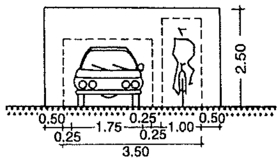
❻ Van/bicycle



❼ Bus/bus



❽ Car/car



❾ Car/bicycle

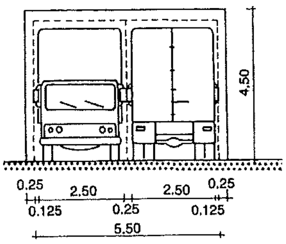
Vehicle traffic space is the sum of the space required by the assessment vehicle, the margin for movement at the sides and above, the addition for two-directional traffic, and the spaces above the drainage channel at the edge of the road and the hard shoulder. The maximum width of the assessment vehicle is, in accordance with European standards, 2.55–2.60 m.

Traffic space for bicycles is one lane each, 1.00 m wide and 2.25 m high → p. 384. Traffic space for pedestrians is a walking strip 0.75 m wide and 2.25 m high. The height of the traffic space for vehicles is 4.20 m, plus a safety margin 4.50 m (or, better, 4.70 m), in order to be able to renew elevated superstructure. For footpaths and cycle tracks, the clear height is 2.50 m.

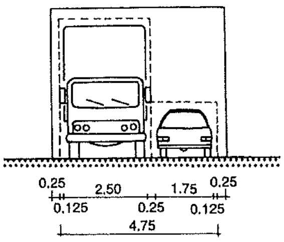
The width of the safety space at the sides is measured from the edge of the traffic space to the side. The necessary width depends on the permissible maximum speed.

Permissible speed ≧70 km/h, safety space ≧1.25 m (1.00 m)
Permissible speed ≧50 km/h, safety space ≧0.75 m → ⓲

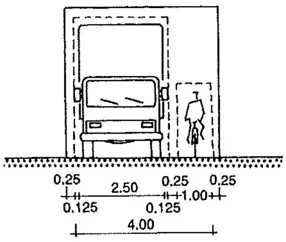
Space required at reduced speed (≦40 km/h)



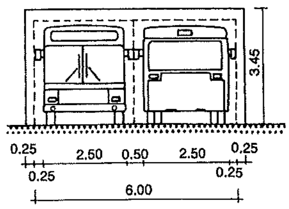
❿ Truck/truck



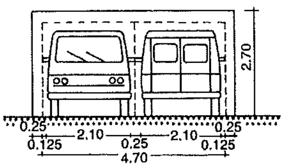
⓫ Truck/car



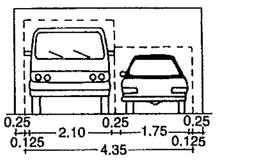
⓬ Truck/bicycle



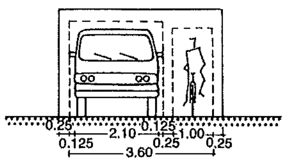
⓭ Bus/bus



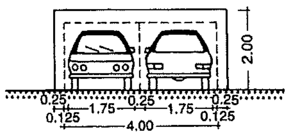
⓮ Van/van



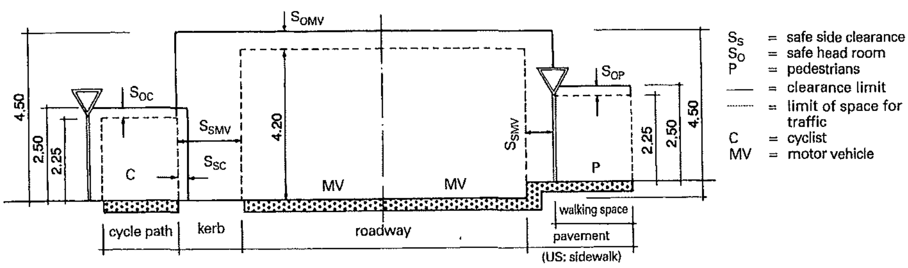
⓯ Van/car



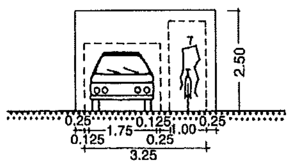
⓰ Van/bicycle



⓱ Car/car



⓲ Dimensions of clear space/traffic space for vehicles



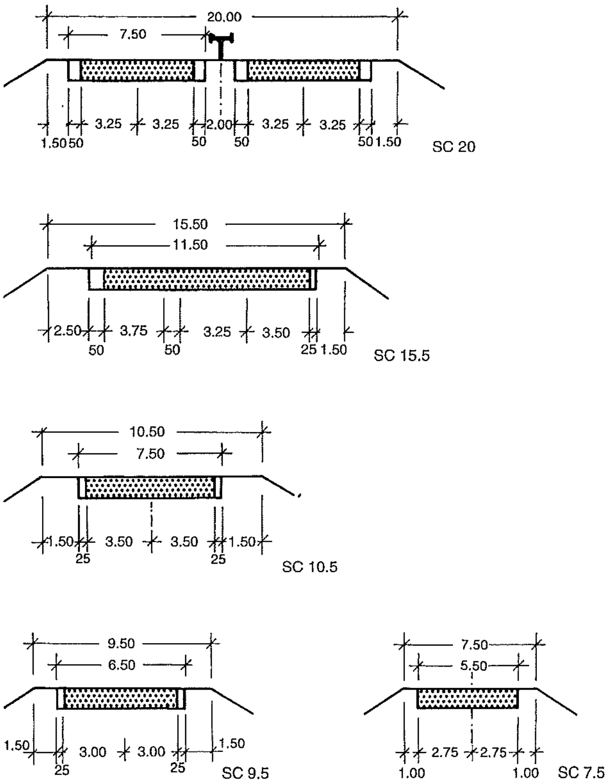
⓳ Car/bicycle

In order to achieve standardised design in the construction and operation of roads, standard cross-sections are provided for the roads outside built-up areas, which should not be deviated from without reason → ❶. Knowing the number of vehicles forecast and the category of the road, the suitable cross-section can be determined using → ❷ p. 377.

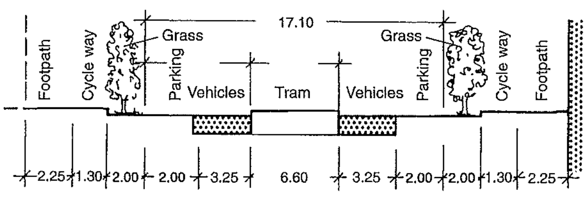
For roads with adjacent building, there are no standard cross-sections. A suitable profile is developed considering the various requirements of users and adjacent property owners for sections of the road. The precondition for this is the decision as to which type of vehicle the road space should be designed for → p. 391. Examples of various built-up road cross-sections are given here → ❷ – ❼.

The intention should be to give the road a distinctive image. This can be achieved through clear, differentiated dimensions, differing arrangement of the various cross-sections, a balanced relationship of the width and height of the street space and diversity of planting. As a result of this, the layout of the street space should enable orientation in the street and also in the town itself.

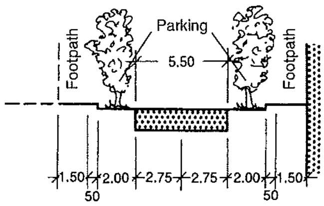
The cross-sections lying at each side of the carriageway influence the creation of functional and visual structure. For design purposes, the following elements should be discussed in addition to function and effect: the footpaths and cycle tracks associated with the road, stopping and parking areas, screening and protection areas, delivery areas and commercial and sales areas.



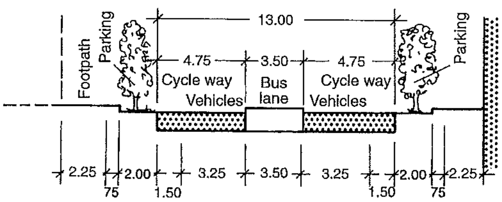
❶ Standard cross-sections (SC) for roads without adjacent buildings



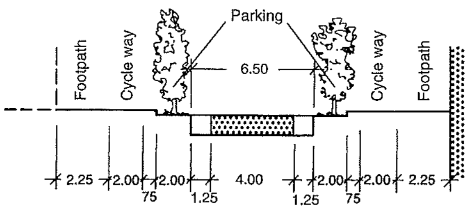
❷ Pedestrian and cyclist area separated from road and parking by grass strips; tram on its own track bed



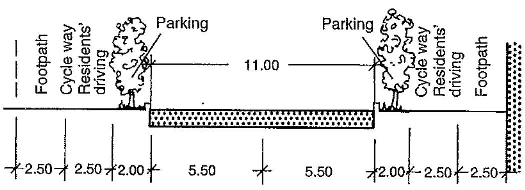
❸ Feeder road, carriageway designed for encounters of trucks with reduced speed; drivable side strip in case larger vehicles meet



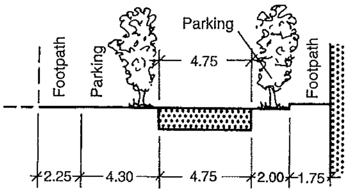
❹ Cycle way near the road has advantage at crossings; bus lane in middle of road



❺ Feeder road, carriageway designed for encounters of cars with reduced speed; drivable side strip in case larger vehicles meet



❻ Extra-wide road, which can be driven in four lanes, with the parking strips physically separated from the road. They can be accessed across the lanes for cyclists and adjacent residents.



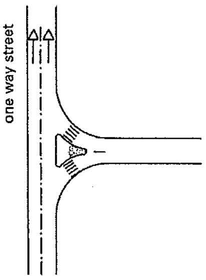
❼ Road for residents, designed for the reduced speed car/truck encounter; parking strips parallel and at right angles to the road

Intersections are categorised into **grade-separated** and **at-grade**. Grade-separated means that the roads cross at different levels (with at least one bridge) and are connected by ramps or slip roads (a motorway-type junction). Intersections on one level are at-grade (with and without traffic lights). These can be T-junctions (one road meets another) → ❶ – ❷ or crossroads (two roads cross) → ❺ – ❽.

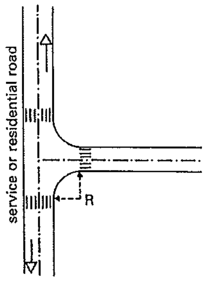
The design of crossings as roundabouts → ⓮ – ⓯ has become common in some countries (e.g. UK, Germany). Small roundabouts are defined as diameter = 25–40 m, large roundabouts >40 m. Their advantages are: less danger of serious accidents, traffic light control no longer required, less noise nuisance, energy saving and reduction in speed on urban roads. The diameter of the roundabout depends on the necessary waiting queue length, which depends on the traffic volume.

A staggered traffic crossing allows more space, clearly understandable road section and spatial definition of the road. This is suitable for slow traffic in residential areas → ⓰.

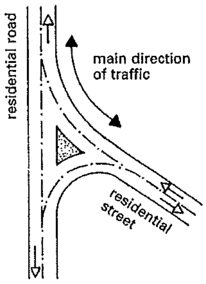
Building is forbidden within 20 m of federal main roads, measured from the outer edge of the carriageway. Building is restricted up to 40 m from the edge of the carriageway. → p. 378 Motorways.



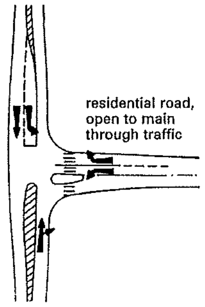
❶ At-grade T-junction



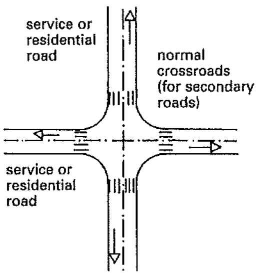
❷ → as ❶



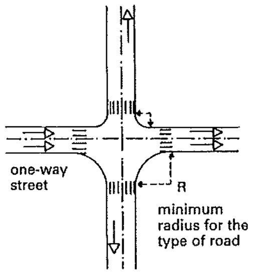
❸ T-junction in a residential feeder road



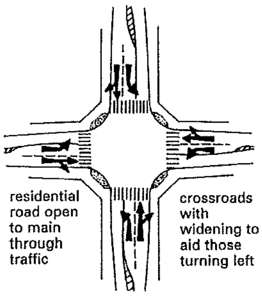
❹ With profile widened for left turning vehicles



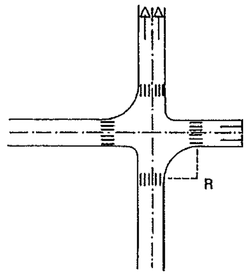
❺ At-grade crossroads



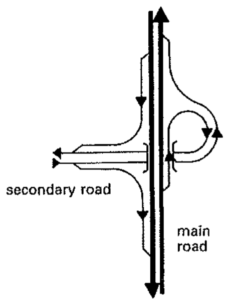
❻ → as ❺



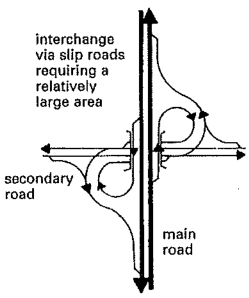
❼ → as ❺



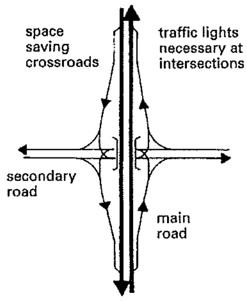
❽ → as ❺



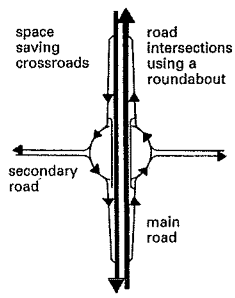
❾ T-junction/crossroads, grade-separated



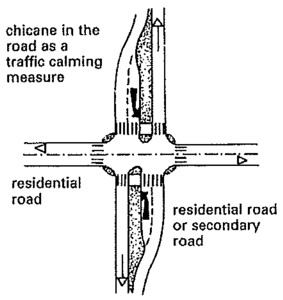
❿ → as ❾



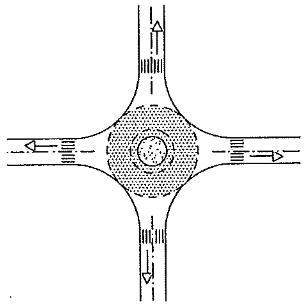
⓫ → as ❾

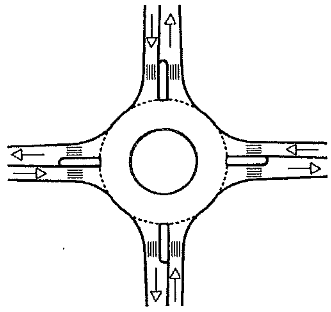


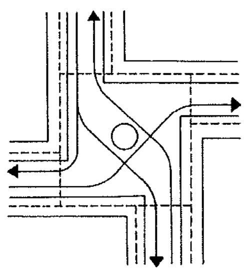
⓬ → as ❾



⓭ Narrowing of the carriageway

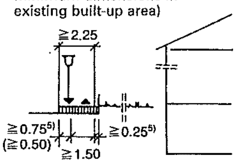

⓮ Small roundabout, D = 25–35 m, inner circle paved


⓯ Larger roundabout, D >40 m, with pedestrian islands

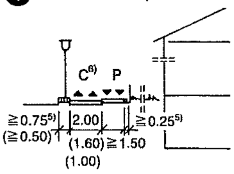

⓰ Staggered road crossing, only for slower traffic

Transport

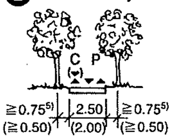
cross-sections[1]
(values in brackets are minimum dimensions in existing built-up area)



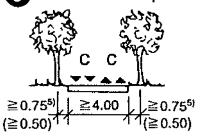
❶ Roadside footpath



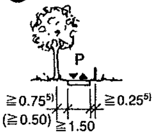
❷ Roadside cycle way



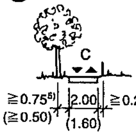
❸ Combined footpath and cycle way



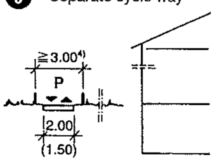
❹ Cycle track



❺ Separate footpath



❻ Separate cycle way



❼ Residential access, not for vehicles

Values of design parameters				
R_1 min [m]	S[2] max [%]	R_B min [m]	R_S min [m]	min. clear height [m]
	6(12)[8]			2.50
10 (2)[7]	as for relevant type of road	30	10	2.50
10 (2)[7]	3 (4 in) <250 m)[8] (8 in <30 m)[8]	30	10	2.50
10 (2)[7]	3 (4 in <250 m)[8] (8 in <30 m)[8]	30	10	2.50
	6(12)[8]			2.50
10 (2)[7]	3 (4 over <250 m)[8] (8 over <30 m)[8]	30	10	2.50
	6(12)[8]			3.50 (2.50)

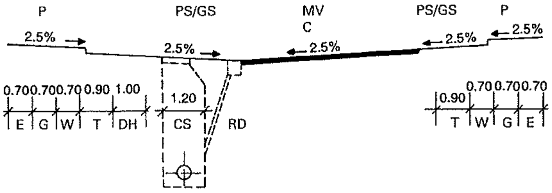
Notes
[1] slight deviations from the given dimensions can be necessary to suit the size of paving slabs
[2] S_{min} = 0.5% (drainage)
[3] length of non-vehicle residential access: up to 2 storeys ≦80 m, 3 storeys ≦60 m, 4 and more storeys ≦50 m
[4] with separated drainage system 4.00–4.50 m
[5] additional width suggestions: continuous rows of trees require at least 2.50 m wide planting strip
[6] two-way traffic only in exceptional cases
[7] rounded out radius at intersections
[8] in exceptional cases

Abbreviations: → ❶ – ❼
P = pedestrian
C = cyclist
R_1 = radius of curves
S = longitudinal slope
R_B = rounded out brow radius
R_S = rounded out dip radius

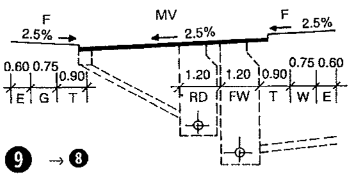
❶ – ❼ Pedestrian and cycle traffic areas

Areas for walking should always be designed to be varied and interesting, also taking into account likely children's usage. Weather protection can be provided by trees, arcades and maybe protecting roofs. Roadside pavements should if possible not be narrower than 2 m (of which 1.50 m min. width and 0.50 m safety distance from the carriageway). A much wider pavement is, however, often appropriate. Near schools, shopping centres, leisure facilities etc., a min. width of 3 m is ideal. → ❶ – ❼

Roadside cycle ways should be min. 1.00 m wide for one-way traffic and 2.00 m (min. 1.60 m) wide for two-way traffic, with safety strips of 0.75 m added to the road. Combined footpaths and cycle ways should be 2.50 m (min. 2.00 m) wide → p. 384.

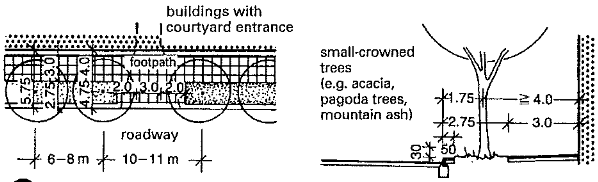


❽ Basic widths for utilities and layout in road space

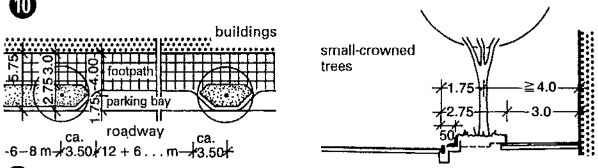


❾ → ❽

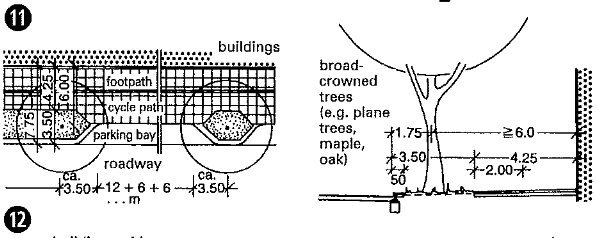
E = electricity
G = gas
W = water
DH = district heating
T = telephone cable
CS = combined sewer
FW = foul water drain
RD = rainwater drain
F = footpath
R = cycle riding
MV = motor vehicle
PS/GS = parking or green strip



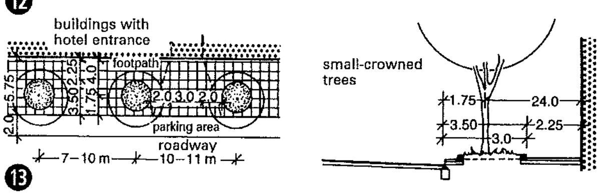
❿



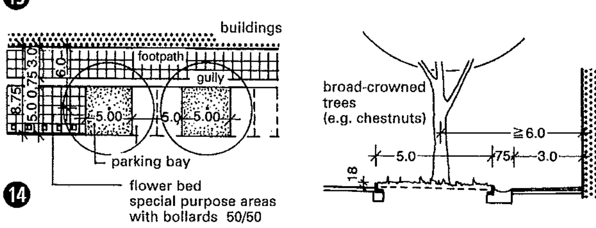
⓫



⓬

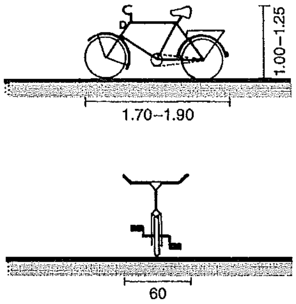


⓭

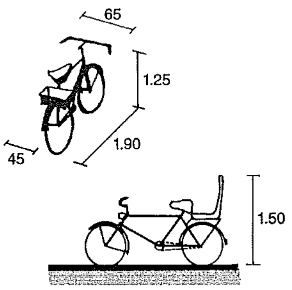


⓮

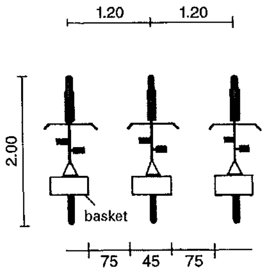
❿ – ⓮ Examples of the layout of street space in built-up areas



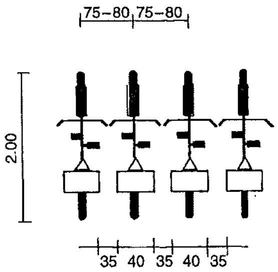
❶ Basic dimensions of bicycles



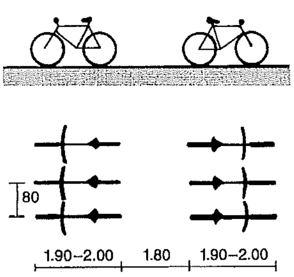
❷ Bicycle with basket/child seat



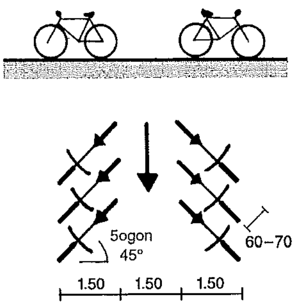
❸ Comfortable bicycle parking



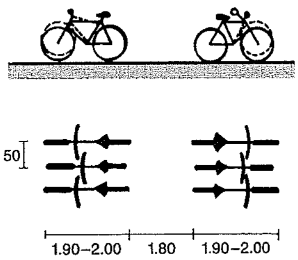
❹ Cramped bicycle parking



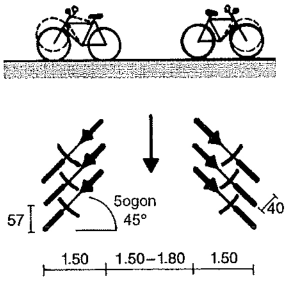
❺ Basic dimensions for the parking of bicycles, straight



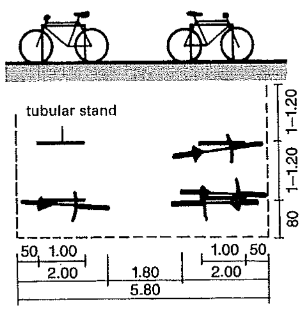
❻ Level arrangement, slanting



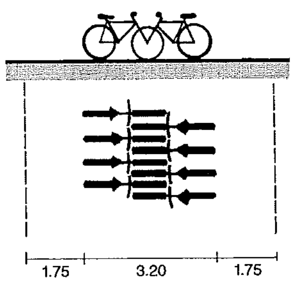
❼ Alternating heights, straight



❽ Alternating heights, slanting



❾ Bicycle parking space with stands



❿ Overlapping bicycles

Dimensions of bicycles → ❶ – ❷. Note allowances for baskets and children's seats. Include space for special bicycles: recumbent bicycles are up to 2.35 m long; tandems up to 2.60 m; bicycle trailer (with shaft) approx. 1.60 m long, 1.00 m wide; bicycles adapted for disabled people and for delivering goods.

Offer comfortable parking → ❸ wherever possible; cramped parking can cause injury, soiling and damage when locking, loading or wheeling in and out. Double rows with overlapping front wheels can save space → ⓬. In contrast, stacking vertically is problematic as it can cause damage.

There should be an appropriate number of parking spaces, according to rules of thumb and building regulations → ⓫. Cycle stands offer steady support, even when loading the bicycle. Locking should be possible using only one U-lock, securing the front wheel and the frame to the stand at the same time. Frame stands are therefore suitable → ❾. Bicycle stands which do not provide sensible locking opportunities are only suitable for internal use in areas of restricted access. Provide an intermediate bar for children's bicycles. Bicycle stands are mostly used on both sides, in which case the space required is 1.20 m → ❾.

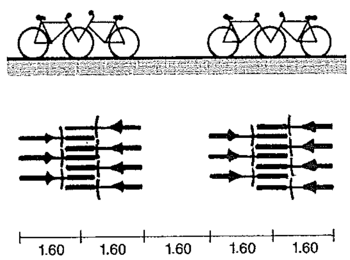
Bicycle passage width 1.80 m → ❼ – ❾; also provide cross-aisles. The entire layout should be as clear and helpful for orientation as possible. Additional parking areas may be required for bicycle trailers and special bicycles.

Where bicycles are parked for many hours, provide roofing and lighting. The parking location should be placed so it is easy to find and ride into, and where there are social controls. Supervised bicycle parking can be appropriate for major events, stations, open-air swimming pools and shopping centres. Locations for bicycle parking can also be converted from car parking spaces.

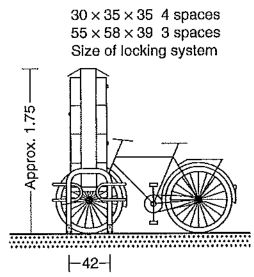
Flats	1 per 30 m² total residential area
Visits for private flats	1 per 200 m² total residential area
Student residence	1 per bed
General school	0.7 per pupil
Adult education	0.5 per visitor
Lecture theatre	0.7 per seat
Libraries	1 per 40 m² of main usable area
College refectory	0.3 per seat
Workplace	0.3 per workplace
Stores for daily shopping	1 per 25 m² sales area
Shopping centre	1 per 80 m² sales area
Shop-type services for daily needs	1 per 35 m² sales area
Office services, doctor's surgery	0.2 per simultaneously present customers
Sport grounds, halls, indoor pool	0.5 per cloakroom place
Assembly place with wide usage	1 per 20 visitor places
Other assembly places	1 per 7 visitor places
Urban public house	1 per 7 seats
Beer garden	1 per 2 seats

If more than one use occurs in one building at the same time, then the values should be added together.

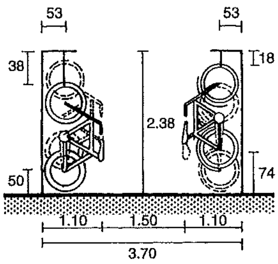
⓫ Guideline values for determining the capacity of bicycle parking



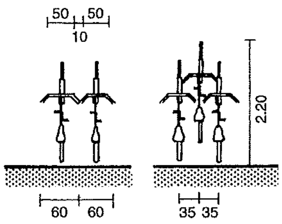
⓬ Overlapping front wheels with central passage



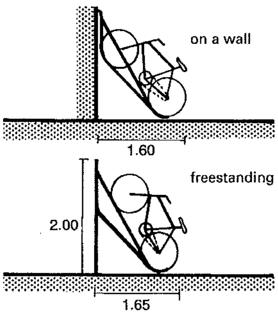
⓭ Locking system



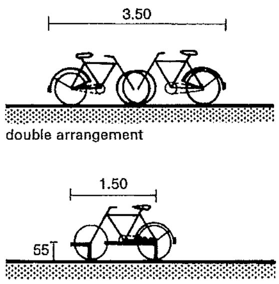
❶ Cycle racks



❷ Parallel   Intermeshed



❸ Tilted racks



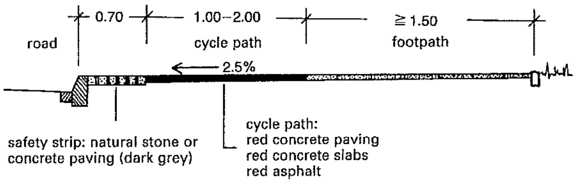
❹ With frame holder

Space required by bicycles: brisk riding in one direction from 1.40 m width, better 1.60 m; overtaking and meeting oncoming bicycles at reduced speed 1.60–2.00 m width; widths of 2.00–2.50 m are better, if bicycles with trailers also use the cycle way.

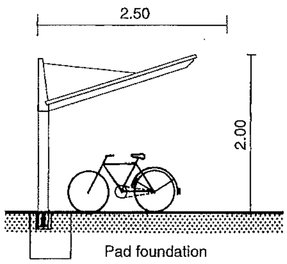
The basic dimensions for the traffic space of bicycles can be deduced from the basic width of 0.60 m plus the height of the cyclist → ❺ and the required margin of movement in various situations.

Passages between cycle stands should not be made too narrow: passage width min. 1.50 m (preferably 2.00 m) up to a length of 10 m, 1.80 m width up to 15 m, 2.20 m width up to 25 m. Interrupt with a passage every 15 m. Passage width between multi-storey stands min. 2.50 m. The longer the stands, the wider the passage.

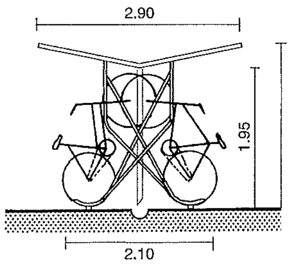
Bike-Safe 1–3 storeys, 15–42 bicycles. Ground area 4 × 4 m height above ground level 5 m → ⓮



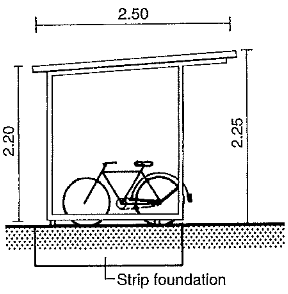
❺ Road–cycle way–pavement



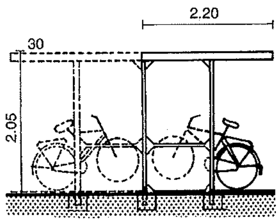
❻ Weather protection roof



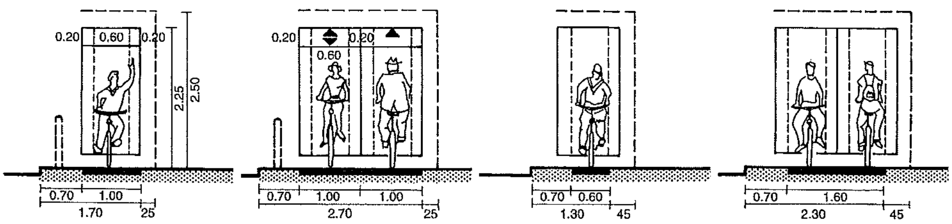
❼ Double racks



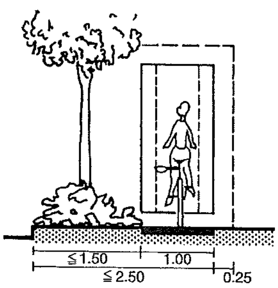
❽ Tubular profile roof structure



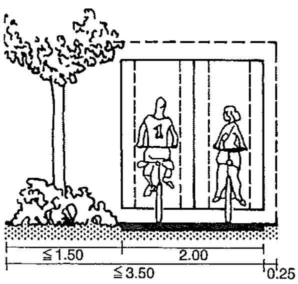
❾ Roofed cycle stands



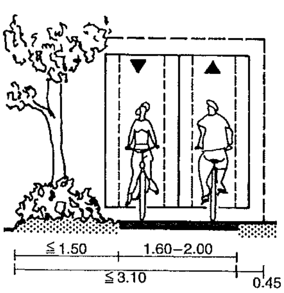
❿ Cycle way width, normal cross-section   Two lane   Limited space   Minimum cross-section



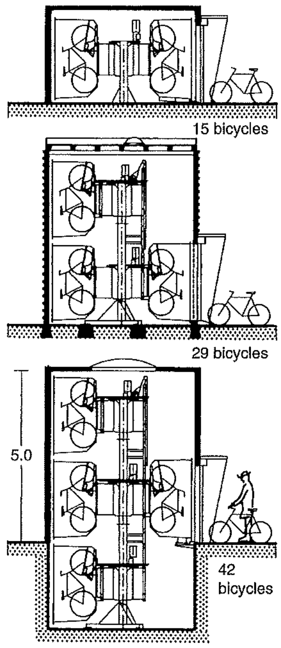
⓫ Grass strips between cycle way and road. Good solution



⓬ Optimal solution



⓭ Grass strips are necessary for two-way traffic



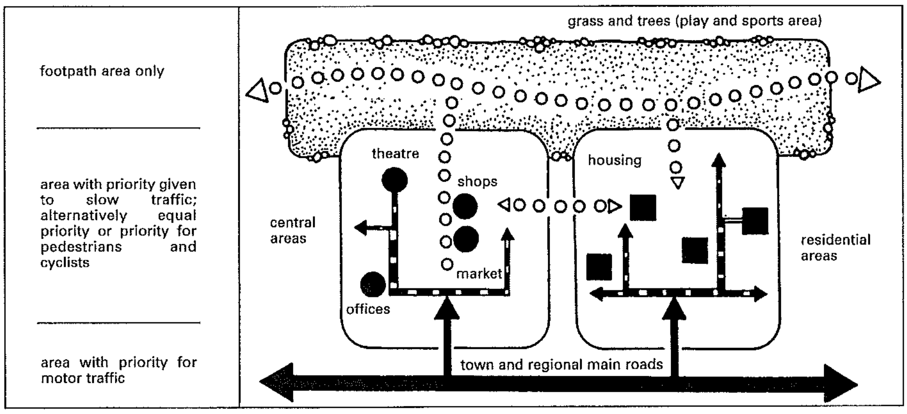
⓮ Bike-Safe

Transport

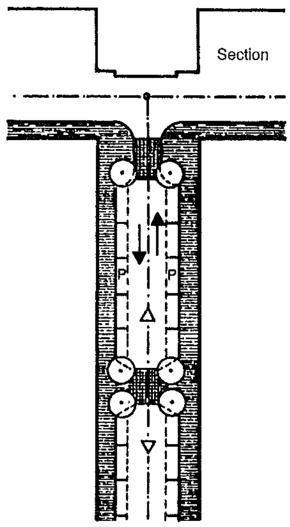
ROADS
Street spaces
Types of road
Motorways
Traffic space
Inter-urban roads
Cross-sections
Intersections
Footpaths and cycle ways
Bicycle traffic/ storage
Traffic calming
Noise protection

no. measures / desired effects	suppression of outside traffic	speed reduction	emphasis on residential character	extra safety for pedestrians/children	extra space for pedestrian movement	reduction of traffic noise	enhanced consideration (positive motivation)	key to measures A – traffic system B – detailed layout C – traffic control ●● desired effect ● probable effect ○ possible effect
A 1 blind alleys culs de sac	●●	○		○		●		
2 crescents	●					○		
3 one way streets	●				○			
B 1 change of road surface material		●						
2 narrowing of road section	●	●●		●		●		
3 visual rearrangement of road space	●	●	●●	●		●	●	
4 dynamic obstacles (humps)	●	●●		●				
5 reorganisation of stationary traffic		●●		●				P P P P
6 raised paving	●	●●	●●	●	●●	●	●●	
C 1 sign: 'Residential area'	●	●	●●	●●		●	●	traffic signs 325/326 StVO (road traffic regulations)
2 speed 30 km/h		●		●		●		30
3 change of priority for drivers	○	●		○				

❶ Traffic calming of roads in residential areas: overview of measures and effects

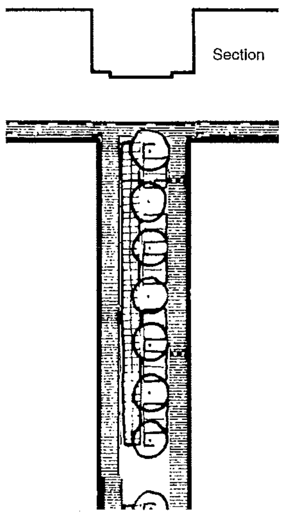


❷ Schematic diagram of the spatial layout of traffic management priorities



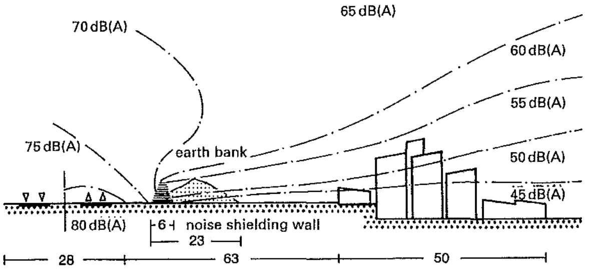
Individual measures:
B1 + B2 + B3 + (where appropriate, B4 + B6) + C1 + C2; driving and pedestrian areas separated, reduction in road size in favour of wider pavements, speed reduction by narrowing the road and partial use of raised paving;
this gives more space and greater safety for pedestrians – improved layout through space subdivision

❸ Road layout proposal A → ❶

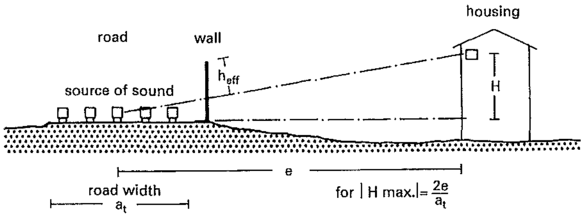


(A3) + B1 + B2 + B3 + B4 + B5 + B6 + C1; layout for driving, parking and walking in a common (mixed) area so multiple use of the whole road area is possible;
speed is limited to 'walking pace' (or 20 km/h max.);
total reorganisation of the whole layout, taking into consideration the primarily residential needs

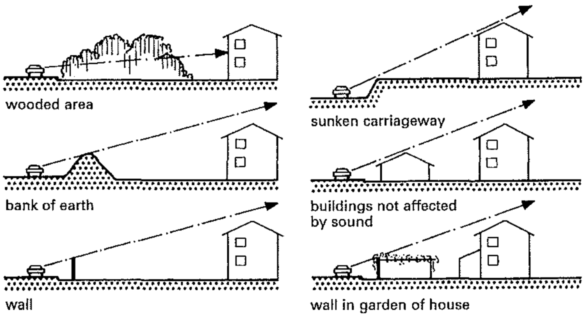
❹ Road layout proposal B → ❶



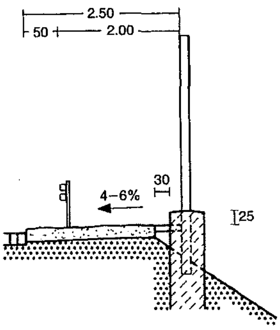
❶ Isophone diagram. The effect on noise level on earth wall or noise mitigation wall



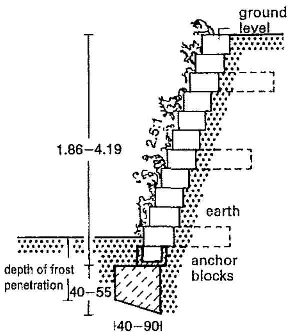
❷ Determining the required height of a noise mitigation wall



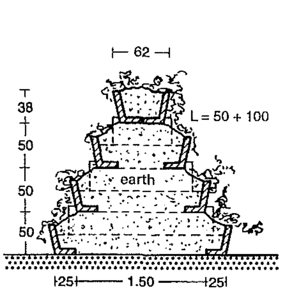
❸ Noise mitigation measures on a main road



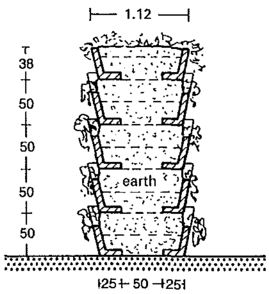
❹ Standard arrangement of noise barriers on roads



❺ Protection wall of concrete blocks H ≦1. 19



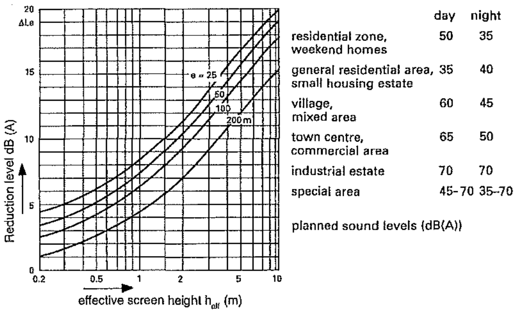
❻ Pyramid noise barrier (precast concrete elements)



❼ Noise barrier wall

Guidelines for road noise protection

Increased environmental awareness has made noise mitigation ever more important, especially in traffic spaces. In particular, the intensity of noise caused by greater traffic load, and denser building, demands effective protection in the form of earth walls, noise reduction walls and noise reduction pyramids → ❶ – ❼. Road traffic noise should be reduced by about ≦25 dB (A) on the other side of the noise reduction wall. This reduction is described as Δ LA, R, STR. and is a modified noise reduction value for road traffic noise. Noise reduction walls can be reflecting Δ LA, a, STR. <4 dB (A), absorbing 4 dB (A) ≦LA a STR. <8 dB (A), highly absorbing 8 dB (A) ≦LA a STR. The relevant standard and the Guidelines for Road Noise Protection (RLS – 81) give detailed calculation methods. The mitigation effect of a wall is not dependent on the construction material, but mostly on the height of the wall. The effect against road traffic noise is based on the creation of a noise shadow, but this, in contrast to a visual shadow, is not fully effective. Bending of the noise allows a part to reach the shadow zone. The proportion is smaller, the higher the wall and the longer the bypass route of the deflected noise. A multitude of pre-cast concrete elements are available from the industry, and also noise reduction walls of glass, timber and steel.



❽ Reduction of noise level

Required reduction		10	15	20	25	30	35
Required	Grass area	75–125	125–250	225–400	375–555	—	—
distance (m)	Woods	50–75	75–100	100–125	125–175	175–225	200–250

❾ Reduction of noise with distance

Barrier or wall, height (m)	1	2	3	4	5	6	7
Reduction in dB (A)	6	10	14	16.5	18.5	20.5	23.5

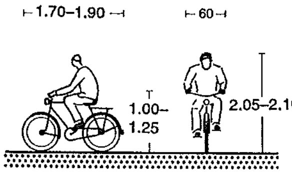
❿ Reduction of road traffic noise with height of barrier

Traffic loading both directions daytime, vehicles/h	Assignment of road types to traffic loading	Distance of emissions location from centre of road (m)	Noise level range
<10	residential road	—	0
10–50	residential road (2-lane)	>35 26–35 11–25 ≦10	0 I II III
>50–200	residential feeder road (2-lane)	>100 36–100 26–35 11–25 ≦10	0 I II III IV
>200–1000	built-up section of rural road and residential feeder road (2-lane)	101–300 36–100 11–35 ≦10	I II III V
	rural road outside residential area or in industrial zone (2-lane)	101–300 36–100 11–35 ≦10	II III IV V
>1000–3000	urban main traffic road or road in industrial zone (2-lane)	101–300 36–100 <35	IV IV V
>3000–5000	motorway link/main road, motorway (4-lane)	101–300 ≦100	IV V

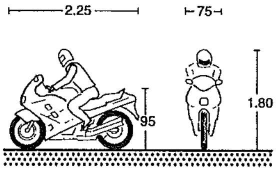
⓫ Approx. estimation of existing or expected road traffic noise

see also:
Windows pp. 97, 100
Glass pp. 105, 107

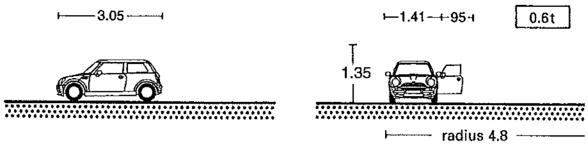
Dimensions, turning circles and weights of typical vehicles regarding space requirements and regulations for garages, parking spaces, and access and exit driveways.



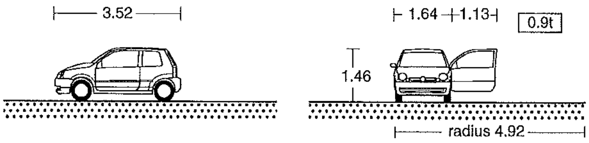
❶ Bicycle



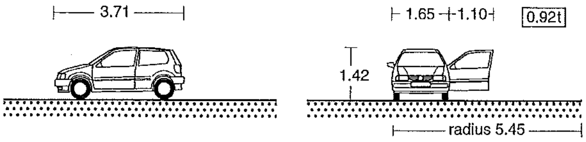
❷ Motorcycle



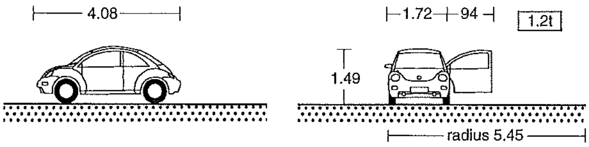
❸ Mini



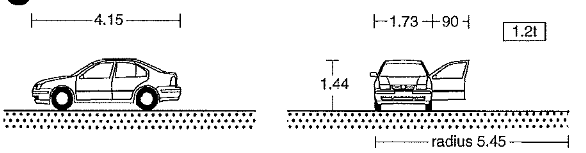
❹ VW Lupo



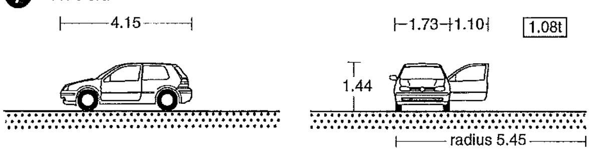
❺ VW Polo



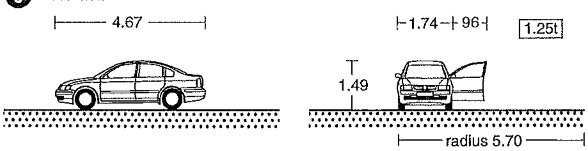
❻ New Beetle



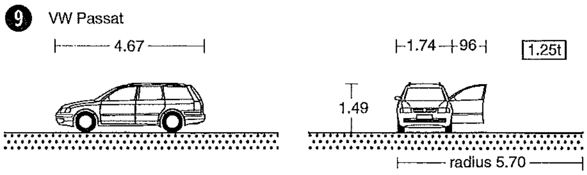
❼ VW Bora



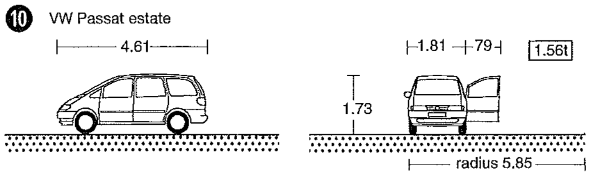
❽ VW Golf



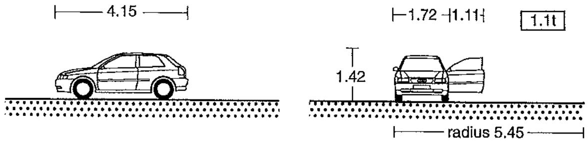
❾ VW Passat



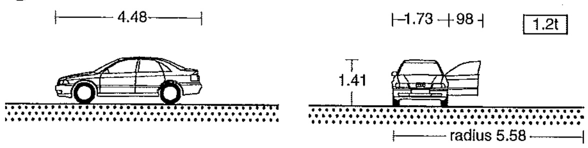
❿ VW Passat estate



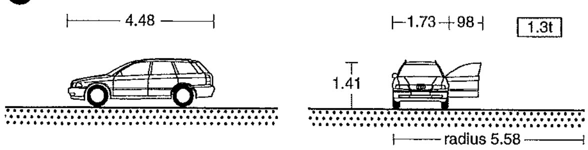
⓫ Sharan



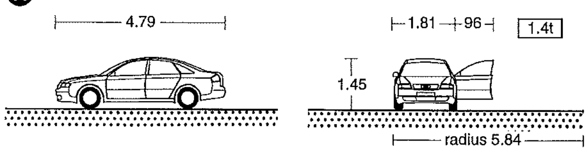
⓬ Audi A3



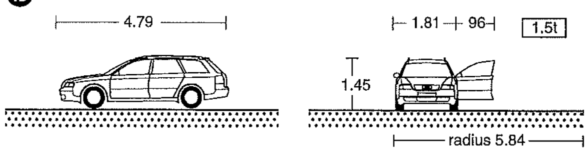
⓭ Audi A4



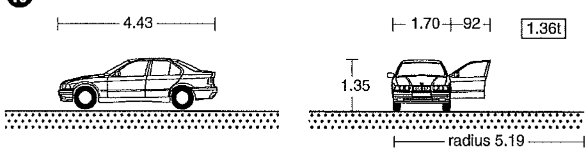
⓮ Audi A4 estate



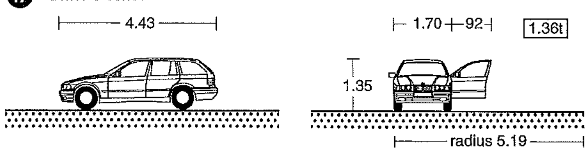
⓯ Audi A6



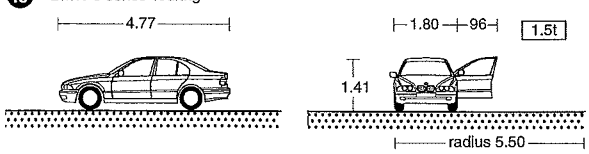
⓰ Audi A6 estate



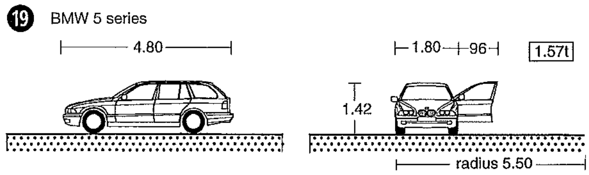
⓱ BMW 3 series



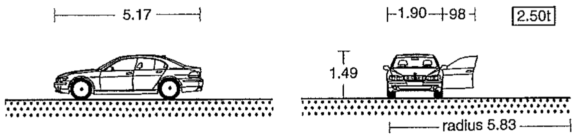
⓲ BMW 3 series Touring



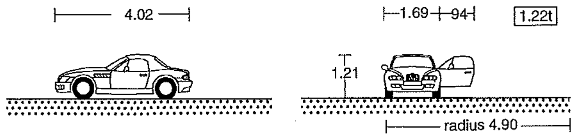
⓳ BMW 5 series



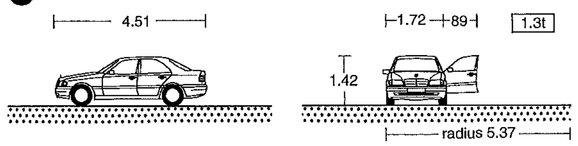
⓴ BMW 5 series Touring



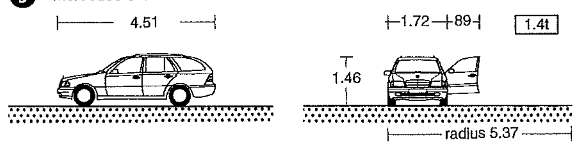
1 BMW 7 series



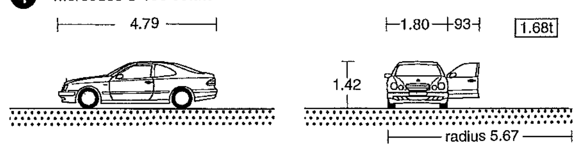
2 Z3 Roadster BMW



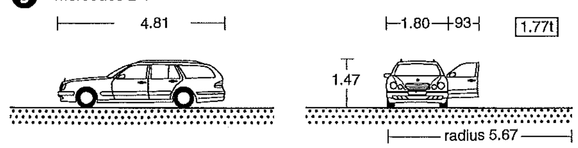
3 Mercedes C 180



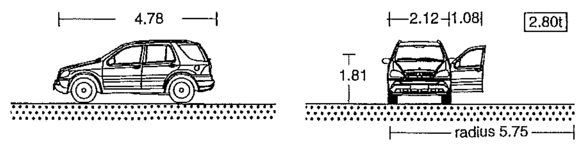
4 Mercedes C 180 estate



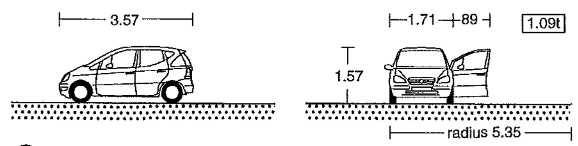
5 Mercedes E 430



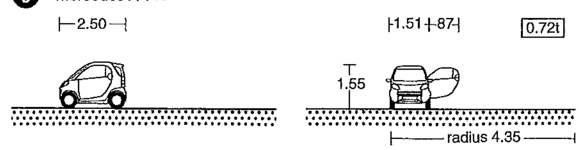
6 Mercedes E 430 estate



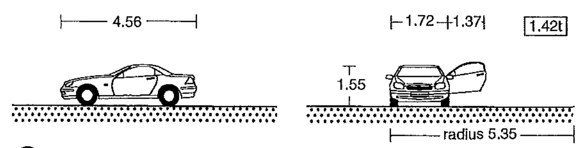
7 Mercedes M



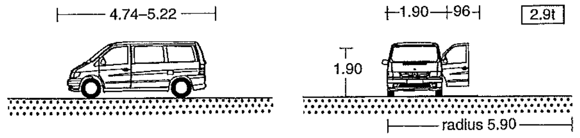
8 Mercedes A 140



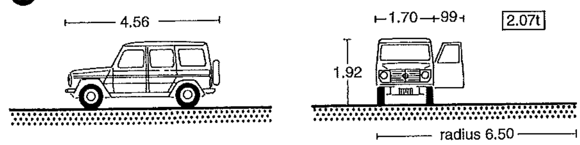
9 Smart



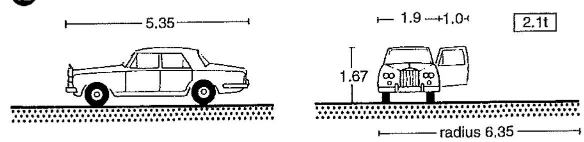
10 Mercedes CLK



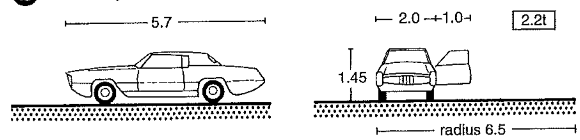
11 Mercedes Vito



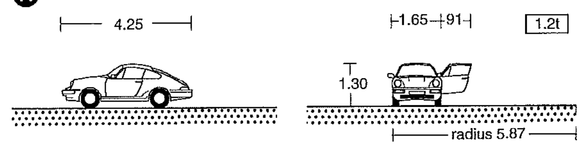
12 Mercedes station wagon, long, five-door



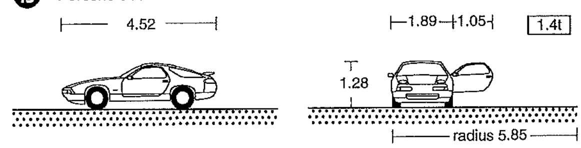
13 Rolls-Royce



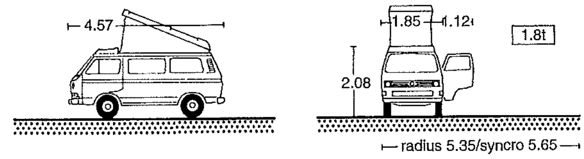
14 American car



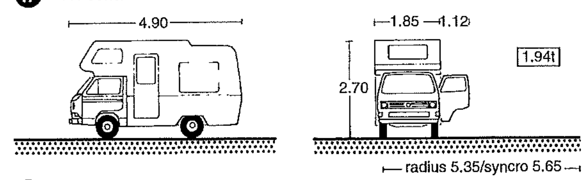
15 Porsche 911



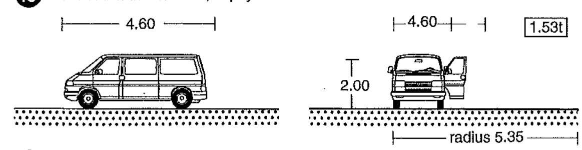
16 Porsche 928



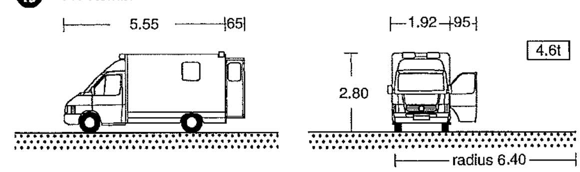
17 VW Joker



18 VW Karman-Cheetan, Gipsy



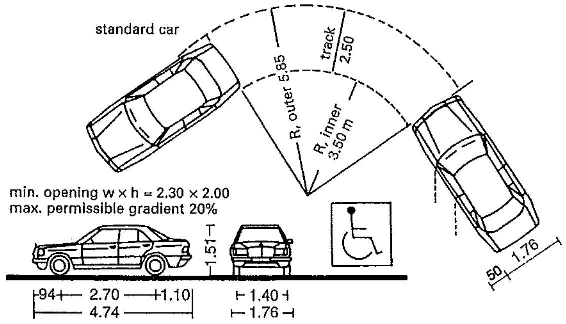
19 VW Kombi



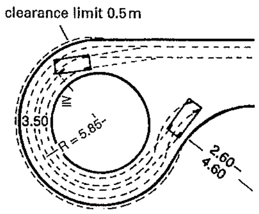
20 Ambulance

Transport

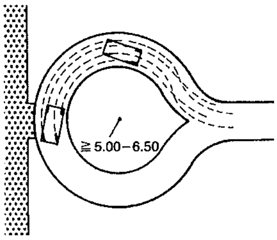
PARKING FACILITIES
Vehicles – cars
Vehicles – turning
Parking spaces
Multi-storey car parks
Ramps
Multi-storey car park regulations
Parking systems
Vehicles – trucks
Trucks – parking and turning
Service areas
Petrol stations
Car wash



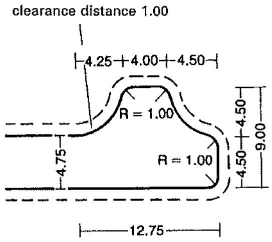
❶ Standard car



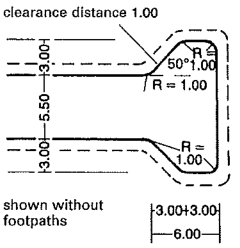
❷ Turning circle of a car



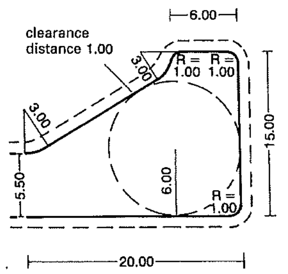
❸ Entrance drive, car turning circle radius ≧5–6.50 m



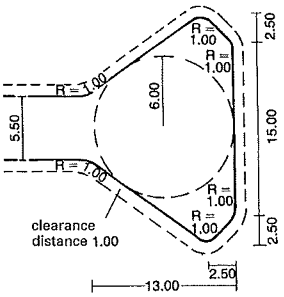
❹ Hammerhead turning place for cars



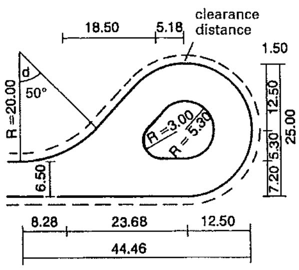
❺ Hammerhead turning place for cars and HGVs up to 8 m length (refuse collection vehicle, fire engine, HGV 6 t)



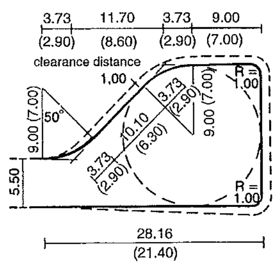
❻ Turning place for HGVs up to 10 m and 22 t (3-axle refuse collection vehicle)



❼ Variant of ❻



❽ Turning loop for HGVs with trailer and articulated buses



❾ Turning circle for 2-axle refuse collection vehicle (r = 9) or for vans (r = 7), values in brackets

The type, size and design of a place where vehicles can turn depend on the particular use of an area, the vehicles and the urban planning function. It is difficult to make generally valid recommendations for the selection of the correct turning place. The requirements of the fire services and refuse disposal trucks have to be considered in turning place decisions. Some authorities responsible for waste disposal decline to remove rubbish from dead-end streets where refuse disposal trucks can only perform a three-point turn or have to drive backwards for considerable distances.

Turning places can be formed as hammerheads → ❹ – ❺, turning circles or turning loops → ❻ – ❾. Hammerheads demand manoeuvres such as three-point turns, so turning circles and loops are preferable as they allow trucks to turn in one swing.

Turning places should for practical reasons be laid out asymmetrically to the left → ❻ – ❾. The perimeter of turning places should allow sufficient space without fixed objects being endangered by the overhanging parts of vehicles. The centre of turning loops can be planted → ❽. Hammerhead turning places → ❹ are only suitable for cars. They are not necessary where the road is more than 6 m wide, which can also include garage forecourts or footpath crossings.

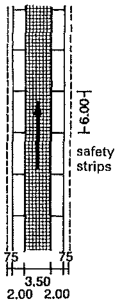
	External dimensions						
			Overhang length				External turning
Type of vehicle	Length	Wheelbase	Front	Back	Width	Height	circle radius
	[m]	[m]	[m]	[m]	[m]	[m]	[m]
Bicycle	1.90				0.60	1.00	
Moped	1.80				0.60	1.00	
Motorcycle	2.20				0.70	1.00	
Car	4.74	2.70	0.94	1.10	1.76	1.51	5.85
HGVs:							
Van/campervan	6.89	3.95	0.96	1.98	2.17	2.70	7.35
HGV (2 axles)	9.46	5.20	1.40	2.86	2.29	3.80	9.77
HGV (3 axles)[1]	10.10	5.30[1]	1.48	3.32	2.50[4]	3.80	10.05
HGVs with trailer:	18.71						
Towing vehicle (3 axles)[1]	9.70	5.28[1]	1.50	2.92	2.50[4]	4.00	10.30
Trailer (2 axles)	7.45	4.84	1.35[3]	1.26	2.50	4.00	10.30
Articulated HGVs:	16.50						
Tractor unit (2 axles)	6.08	3.80	1.43	0.85	2.50[4]	4.00	7.90
Semi-trailer (3 axles)[1]	13.61	7.75[1] 1.61	4.25	2.50	4.00	7.90	
Buses:							
Coach, bus	12.00	5.80	2.85	3.35	2.50[4]	3.70[6]	10.50
Coach, bus[2]	13.70	6.35[2]	2.87	4.48	2.50[4]	3.70[6]	11.25
Coach, bus[2]	14.95	6.95[2]	3.10	4.90	2.50[4]	3.70[6]	11.95
Articulated bus	18.75	5.98/5.99	2.65	3.37	2.50[4]	2.95	11.80
Refuse collection vehicles:							
2 axles (2 Mü)	9.03	4.60	1.35	3.08	2.50[4]	3.55	9.40
3 axles (3 Mü)	9.90	4.77[1]	1.53	3.60	2.50[4]	3.55	10.25
3 axles (3 MüN)[2]	9.95	3.90	1.35	4.70	2.50[4]	3.55	8.60
Highest values permitted in Germany:							
HGV	12.00						
Trailer	12.00				2.55[4)5)]	4.00[6]	12.50
HGV with trailer	18.75						
Articulated HGV	16.50						
Articulated bus	18.00						

Notes: 1) for vehicles with 3 axles, the rear tandem axle is integrated to a middle axle
2) for 3-axle vehicles with a trailing axle, the wheelbase corresponds to the distance between the front axle and the forward axle of the rear tandem axle
3) without tow bar length
4) without external mirror
5) additional equipment for air-conditioned HGVs up to 2.60 m
6) as double-decker bus 4.00 m

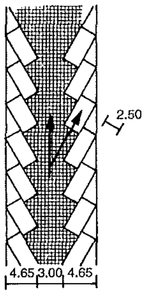
❿ Basic vehicle data → p. 397–398

Type of road	Use of zone	Design vehicle	R (m)	Notes
access road to houses, residential road with little traffic	residential	car	6	– turning circle for cars – special provision for refuse collection vehicles (e.g. link road connection via lanes with limited traffic access)
residential road	predominantly residential	cars, 2-axle refuse collection vehicle	8	– turning circle for small buses and most refuse collection vehicles – possibility for all permissible vehicles to perform three-point turn
residential road	residential, also	car, waste disposal, 3-axle HGV,	10	– adequate turning circle for great majority of permissible HGVs
	considerably	standard bus,	11	– turning circle for newer buses
	commercial	articulated bus	12.5	– turning circle for articulated buses
	predominantly commercial	lorry with trailer, articulated bus	12.5	– adequate turning circle for all permissible HGVs
An additional 1.00 m width should be kept free at the outside of turning places for vehicle overhangs.				

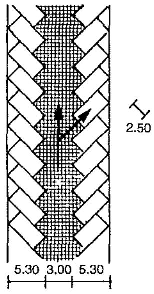
⓫ Recommendations for determination of external turning circle radius (R)



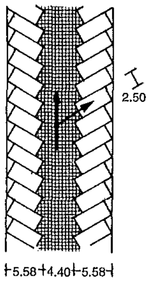
1 Parking parallel to the road



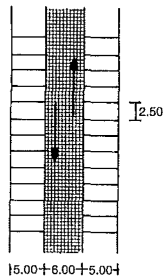
2 30° oblique parking and exiting is simple, but one-way traffic only



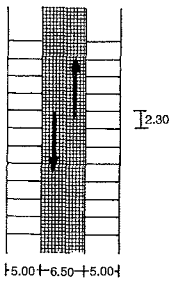
3 45° oblique parking, one-way traffic only



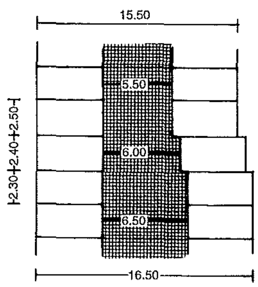
4 60° oblique parking, one-way traffic only



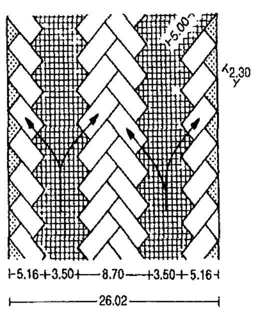
5 90° parking and exiting is possible in both directions. Access width 5.50 m for increased manoeuvring



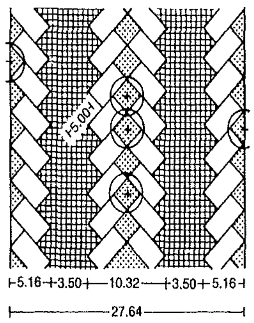
6 90° parking and exiting is possible in both directions. Parking space width 2.30 m



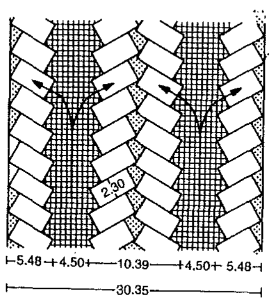
7 Parking spaces and access widths



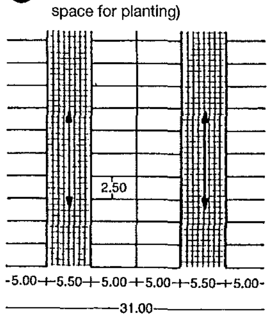
8 45° parking, one way traffic only



9 Parking, one way traffic only (leaves space for planting)



10 60° parking, one way traffic only



11 90° parking, access 5.50 m wide, parking space 2.50 m wide

Parking spaces are usually outlined by 12–20 mm wide yellow or white painted lines. When parking is facing a wall, these lines are often painted at a height of up to 1 m for better visibility. Guide rails in the floor along the side have also proved popular for demarcation of parking limits, and can be about 50–60 cm long, 20 cm wide and 10 cm high.

Where vehicles are parked in lines facing walls or at the edge of the parking deck in a multi-storey car park, it is common practice to provide buffers, restraining bars or railings up to axle height to prevent cars from going over the edge. Where cars are parked face to face, transverse barriers about 10 cm high can be used to act as stops at the front. Overhang on vehicles must be taken into account → 15. For lining up in front of a wall, a stop rail or rubber buffer will be sufficient → 15.

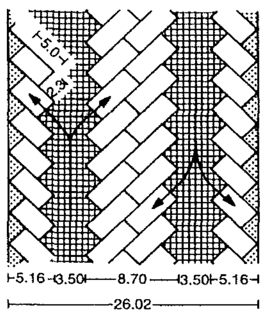
Parking arrangement	Space requirement per place incl. access (m^2)	No. places in 100 m^2 area	No. places on 100 m of road (one side only)
→ 1 0° parallel to road. Difficult parking and exiting – good for narrow roads	22.5	4.4	17
→ 2 30° oblique to road. Simple parking and exiting. Area busy	30.8 (27.6)	3.2 (3.6)	20 (21)
→ 3 45° oblique to road. Good parking and exiting. Area per place relatively low. Normal type of layout	24 (21.7)	4.2 (4.6)	29 (31)
→ 4 60° oblique to road. Relatively good parking and exiting. Area per place low. Frequently used layout	22.5 (20.5)	4.4 (4.9)	34 (37)
→ 5 and 6 90° right angle to road. Low area per place. Considerable turning of vehicle necessary	20 (19.0)	5 (5.3)	40 (44)

The given values are for a parking space 2.50 m wide.
The values in brackets (parking place width 2.30 m) should be used only in justified and exceptional cases.

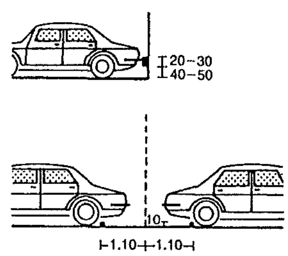
12 Space requirements

Arrangement of garage parking spaces to the access. At an angle of:	Required access width (in m) for a garage parking space width of:		
	2.30	2.40	2.50
90°	6.50	6.00	5.50
75°	5.50	5.25	5.00
60°	4.50	4.25	4.00
45°	3.50	3.25	3.00
up to 30°	3.00	3.00	3.00

13 Access width. (Parking space 2.50 m wide is standard. This value should if possible always be complied with in public areas)

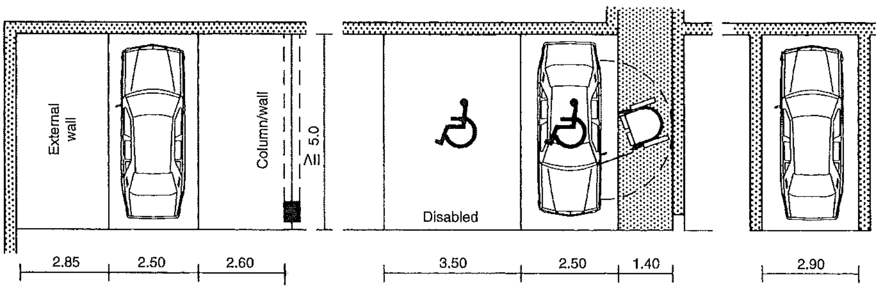


14 Oblique parking layout

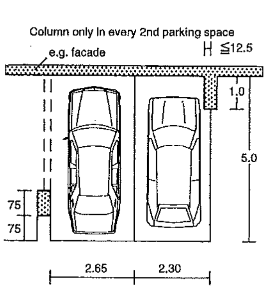


15 Transverse bumpers and impact buffers

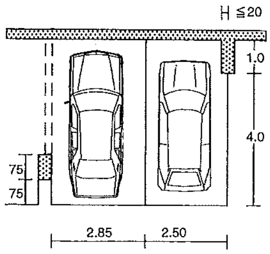
If individual parking spaces are bordered by pillars, walls or columns, then the width of the parking space on the relevant side is increased by 0.10 m → 1 – 3. (This does not, however, apply to mechanical lifting platforms or automatic garages.) If parking spaces are bounded by a footpath, cycle way or separation strip on the facing side via a kerb, then the kerb will be used to estimate the border of the parking space → 4 + 8. The examples show how parking spaces can be integrated into their surroundings by design elements without impairing their function → 5 – 7.
To increase open areas, parking spaces can be partly or completely lowered or provided with green roofs. The greening not only has design value but also provides shadow and improves the ecological situation (dust absorption) → 7.



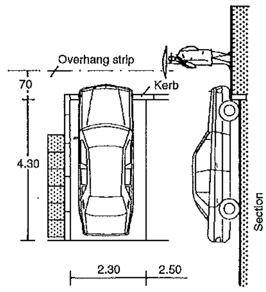
1 If parking spaces are bordered by pillars or walls, then the width is increased



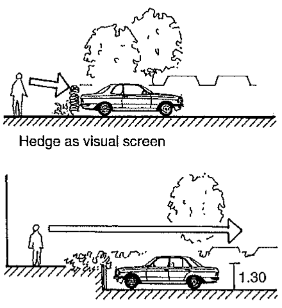
2 Reductions are possible in private buildings



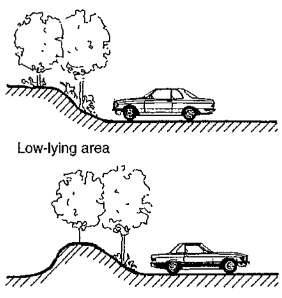
3 Comfortable parking and exiting



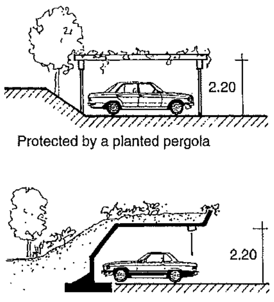
4 With kerb border



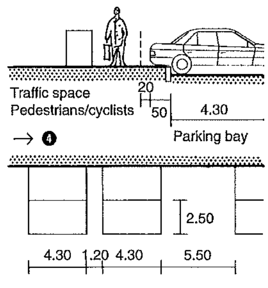
5 Lowered parking space



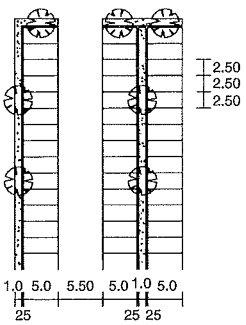
6 Parking behind an earth wall



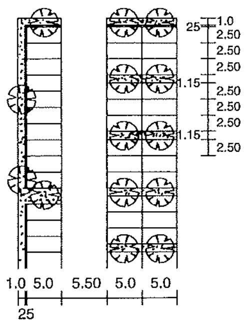
7 With earth covering



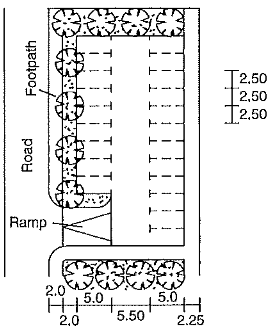
8 Block layout



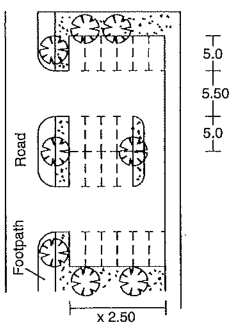
9 Car park with planting



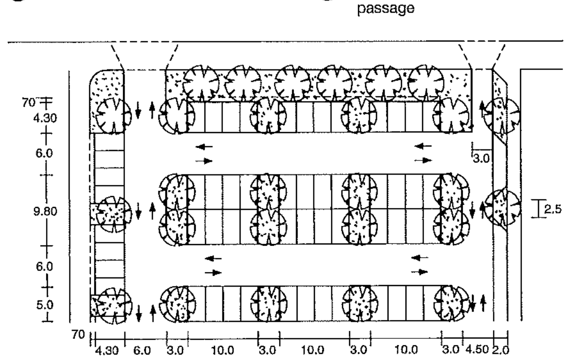
10 Planting at right angles to the access passage



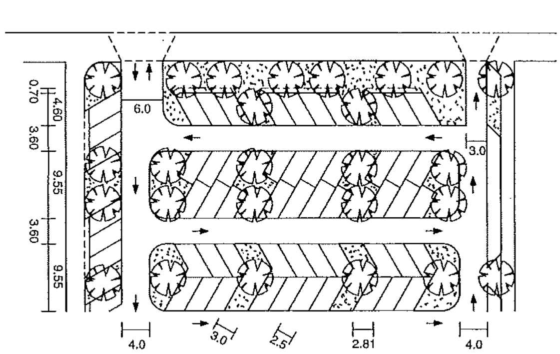
11 Lowered parking area → 5 – 6



12 Parking next to the road



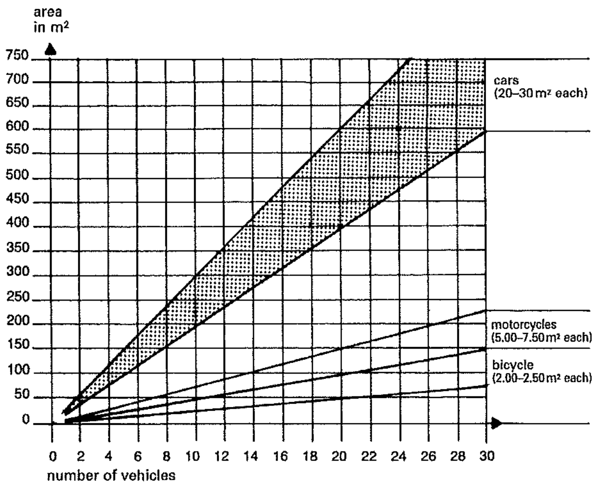
13 Example: car park



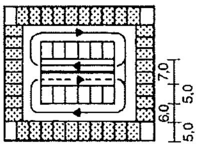
14 Variant: oblique layout in car park

Transport

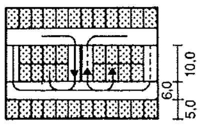
PARKING FACILITIES
Vehicles – cars
Vehicles – turning
Parking spaces
Multi-storey car parks
Ramps
Multi-storey car park regulations
Parking systems
Vehicles – trucks
Trucks – parking and turning
Service areas
Petrol stations
Car wash



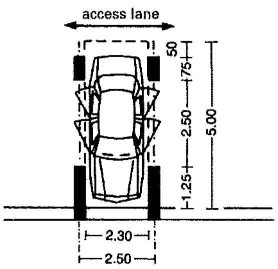
❶ Space requirement of car parks including access areas → p. 390 ⓬



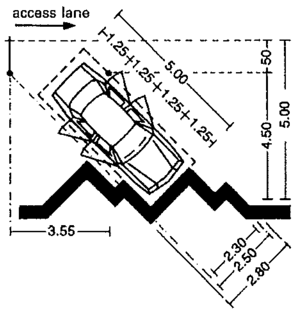
❷ Longitudinal ramp, for exact dimensions see p. 390



❸ Transverse ramp



❹ Possible column arrangement for right-angled parking



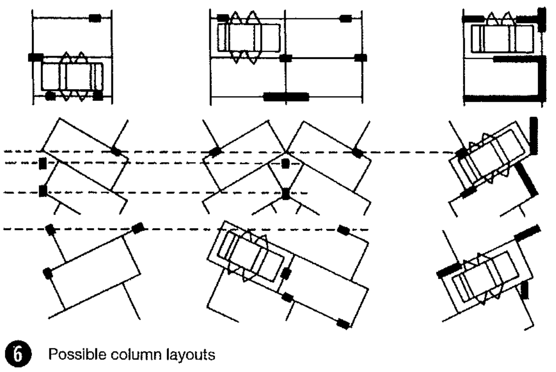
❺ 45° oblique parking

For multi-storey car parks the requirements for the layout of parking spaces and access are in principle the same as for open car parks. The Garage (multi-storey car park) Regulations require a minimum width for parking spaces of 2.30 m. The Research Company for Roads and Traffic (FGSV), however, recommends a minimum width of 2.50 m for all publicly accessible parking spaces on account of the increasing size of cars.

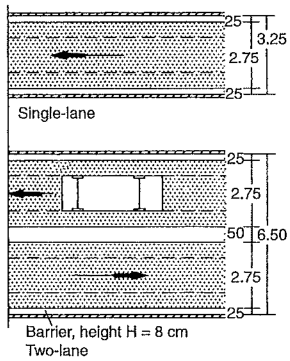
All structural elements (ceilings, walls, columns, reinforcements) of multi-storey car parks must be fire resistant. The recommended clear access height for car parks above and below the ground is 2.20 m. An addition of 25 cm is practical for the direction signage for cars and pedestrians, plus a further 5 cm for later resurfacing. This gives a total height of 2.50 m plus construction over the access ways, thus a storey height of 2.75–3.50 m, depending on the chosen method of construction. A relatively close spacing of columns can reduce building cost without impairing function if the construction height is carefully chosen → ❷ – ❸. Wide-spanning column-free constructions have 7–12% less column area on plan → ❹.

Underground car parks result in considerably higher costs for construction and operation than those above ground.

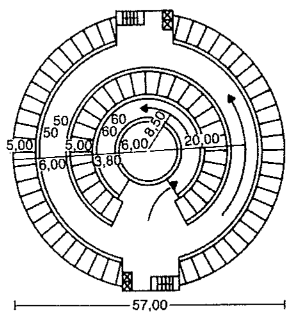
Uphill sections and ramps must be designed and built in line with the above → ❽. Straight or spiral car park ramps are created by sloping the floor slab → p. 393, or forming spirals → ❻, with vehicles both sides of the access way. The areas, including access areas, on which a certain number of vehicles can be parked can be determined for preliminary design from → ❶. The examples → p. 393 and p. 394 show layouts of multi-storey car parks and ramp arrangements. Reinforced concrete construction (in in-situ concrete, pre-cast elements or a combined form) comply best with the fire-resistance requirements. Steel structures are normally designed as a main beam/secondary beam system and mostly have to be clad with concrete or fire protection boards, or sprayed, for fire resistance reasons. Car parks catering for passenger cars should be designed for a live loading of 3.5 kN/m² and the ramps for 5 kN/m² for design purposes, for greened roofs 10 kN/m².



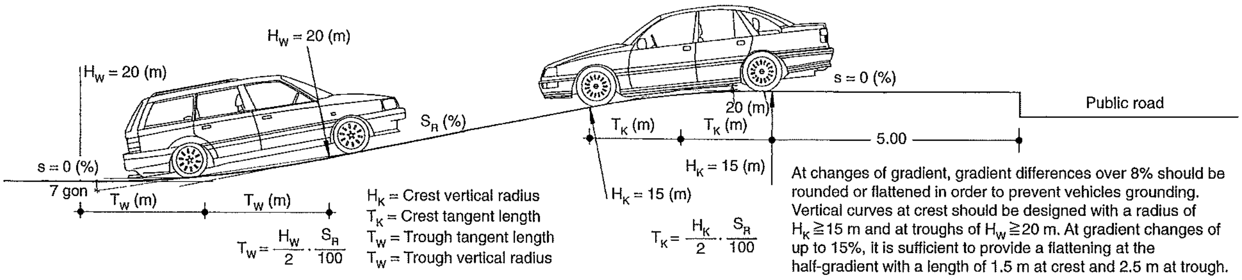
❻ Possible column layouts



❼ Minimum width of straight ramps



❽ Spiral car park ramp



At changes of gradient, gradient differences over 8% should be rounded or flattened in order to prevent vehicles grounding. Vertical curves at crest should be designed with a radius of $H_K \geqq 15$ m and at troughs of $H_W \geqq 20$ m. At gradient changes of up to 15%, it is sufficient to provide a flattening at the half-gradient with a length of 1.5 m at crest and 2.5 m at trough.

❾ Ramps – changes of slope

PARKING FACILITIES

Ramps

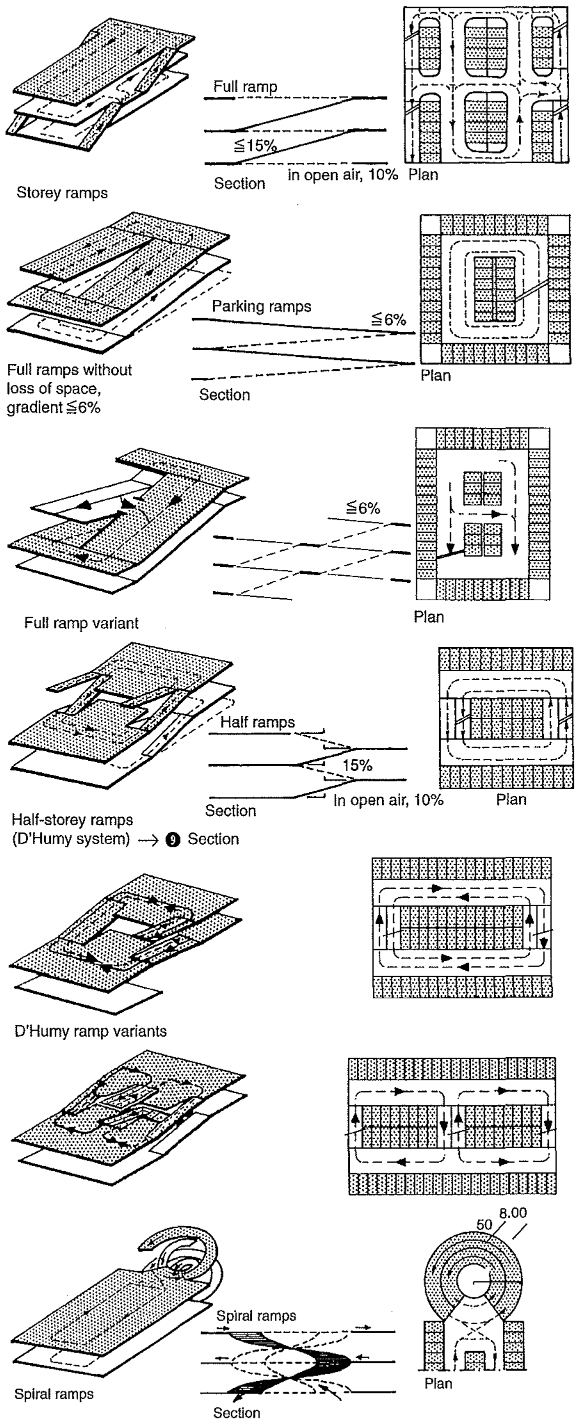
There are various systems of ramps to overcome height differences and to access the various storeys of multi-storey car parks. The gradient of ramps should not exceed 15%, for small car parks 20%. Between public roads and ramps with more than 5° gradient, there must be a horizontal run of ≧5 m length, or in the case of ramps for cars the run should be ≧3 m long, with ramps at up to 10% gradient. Possible arrangements of ramps can be divided into four groups:

Straight, parallel and continuous multi-storey ramps with intermediate landing, access and exit opposite → ❶.

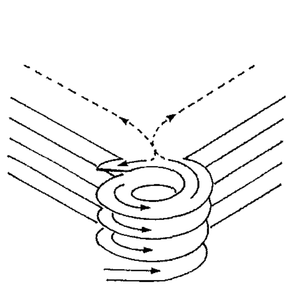
Sloping floor levels (no-loss full ramp system). The entire area with parking spaces is on a slope, a space-saving system. Slope ≧6%.

Half-storey offset levels (D'Humy ramps). Parking spaces are on half-storeys and the height difference is overcome by short ramps. This is a space-saving system but not very smooth to drive around and therefore only intended for smaller car parks → ❶, ❻ and ❽.

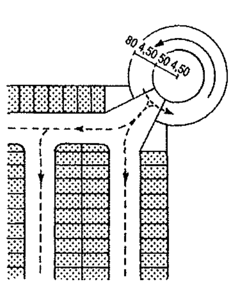
Spiral ramps. This system is relatively expensive yet has poor visibility, and the circular form leads to residual areas, which are hard to exploit → ❶ – ❺. The spiral ramps must have a transverse gradient of ≧3%. The radius of the inner road edge is ≧5 m. In large multi-storey car parks, ramps also used by pedestrians must have a ≧80 cm wide raised pavement, unless routes for pedestrians are provided elsewhere.



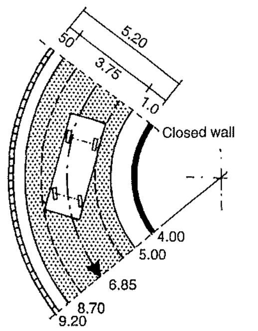
❶ Ramp systems



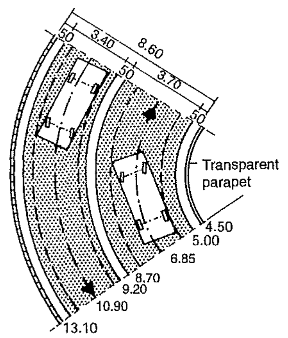
❷ Separate spiral ramp towers at the corners of the building



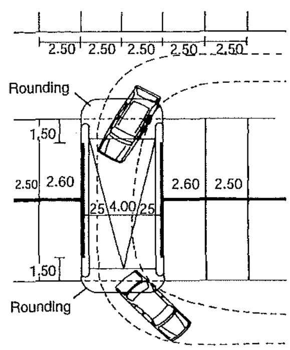
❸ Schematic plan → ❷



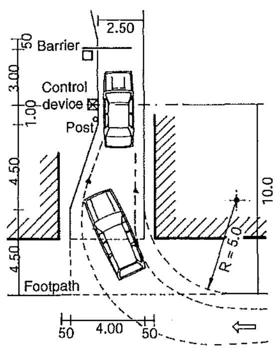
❹ Minimum ramp widths



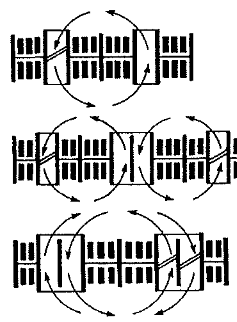
❺ Minimum ramp widths in curve with minimum radius



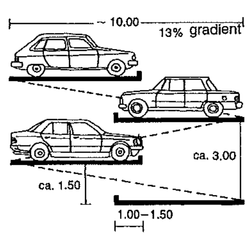
❻ Half-ramp with one-way traffic



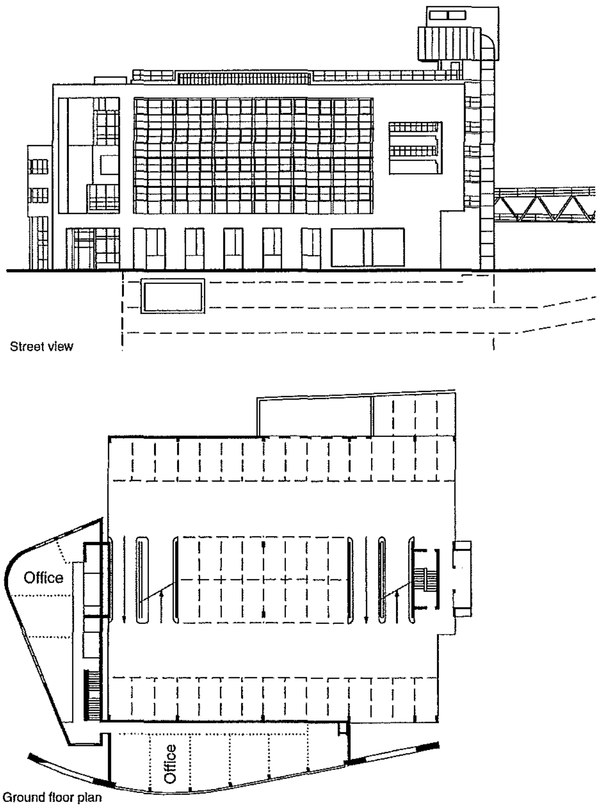
❼ Access control



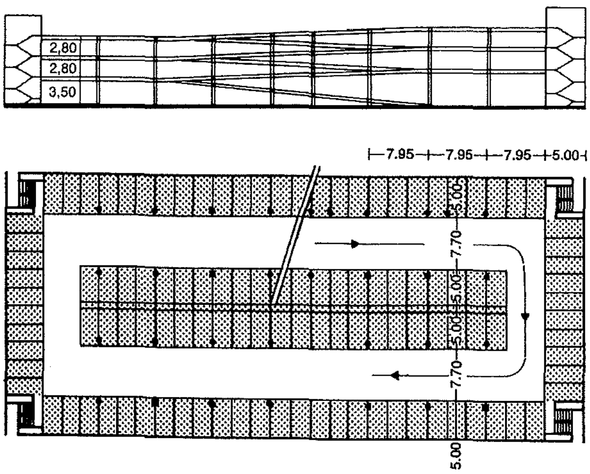
❽ Basic forms of D'Humy ramps. Ramps with 13–15% gradient



❾ Dovetailing of half-storeys → ❽



❶ Multi-storey car park with additional use: offices incorporated in the façade
Arch.: Kister Scheithauer Gross



❷ Multi-storey car park with access route ramps

According to the Garage (multi-storey car park) Regulations, small car parks are of $\geqq$100 m^2, medium car parks 100–1000 m^2 and large car parks $\geqq$1000 m^2 usable area. Underground car parks are defined as having the floor level $\geqq$1.30 m below ground level. Large multi-storey car parks must have separate access and exits. They are located near large traffic concentrations like those at stations, airports, shopping centres, theatres, cinemas, offices, administrative buildings and large residential buildings. Medium and large multi-storey car parks must be in easily accessible areas.

Such car parks must have a clear height of min. 2.0 m in areas accessible on foot, also under support beams, ventilation ducts and other building elements. The ground floor is generally higher, as it usually has other uses.

Escape routes of max. 30 m are required to the stairs or exits.

For vans the clear height is 2.50 m. Floor loadings according to the relevant standard. Open multi-storey car parks have apertures, which cannot be closed, leading directly into the open air, with a size of one third of the total area of the envelope wall, with the opposite wall at a maximum distance of 70 m. These provide transverse ventilation even with weather protection measures.

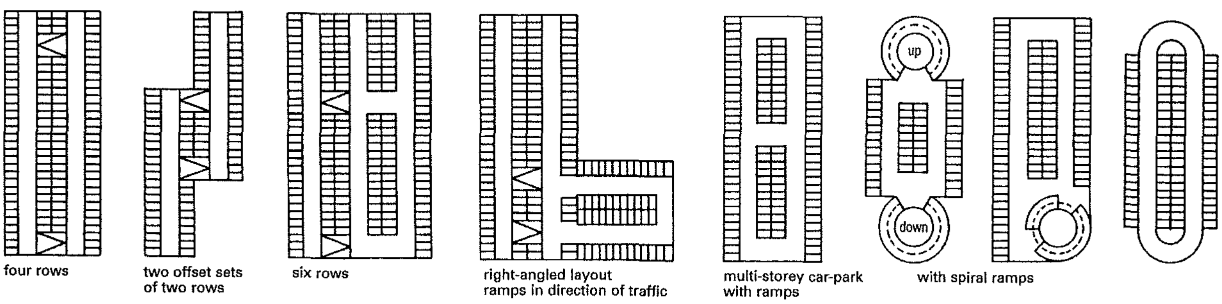
Concerning the minimum dimensions for access, exits and internal routes, these must include no space for starting to drive round a curve. Particularly where ramps join to internal routes at right angles, additional room must be provided for the start of driving round the corner and the relevant minimum radii must be complied with. It must also be possible for larger cars to drive in and out without manoeuvring processes → p. 393 ❻. The planned traffic routeing must always be checked against the relevant swept curves.

Criteria for the quality of multi-storey car parks:
The scale of the façades of multi-storey car parks should fit into their surroundings. The façade elevation can also be used for other functions, for example as offices → ❶. Further criteria: integration into urban planning coherence, natural lighting and ventilation, greening, uncomplicated system for charging fees, good access to public transport – Park and Ride.

Safe operation
Video surveillance, glass areas in lobbies (observe fire protection requirements), visual contact with the outside, visibility through the longest possible column spacing, light colours differentiating the storeys, distinctive marking of parking spaces to help visitors find them again.

Indication of sanitary facilities		
supervisory and maintenance staff:		1 WC, 1 washbasin, 1 bucket sink
50–100 parking spaces	ladies:	1 WC, 1 washbasin
	gents:	1 WC, 1 washbasin 1–2 urinals

❸ Guidelines for sanitary facilities in large multi-storey car parks

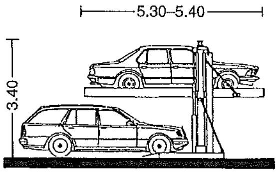


❹ Examples of the layout of parking spaces and ramps

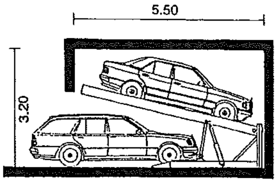
Transport

PARKING FACILITIES

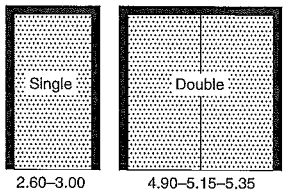
Vehicles – cars
Vehicles – turning
Parking spaces
Multi-storey car parks
Ramps
Multi-storey car park regulations
Parking systems
Vehicles – trucks
Trucks – parking and turning
Service areas
Petrol stations
Car wash



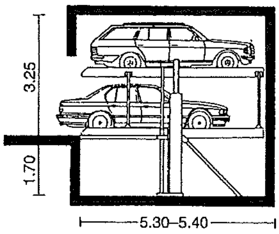
1 Dependent parking of two vehicles



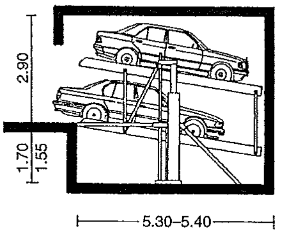
2 Dependent parking, inclined, without a pit



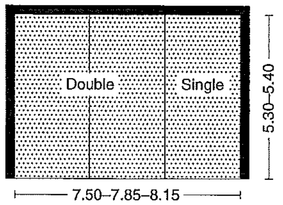
3 Plan



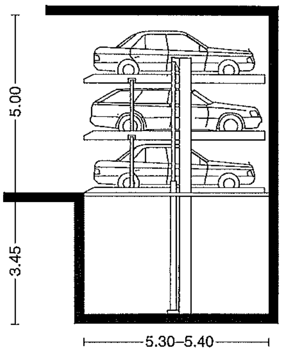
4 Independent parking of two (four) vehicles above each other



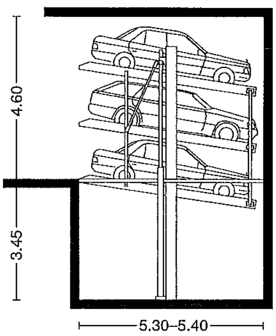
5 Space-saving parking on an incline



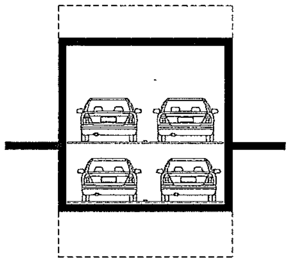
6 Plan



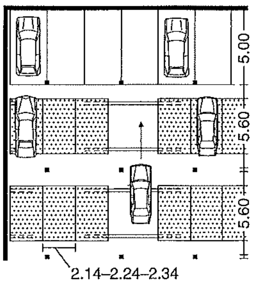
7 Three parking spaces, accessible horizontally



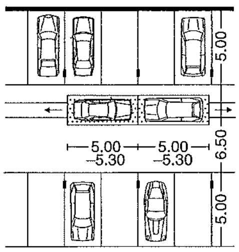
8 Accessible on an incline



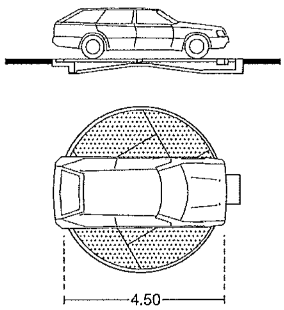
9 Parking lift double system → 3 - 6



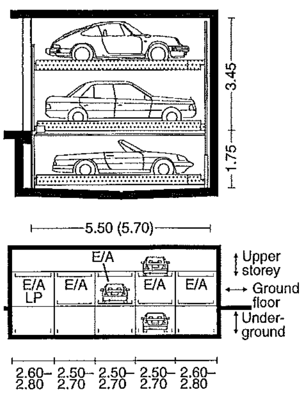
10 Parking platform – sideways movement



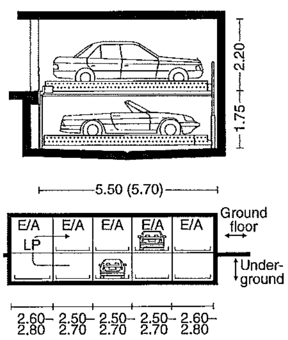
11 Parking platform – lengthways movement



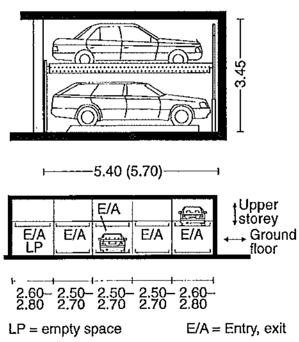
12 Turntable rotating 360°



13 Combilift with three parking levels and pit



14 Combilift with two parking levels and pit



15 Combilift with two parking levels

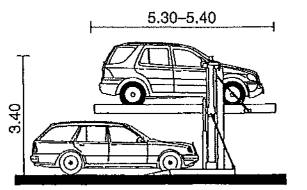
Parking systems are mostly used for private parking. The selection and specification of the system should also take larger than normal vehicles into account (e.g. off-road vehicles, vans and sports utility vehicles – SUVs).

Two cars can be parked one above the other in single garages on movable platforms → 1 - 2. The operation is electric, or in case of power cuts, with a hand pump. A parking lift can handle up to three cars → 7 - 8 as a row of garages in a courtyard or parking garages, and operated by the doorman with a control panel. Loading per parking space is 2500 kg. The gradient on driving into and out of the garage ≦14%.

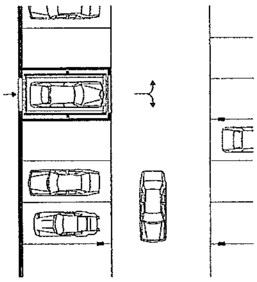
Parking platform systems → 10 - 11 enable space-saving parking for various amounts of room. Cars stand on parking platforms, which are moved via a control desk to clear the access route.

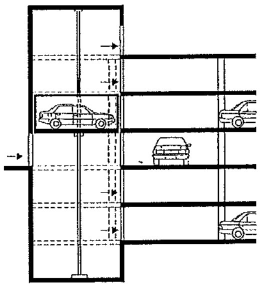
Parking platforms – lengthways movement: parking platforms are moved at the touch of a button → 11. Unoccupied parking platforms can be driven over. Sideways movement → 10 is used where greater available depth could provide two, three or more rows of places but too much area would otherwise be lost for access. Therefore, in front of a stationary row of places, sideways-moving parking platforms are provided, which can be moved so that the places behind can be reached.

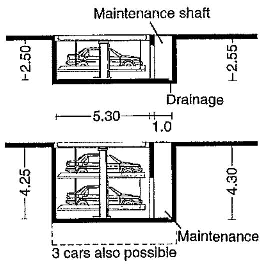
Parking platform/parking lift → 1 - 9 dependent parking: in the open air parking systems can be built only with horizontal platforms → 1 see also p. 396.



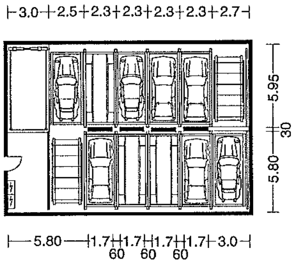
16 Parking systems should consider the heights of different cars


❶ Parking with a car lift

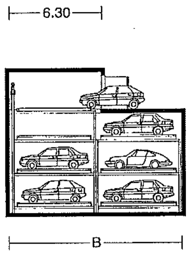

❷ Parking without ramps, section → ❶



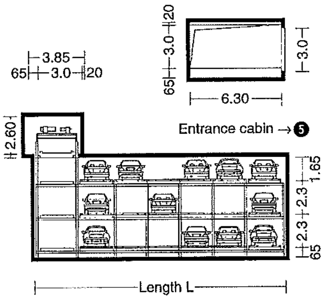
❸ Underground garage (Wöhr)



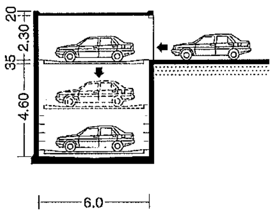
❹ Floor parker (Wöhr)



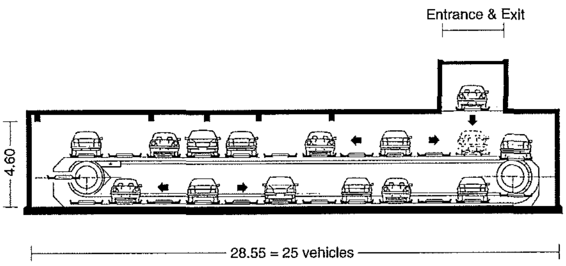
❺ Cross-section → ❹



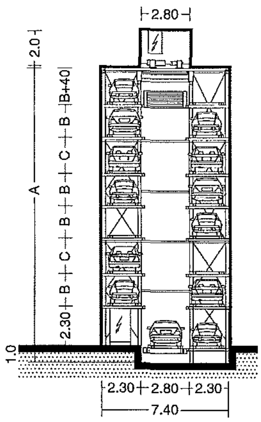
❻ Longitudinal section → ❹



❼ Circulating parker

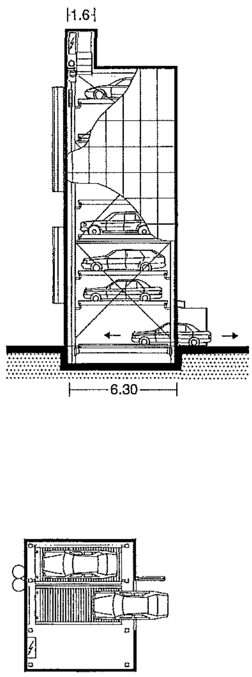


❽ Cross-section → ❼ (Pristinger)

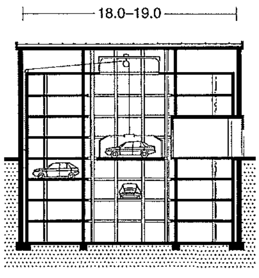


Parking levels	Parking spaces	Cars up to height of A = 175 cm B = 188 cm C = 208 cm
2	5	646 cm
3	7	854 cm
4	9	1042 cm
5	11	1230 cm
6	13	1438 cm
7	15	1626 cm
8	17	1814 cm

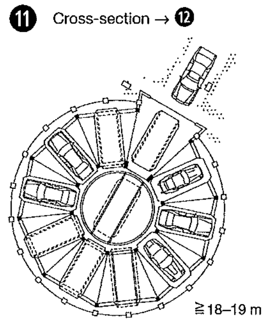
❾ Cross-section of Parksaf (Wöhr)



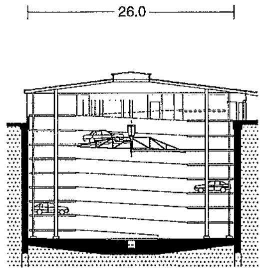
❿ Cross-section → ❾



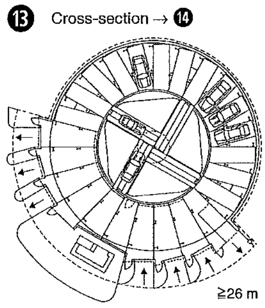
⓫ Cross-section → ⓬



⓬ Parking cylinder: 10 vehicles/floor (Meyer)

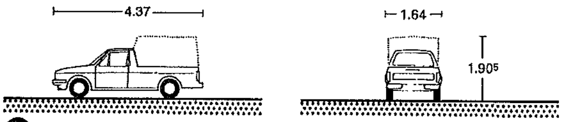


⓭ Cross-section → ⓮

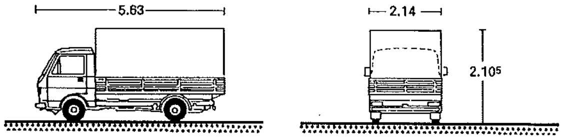


⓮ Parking cylinder: 24 vehicles/floor

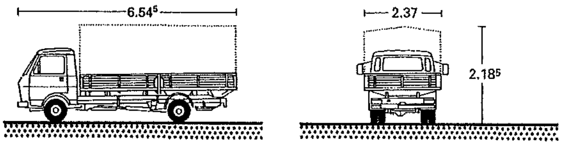
Car lift – parking lift → ❶
A simple mechanical parking mechanism that can be installed in multi-storey car parks to replace the function of ramps, normally because they are impossible due to lack of space. The lift transports the vehicle with driver to the chosen level. Horizontal transport is usually by driving as normal. The average number of parking spaces is 8–30 on one or more levels.
The fully mechanical parking tower → ❾ – ❿ creates additional parking space not horizontally but mainly vertically. Vehicles are no longer moved horizontally; the lift transports the vehicles to levels with a parking bay to the left and right. Parking towers are ideal for providing 10–40 parking spaces in building gaps, and can be underground or overground.
Parking shelves → ❻ provide vertical and horizontal transport of vehicles. This is an expensive system and only suitable for large installations. Theoretically, it can be extended in height and length as required.
The **circulating parker** → ❼ – ❽ can be delivered in vertical and horizontal versions, usually with 20–40 parking platforms. The platforms circulate until a free platform or the requested car arrives at the entrance. The advantage of the vertical circulating parker is its small ground area of approx. 50 m^2 for about 20 cars. Horizontal circulating parkers are more suitable for underground parking.
Parking cylinder → ⓫ – ⓮ Internal parking spaces are arranged in a circle with approx. 10 vehicles per storey. 10–12 levels are usual, mostly underground. The parking spaces are accessed by a rotating lift, or rotating parking spaces are delivered by a vertical lift.
Sliding parker/floor parker → ❹ – ❻. Lengthways and sideways sliding on one or more levels provides 6–24 places per floor. There must be two empty spaces per floor for manoeuvring. A car lift provides vertical transport.



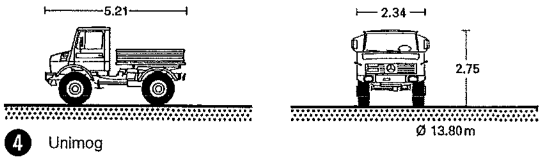
❶ Caddy pickup



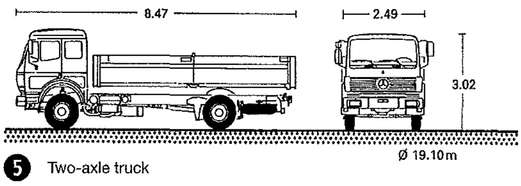
❷ Flatbed truck



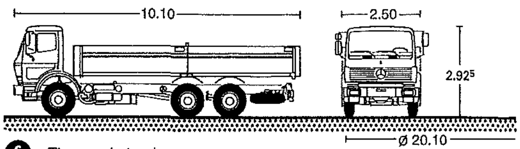
❸ Flatbed truck



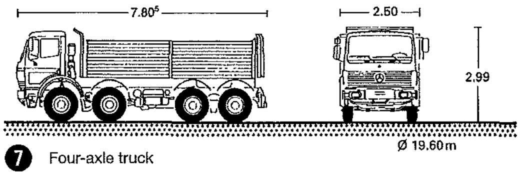
❹ Unimog



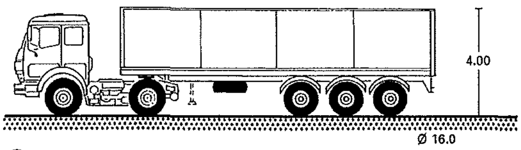
❺ Two-axle truck



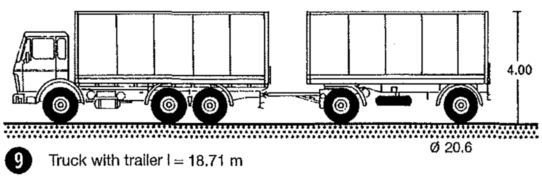
❻ Three-axle truck



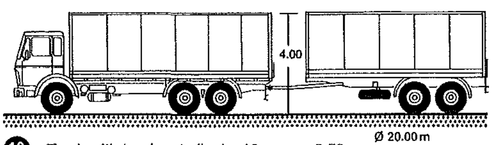
❼ Four-axle truck



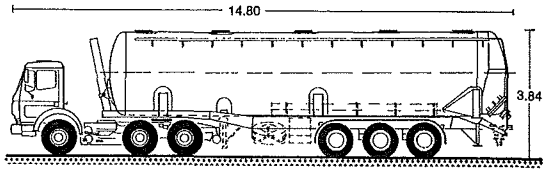
❽ Articulated lorry with semi-trailer l = 16.50 m



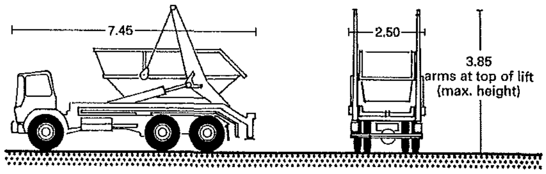
❾ Truck with trailer l = 18.71 m



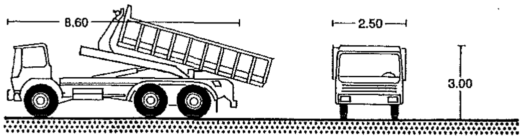
❿ Truck with tandem trailer l = 18 m, w = 2.50 m



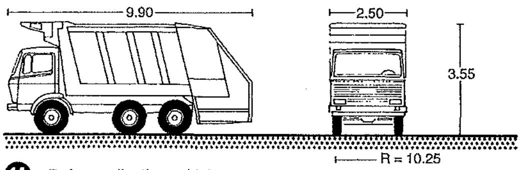
⓫ Articulated silo truck



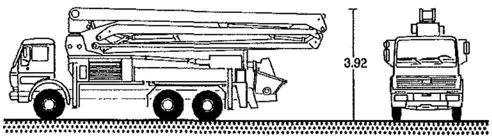
⓬ Skip truck



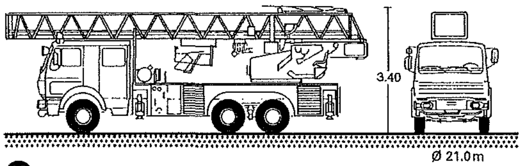
⓭ Truck with tipping body



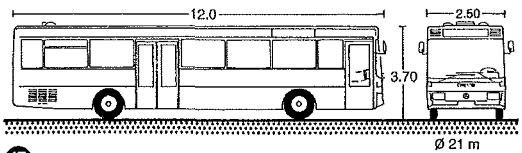
⓮ Refuse collection vehicle



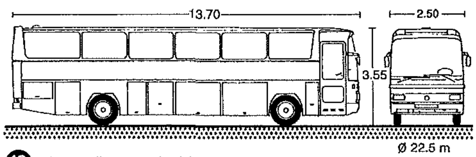
⓯ Concrete pump truck l = 11.80 m



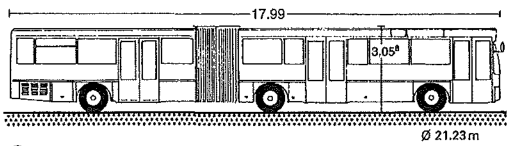
⓰ Turntable ladder fire engine l = 11.50 m



⓱ Standard bus



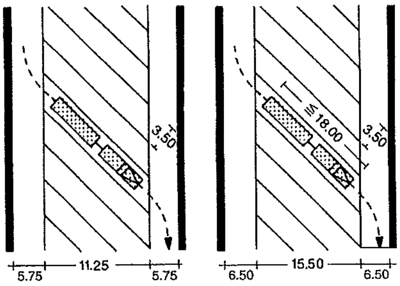
⓲ Long-distance double-decker bus



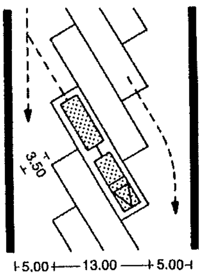
⓳ Standard articulated bus, w = 2.50 m

PARKING FACILITIES

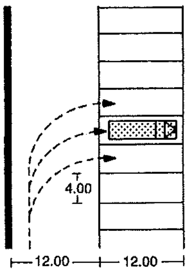
Trucks – Parking and Turning



❶ 45° parking, HGVs and buses
45° parking, articulated buses and lorries



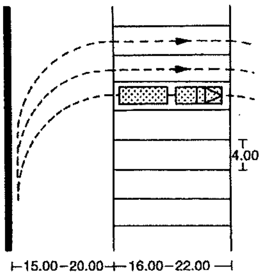
❷ 30° parking, truck with trailer



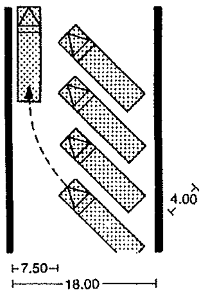
❸ 90° parking, 12 m bus

Owing to the large variation in the size of trucks, it is not worth marking out permanent lanes or bays on the ground. The basic measurements for space and actual requirements for the manoeuvring and parking of trucks are taken from the vehicle dimensions and whether driving straight, cornering, or entering or driving out of the parking place. Especially while cornering, the swept curve of the trailing inner rear wheels must be taken into account.

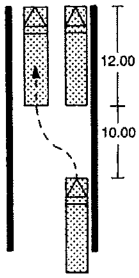
The turning circle for the largest vehicles permitted under the road traffic regulations is an outer turning circle radius of 12 m. An outer turning circle radius of 10 m is nevertheless considered sufficient for the vast majority of trucks which come within the scope of the regulations → p. 389.



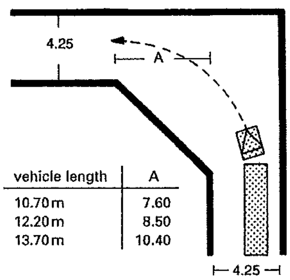
❹ 90° parking, truck with trailer



❺ Parking, less than 45°

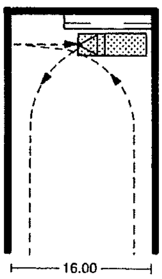


❻ Loss of space, parking parallel to kerb

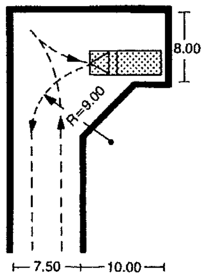


vehicle length	A
10.70 m	7.60
12.20 m	8.50
13.70 m	10.40

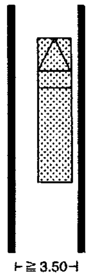
❼ Space needed at street corners



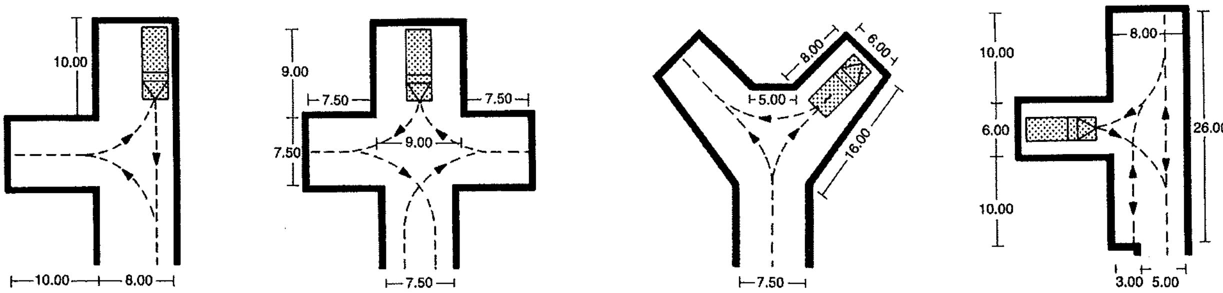
❽ Turning possibilities in restricted locations



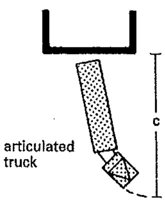
❾ Hammerhead turn in very restricted space



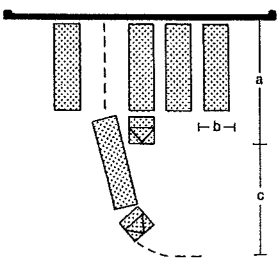
❿ Access



⓫ Further turning places: options for delivery trucks



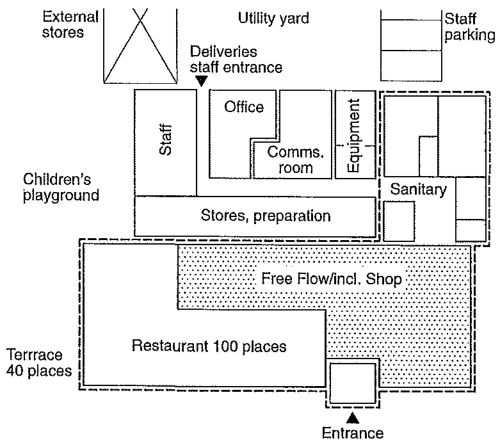
⓬ Single parking



⓭ Parking in a row

Free zone for entry and exit of:	Vehicle length a	Parking space width b	Keep free zone c
HGV 22 t	10.00	3.00 3.65 4.25	14.00 13.10 11.90
HGV single vehicle	12.00	3.00 3.65 4.25	14.65 13.50 12.80
articulated lorry	15.00	3.00 3.65 4.25	17.35 15.00 14.65

⓮ Table for ⓬ and ⓭



❶ Functional scheme for a service area for 100 people

CUSTOMER AREA		approx. m²
Sales rooms		**345.0**
1	Variably assigned	
	according to tenant structure	245.0
	Customer wet rooms	94.8
2	WC corridor	24.8
3	Baby changing room	3.4
4	Truck drivers' showers	8.4
5	Gents WC	22.3
6	Cleaner	6.9
7	Ladies WC	22.5
8	Disabled WC	6.5
BUILDING SERVICES AREA		
9	**Corridor building services area**	**39.5**
	Building services	**25.9**
10	Electricity	7.3
11	Heating	5.3
19	Media	3.3

Stores area		**70.6**
12	Cold store cell	2.7
13	Cool room cell	8.8
14	Cool room cell	8.3
21	Washing up	13.0
23	Preparation	13.7
22/24/25	Stores	26.1
Administration/staff		**57.4**
15	Office	25.6
16/17	Changing rooms Ladies/gents	18.1
18	Staff rest room	6.9
20	Staff WCs Gents/ladies	6.8
Net floor area		**633.2**

The increased capacity of HGV transport and the required rest times for the drivers have resulted in a great demand for service areas featuring parking facilities of generous dimensions and corresponding infrastructure.

Service areas

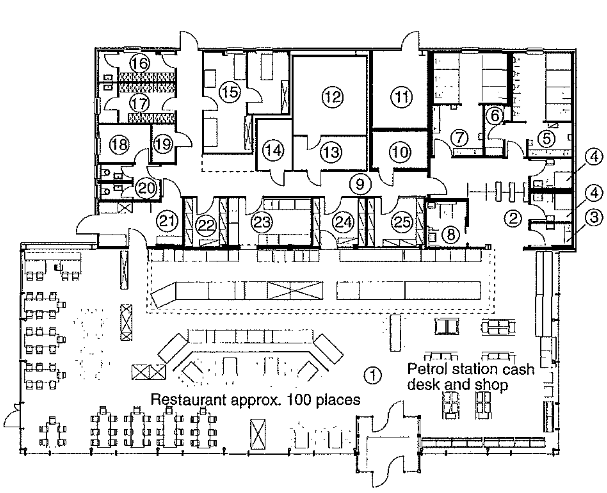
Service areas (Raststätte) on autobahns in Germany are administered by the company Tank und Rast. The facilities are situated directly on the autobahn with access by slip roads. In addition to the petrol station, further service units are operated by leaseholders. According to the size of the facilities, this can be fast snack bars, restaurants, sales areas or overnight accommodation.

Autohofs are service areas which are next to the autobahn, but also accessible through normal junctions.

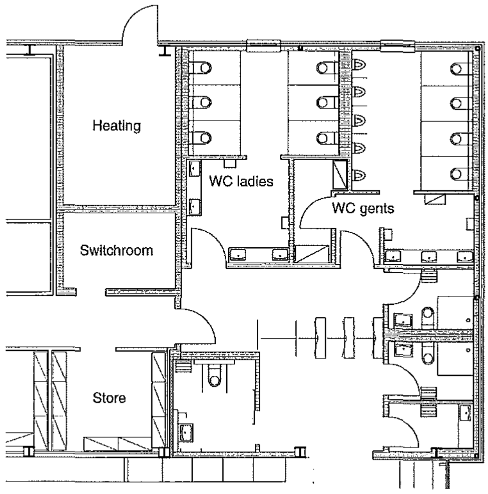
Many other countries have arrangements for service areas similar to those described above.

Service stations

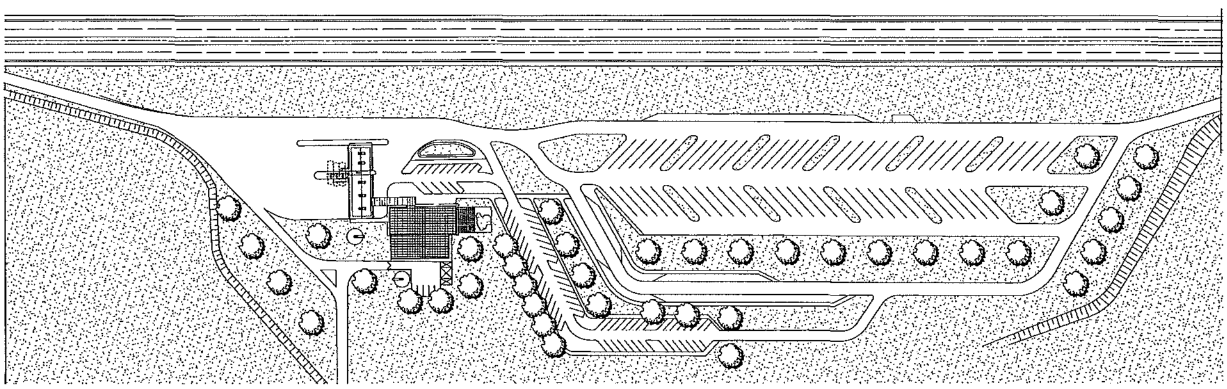
In urban areas, mostly in industrial zones, petrol stations are combined with car washes. The care of cars is the main business.



❷ In smaller service stations, petrol supply and service areas are combined in one building

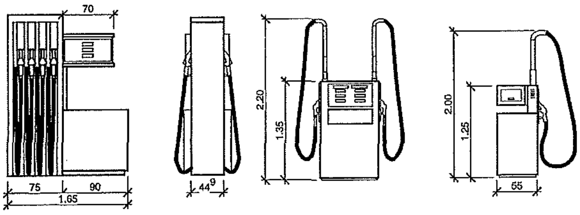


❸ Toilet facilities in service areas are leased like the other services. Charging is made possible by a turnstile

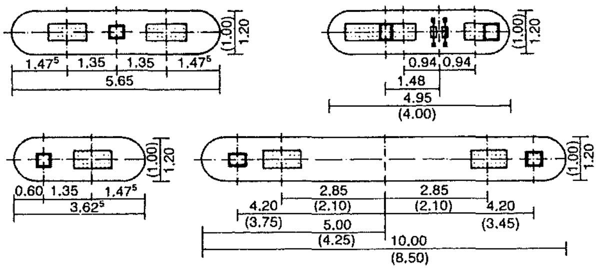


❹ Layout of a petrol and service area

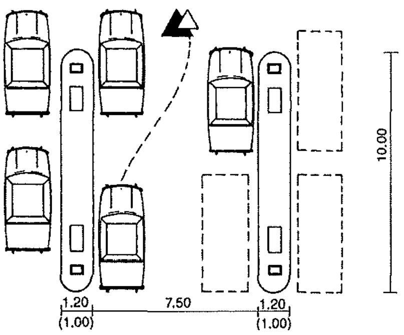
Design: Autobahn Tank u. Rast AG



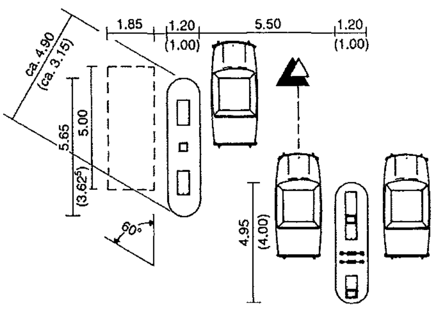
❶ Petrol pump: the multi-product dispenser usual today offers up to five types of fuel at one unit with simultaneous operation from both sides. Single- and double-fuel pumps are now mainly found in company yards.



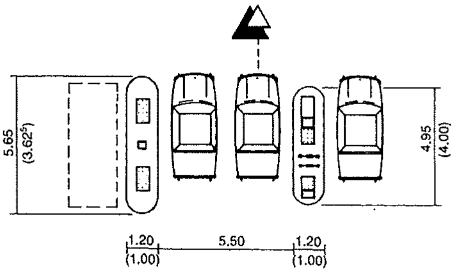
❷ Petrol pump island dimensions (minimum dimensions)



❸ Two long islands parallel to the road, requiring disciplined driving behaviour (minimum dimensions)



❹ Two short islands at angle less than 60° to the road (minimum dimensions)



❺ Two short islands parallel to the road (minimum dimensions)

Petrol stations supply fuel and lubricants, mostly in combination with maintenance and care services. Because petrol station shops in Germany are excepted from the shop closing time regulations, the proportion of sales area devoted to car accessories and goods required daily has increased considerably.

Important regulations and technical rules:
In addition to the relevant building regulations:
WHG (water management law) applies, on account of the storage of fuel and associated water, fire and explosion hazards.
VAwS (regulation of requirements for the handling of substances harmful to groundwater) mostly concerns specialist firms and testing duties.
TRwS (technical rules for substances harmful to water)
TRbF (technical rules for flammable liquids)
Petrol stations must be erected by certified specialist firms (WHG).
State regulations control:

1. Parking space size (2.50×5.00 m = 12.50 m^2)
2. Required number of parking spaces (e.g. depending on the extent of premises, and the number of petrol pumps and people working at the station).
3. Required queuing space for automatic car wash (e.g. area sufficient for 50% of the hourly washing capacity).

For design purposes, dimensions specific to cars should be considered:

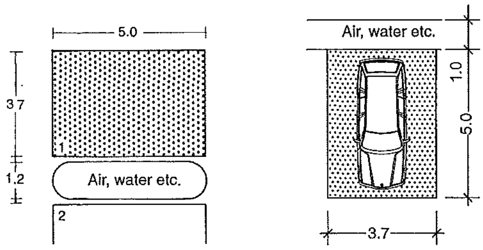
Turning circle:	car 12.50 m	HGV 26.00 m
Vehicle width:	car 1.85 m	HGV 2.50 m
Vehicle length:	car 5.00 m	HGV 18.00 m with trailer

These data can be used to derive the dimensions of pump islands and passage widths → ❸ – ❺.

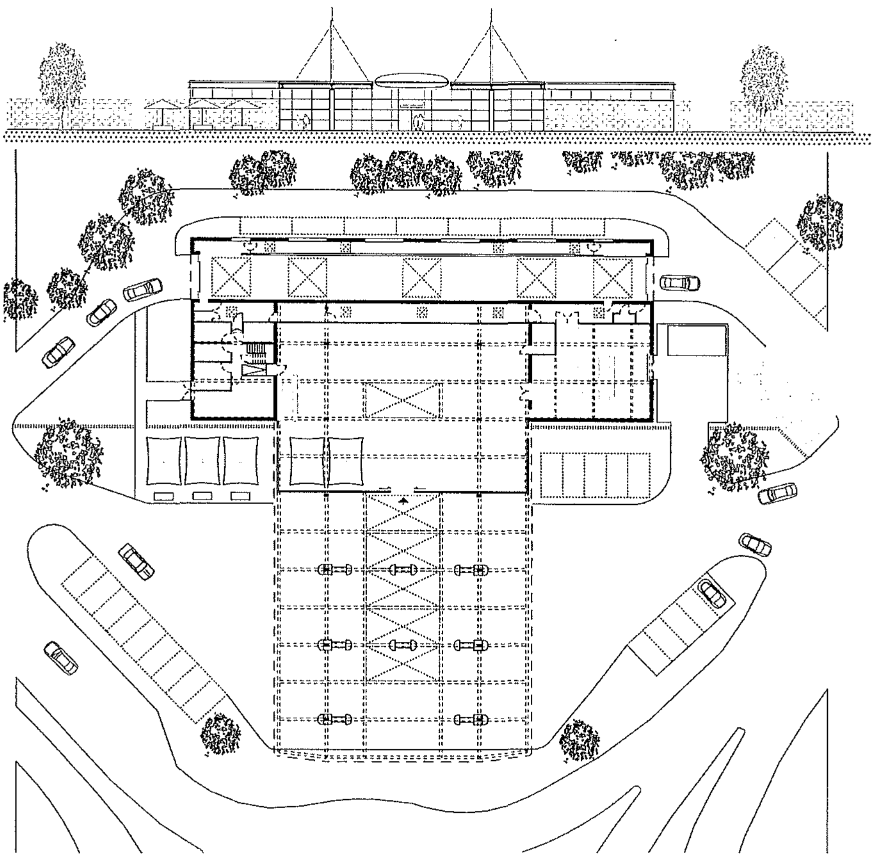
The paving around the petrol pumps must be impervious to liquids and the run-off channelled into side kerbs and/or a downward slope. These areas (length of the petrol hose + 1 m) must drain through a suitable liquid interceptor or be roofed over. Reduced dimensions for the surfaced area impervious to liquids and the siting of the tanks apply to private petrol stations, categorised as petrol stations for private use with low consumption (the quantities are regulated by the states).

Petrol pumps must have protection against vehicle impact with at least 20 cm spacing and 12 cm height → ❷.

Each petrol pump should if possible dispense all the fuels on offer (multi-dispenser petrol pump). For private petrol stations, there are simple petrol pumps with electronic control systems for personalised control of access and quantity → ❶. Autogas (LPG) filling stations require their own dispensers. There are no requirements concerning surfacing, because autogas is not classed as a liquid hazardous to groundwater. Measures should be taken to ensure rapid distribution of any leaking gas (earth wall or dip into which the gas can be blown by the wind).



❻ Service points for self-service oil change, air, water etc.



❶ Plan of petrol station with sales, food and car wash. Allguth Station, Unterföhring   Architects: Haack + Höpfner, Munich

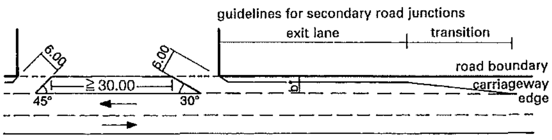
Area required

For a simple petrol station, an area of approx. 800 m² is sufficient, with additional services normally approx. 1000 m², and for large service stations 2000 m² and more → ❷.

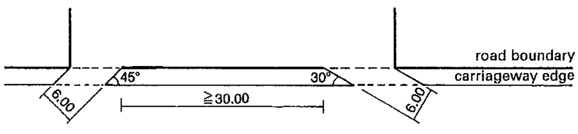
Services and location

Car drivers should be able to fill up with petrol; check the oil level, radiator water level and tyre pressures (and top them up if necessary) and fill up the windscreen washer water; clean the windscreen, headlight glasses and their hands; buy goods; use the WCs; and carry out various car care tasks (car washing, vacuum cleaner etc.). Petrol stations should be easy to drive into, clearly laid out, easily recognisable from a distance and as near to the road as possible.

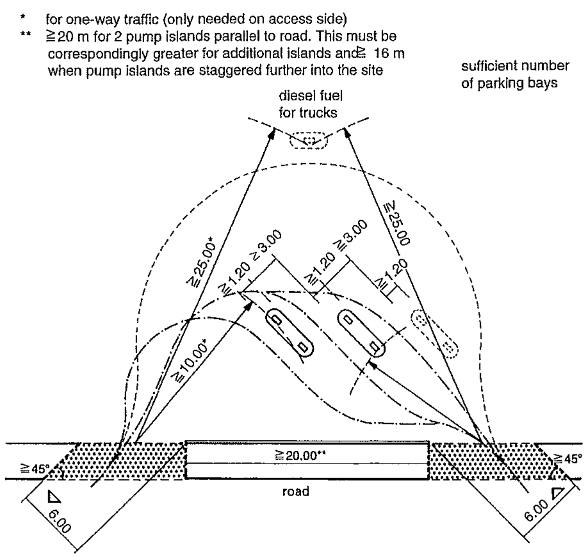
The location should be on the left hand side of the road on the way out of town and not in the queuing area in front of traffic lights. Also unfavourable are road crossings, in which case a better solution is a location before the corner with an exit into the side street.



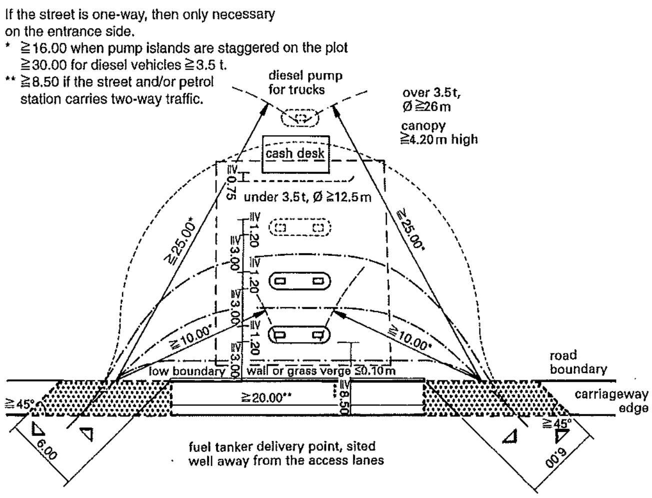
❷ Petrol station access and exit on a clear road



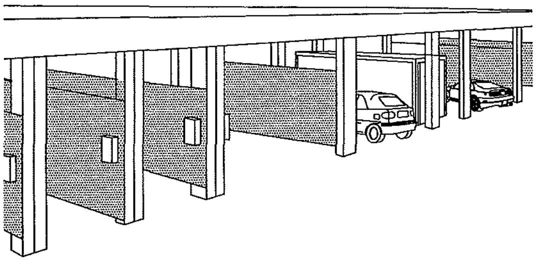
❸ Without slowing and accelerating lanes



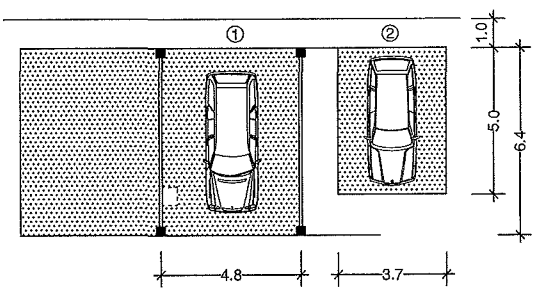
❹ Petrol station with angled position of the pump islands in an urban area (primarily for traffic in one direction)



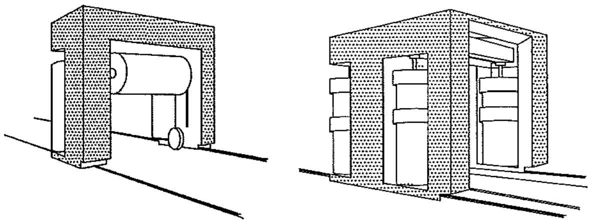
❺ Petrol station for petrol and possibly diesel (HGV ≧3.5 t) in an urban area



❶ Self-service car wash stalls, protected by splash guard walls



❷ Dimensions for a self-operated car wash ❶ operating with separating walls and a central services room ❷ minimum dimensions for an open-air installation



❸ Portal car wash with two sides and a roof brush, and double car wash with four sides and a roof brush

Car wash facilities

These are used for the environmentally friendly washing of cars and are installed as a public service business, also for trucks on the premises of the haulage company. Mobile tyre-washing equipment is available for building sites, tips and landfill sites.

As with petrol stations, the groundwater protection regulations are to be observed. Car washes require, according to system, 100–600 l of water per car. This must be reprocessed and at least 80% recycled. For closed systems (no drainage connection), there is a simplified approval process under groundwater protection regulations. A car wash needs about 40–50 m^3 for settling and silt retention basins (underground tank Ø 3 m). Fresh water is required to cover evaporation losses, to reduce the salt content in winter, to rinse off and for the application of liquid waxes.

Self-service car wash stalls

These are mostly roofed parking spaces, on which cars can be cleaned by the customer with a high-pressure cleaner and hand washing brushes. Small installations have one or two places, larger installations up to 12 places, which can be served by a central services room → ❶ – ❷.

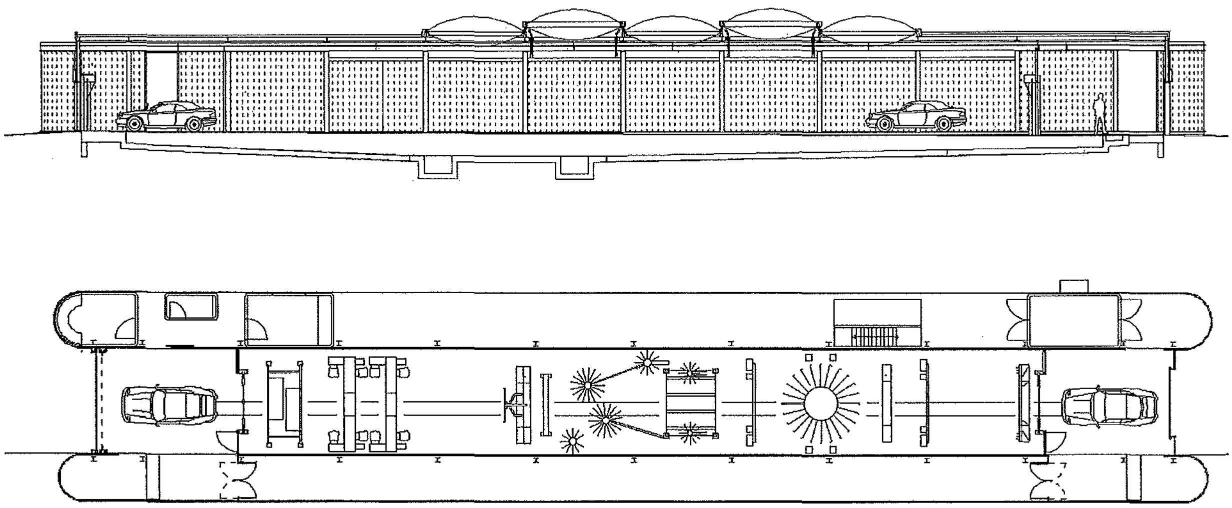
Portal car wash

This takes up little space. The customer has to get out and the entire washing equipment in the portal then travels over to the parked car. This type of car wash can be installed in the open air, but is better indoors, ideally enabling the customer to drive through. Because the portal stops in front of the car parking space when not in operation, the building is min. 9–10 m long, width min. 4.60 m, height min. 3 m (for portals for cars up to 2.1 m in height). The clear space at the side between portal and building elements is min. 50 cm.

A portal car wash can wash about 5000–50 000 cars per year or 5–18 vehicles per hour → ❸.

Tunnel car wash

The vehicles are carried on a conveyor through fixed washing and after-care portals. This technology enables a high capacity and various washing programmes in the same pass time. The length of the car wash is 20–60 m. A tunnel car wash can process 30–100 vehicles per hour or 20 000–200 000 per year. → ❹.



❹ Plan and section of the Allguth car wash, Germering. The surrounding glazing of the side wings (one side for staff and equipment, the other for customers, each approx. 2.8 m wide) permits the functioning of the car wash to be seen. Architects: Haack + Höpfner, Munich

	Underground/urban rail (m)	Tram/bus (m)
Large urban centre		
core zone	400	300
zone with high-density use	600	400
zone with low-density use	1000	600
Medium-sized urban centre		
central zone	400	300
zone with high-density use	600	400
zone with low-density use	1000	600
Subsidiary urban centre		
central area	600	400
remaining area	1000	600
Community	1000	600
for urban railways, the value for tram or underground applies, depending on transport function		

❶ Distances to public transport stops and stations (VDV → refs)

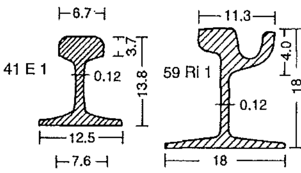
city bus	150–300
bus, tram	250–600
underground	400–1500
urban railway	600–2500

❷ Average distance to a public transport stop in metres (approx., depends on local conditions) (VDV → refs)

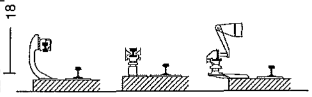
	Bus	Tram	Underground, (e.g. small-profile, Berlin)	Underground (e.g. Munich)	Urban rail
vehicle lengths, trainsets	single bus 8–15 m; articulated bus 18.75 m; double articulated bus 25 m; bus + trailer 25 m	single car 15–45 m; trainsets up to 75 m (according to BOStrab)	25.7 m up to 4 double trainsets	114 m one non-separable train	ET 423: 67.4 m up to 3 trainsets
width	2.55 m	2.20–2.65 m	2.30 m	2.90 m	3.02 m
height	approx. 2.90 up to 4.10 m (double-decker)	approx. 3.40 m*	3.20 m	3.45 m	4.30 m*
platform height	0.12–0.24 m	0.20–1.00 m	0.90 m	1.00 m	0.96 m

* height without pantograph extended to overhead

❸ Important capacity data for means of transport (VDV → refs)



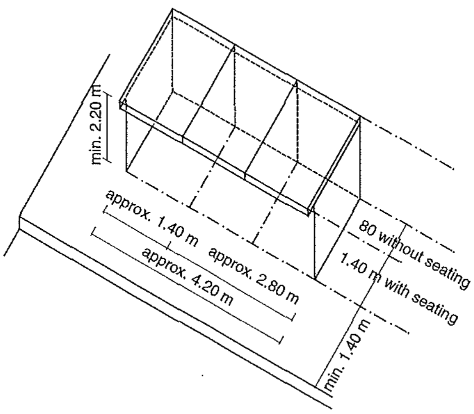
❹ Rail profiles



❺ Live rail (underground) (Fiedler → refs)

Shelters, weather protection

Shelters are required to protect passengers from the weather at transport stops. These are mostly standardised systems made up of basic elements or supplementary modules, often in combination with advertising materials (City Light Posters, for example) as part of the street furniture. Shelters should also attend to customers' safety needs by being transparent.



❻ Waiting shelter for public transport

Legal basis: General Railway Law (AEG), Passenger Transport Law (PBefG), Regulations for the Construction and Operation of Trams (BOStrab), state public transport laws.

Each residential, commercial or industrial area should be accessible by public transport. Accessible means that the distance (as the crow flies) to a transport stop complies with the values in ❶.

All areas with contiguous building development and more than 200 inhabitants (or a corresponding number of commuters and/or students), should be accessible, as should comparable establishments in terms of traffic generation (locations with special functions).

In addition to the bus, there are various types of rail vehicle that can make public transport quicker, more convenient and more attractive than individual travel:

– **Rapid urban transit railways:** predominantly electric, independent rail systems within an urban area (overground and underground – subway in USA) or region, sometimes with at-grade crossings but with absolute priority

– **Urban railways:** as underground railways partially independent from road traffic, or above ground on dedicated permanent tracks or with at-grade crossings with road traffic without absolute priority

– **Trams:** on track beds integrated into roads or dedicated; when trams make use of the public street space, they are subject to road traffic regulations (StVO).

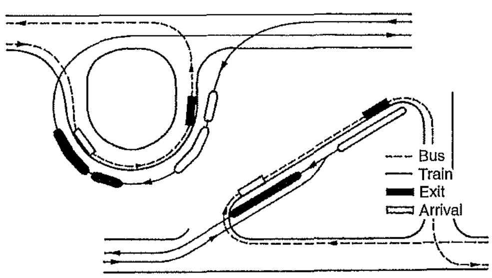
Mixed systems are also possible, e.g. urban railways and trams on the same permanent track or trams using rail tracks (e.g. in Karlsruhe). The use of the permanent track by buses is feasible, resulting in better integration of different transportation elements (stops, bus/tram stations) and priority switching at traffic lights. Of great importance is the spatial and scheduling integration of various means of public transport with each other and also with road and cycle traffic (P(ark) + R(ide), B(icycle) + R(ide) etc.) and appropriate design of changing points → ❼.

Overhead line systems

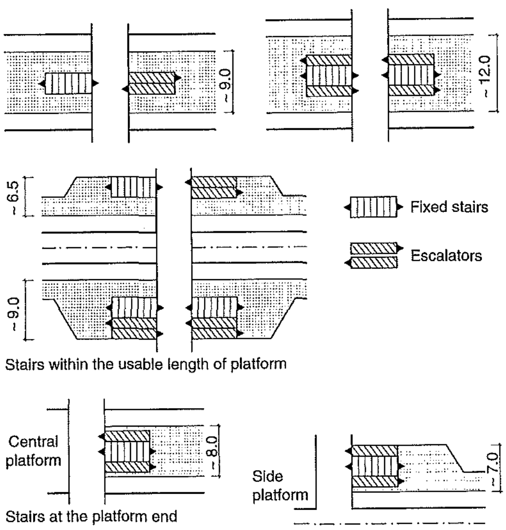
Power supply is normally provided by overhead wire and pantograph on the roof, although underground railways and some urban railways can also use live third rails at the side (approx. 20 cm above the running rails) → ❺.

Rail profiles

Wide-base rails of various dimensions are normally employed (urban rapid transit or urban rail 49 E 1, trams 41 E 1, dimensions → ❹). In street space, grooved rails (59 Ri 1, 60 Ri 1) are used, which can be joint-sealed to the paving at the sides. Open track beds are sometimes greened.



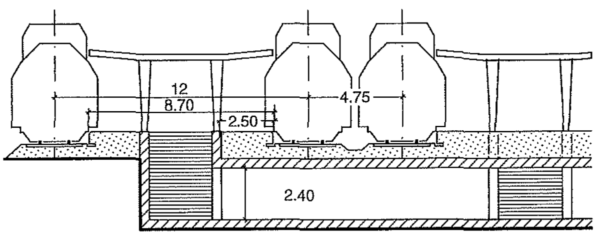
❼ Linkage of urban rail and trams at terminus (Fiedler → refs)



1 Stair layout for side and central platforms (Fiedler → refs)

No. people/potential hindrance	Width × Depth (m)	Capacity (kg)
8/suitable for disabled	1.10 × 1.40	630
13/suitable for carrying loads	1.10 × 2.10	1000
19/suitable for cycles	1.40 × 2.10	1450

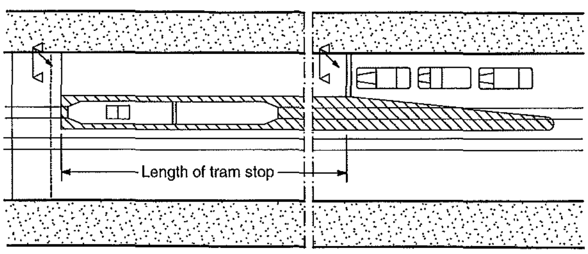
2 Minimum size of lifts (Fiedler → refs)



3 Cross-section through platforms (Fiedler → refs)

Tram stops: platform min. 3.50 m or, to provide space for waiting shelters and two-sided platforms, min. 5.50 m. The permissible minimum width in the road space (according to BOStrab) of 1.50 m should be improved on out of consideration for the passengers (where space is restricted, 2 m is the minimum for a side exit). Safety space: 0.85 m wide from the vehicle gauge on the door side of the rail vehicle, which can also lie on the road pavement.

Dynamic stop: if there is no transport stop island, a traffic light should be placed further back along the road to protect the passengers getting in and out.



4 Dynamic stop (Fiedler → refs)

The design of public transport stops is important. Railway systems are normally designed very specifically for the location. Therefore, platform and floor heights in the vehicle have to be matched in order to ensure passenger-friendly and accessible entrances and exits.

Platform layout

The layout of central and side platforms depends on construction, operational and transport considerations, especially for **platforms in tunnels.**

Central platforms are simpler for the passengers to navigate, but two-way carriages are necessary. If stations are lower and an intermediate storey is required, then this can be used as a grade-separated road crossing by general pedestrian traffic. When the platforms are on one side, then twice the number of accesses, stairs and installations (kiosks, timetables etc.) are needed. One-way carriages are possible because doors are required on the right-hand side only. When stops are located on viaducts, side platforms are preferable because platforms can be projected, so no surface is lost apart from the supports. Successive stops should if possible have the same platform layout (for passenger orientation).

Platform length

This depends on the length of the longest train intended to stop at the station. In the case of underground and urban rapid transit, platform length is the train length plus 5 m (to allow for imprecise braking). Double stops are also possible for trams.

Platform width

The platform width depends on the number of passengers and the location, type and width of the access and exit routes. Platform, stairs and exits should be designed so that the platform can be cleared, without queues, before the next train arrives. The minimum widths are, in general:
- side platforms 3 m
- central platforms with stairs at the end of the platform 6 m
- with stairs within the usable platform length 7 m.

Stairs

Staircases can be located at the end of the platform or within the usable platform length. The width of fixed stairs should be a multiple of 0.60 m (at least 2.40 m) plus width for handrail and cleaning channel. Provide a handrail both sides and additionally in the middle of stairs wider than 6.00 m → **1**.

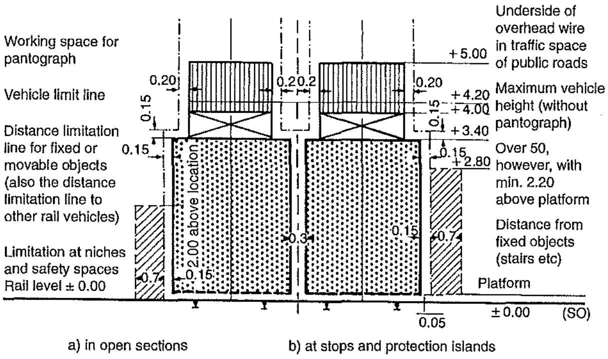
Escalators provide extra comfort for passengers, and accelerate and canalise the traffic flow; they should be used for medium and high passenger numbers. 1–1½-track, or preferably 2-track, escalators should be used (800/1000 mm step width). Construction widths vary between 1.40 and 1.65 m, according to manufacturer.

Lifts

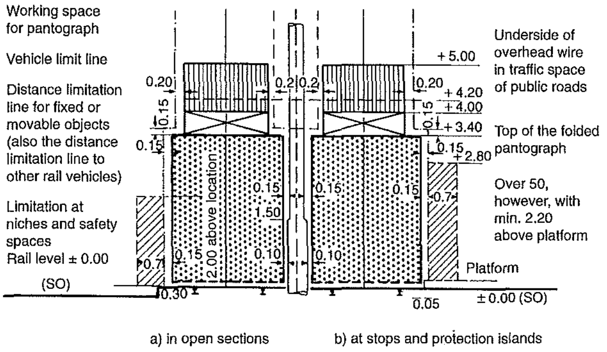
Additional passenger lifts should be installed (possibly as a refit) in above-ground and underground railway stations to aid the journeys of disabled people and others with restricted mobility (due to pushchairs, luggage etc.) → **2**. Lifts should be easily recognisable with waiting areas outside the main traffic flow.

Platform surfacing

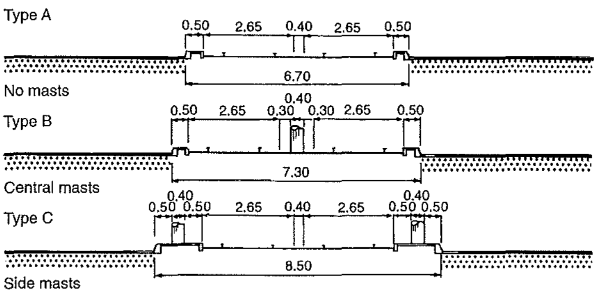
To improve drainage, this should have a camber of at least 1% (max. 3–5% in tunnel stops and 2–3% in open-air stops). Platform edges should be slip-resistant and made of profiled and clearly coloured material (if appropriate with a broad white band) to help those with poor eyesight. Contrasting guide strips, which can be felt with a white stick, should also be provided for visually impaired people.



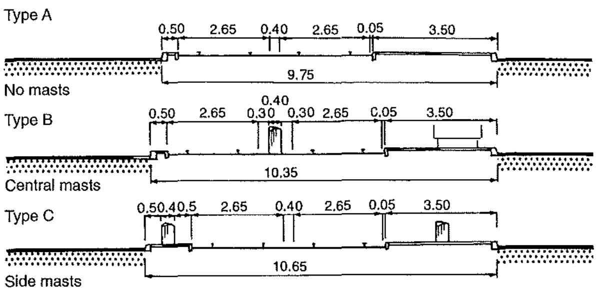
❶ Minimum spacing of tracks in the carriageway of a public road



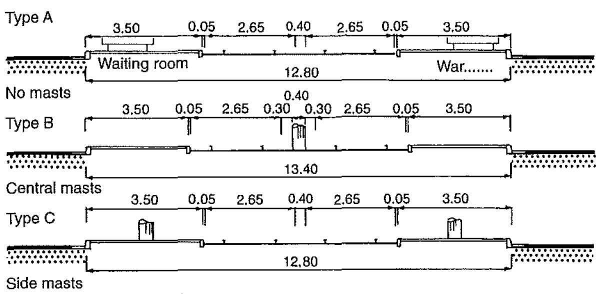
❷ Minimum spacing of tracks on a special track bed within the traffic space of a public road



❸ Standard widths for special track beds in m

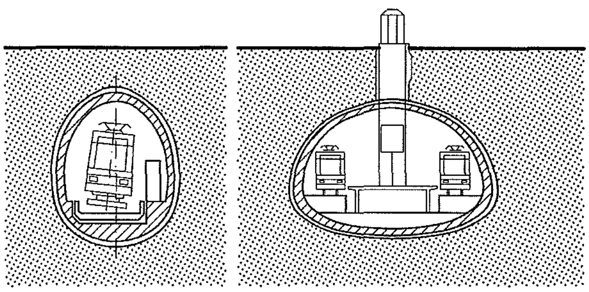


❹ → ❸ One-sided stops

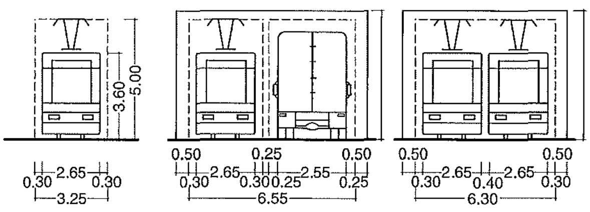


❺ Two-sided stops → ❸

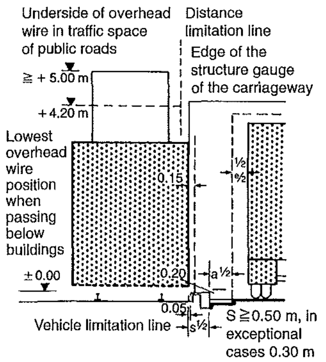
Distance between track centre-lines: depending on the type of transport and its dimensions, min. 2.60 m or 2.95 m, or preferably 3.10 m to compensate for the sideways movement of carriages in medium-sized curve radii. Width of clearance = width of the carriage body, geometrical carriage curvature and extra width for overtaking and oscillation (min. 2 × 0.15 m).
Distance of kerb from carriage body: for special track beds 0.5 m, in exceptional cases also 0.30 m.
Track radii: if possible >180 m, in forks and turning loops min. 25 m.
Gradient: maximum 25‰, exceptionally 40‰.
Camber: max. 1:10, camber max. 165 mm for normal gauge, 1.20 m for metre gauge. If possible, there should be a transition curve before a circular curve, which should coincide with a camber ramp (here greatest slope 1:6 × V).

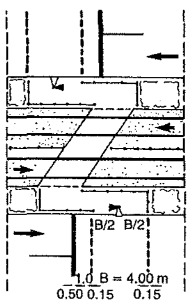


❻ Tunnel cross-section: in a running tunnel and in a station (Stadt Bochum → refs)



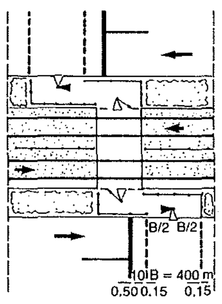
❼ Space requirement for a tram in the road space

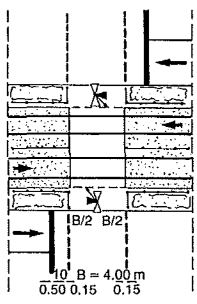




❽ Delineation of the clearances of road vehicle and tram

❾ Track bed crossing location for pedestrians without crossing lights





❿ Track crossing controlled by crossing lights

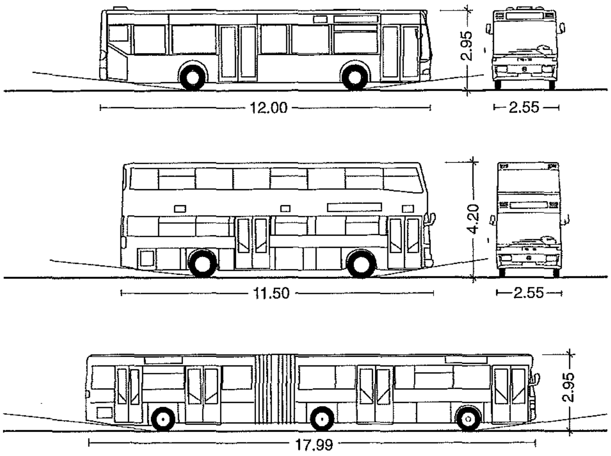
⓫ → ❿

Transport

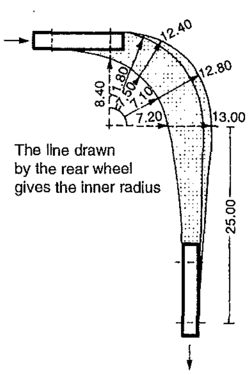
PUBLIC TRANSPORT
Conditions, means of transport
Stops and stations
Traffic spaces
Bus stations

see also: Stairs pp. 120 ff.
Lifts pp. 128 ff.
Railways pp. 408 ff.

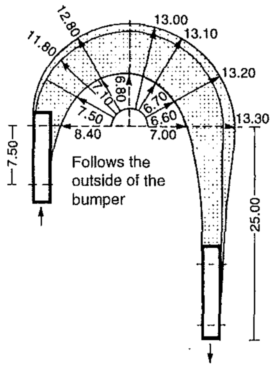
Special widening of curves and turning circles has to be taken into account → ❷ – ⓭. Stops require special dimensions. Bus stop bays are provided only on main feeder roads and roads with heavy traffic loads → ❽. It is desirable for the bus stop to be covered. The many possible platform layouts are shown → ❶ – ❾. Ramps should be provided at the front to allow easy access up a step height of 30 cm → ⓫ – ⓬.
Provide space for temporary parking of cars (Park and Ride).



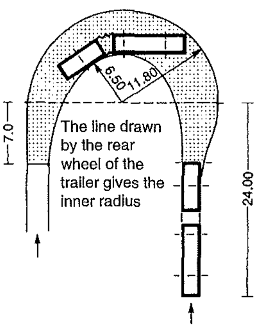
❶ Dimensions of widely used low-floor buses, entry height 30–35 cm, or with kneeling technology approx. 10 cm less



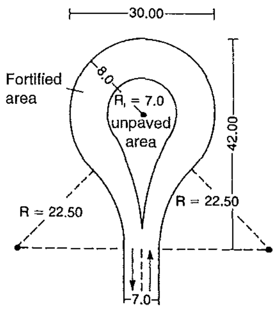
❷ 90° turning circle for rigid, 12 m long vehicles



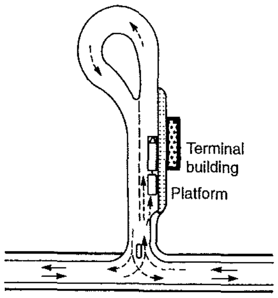
❸ 180° turning circle for rigid, 12 m long vehicles



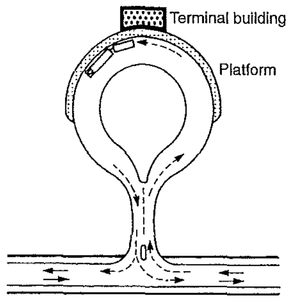
❹ 180° turning circle for articulated, 17 m long vehicles



❺ Turning area



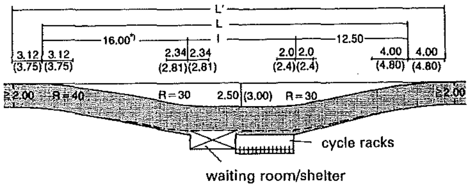
❻ Small turnaround station



❼ Platform outside turning loop

	I	L	L'
bus	12.00	40.50	47.62 (49.05)
two buses	25.00	53.50	60.62 (62.05)
articulated bus	18.00	55.50	61.50 (62.70)

for 3 m wide bus stop bays
*) 25m for bus stop bays for articulated buses



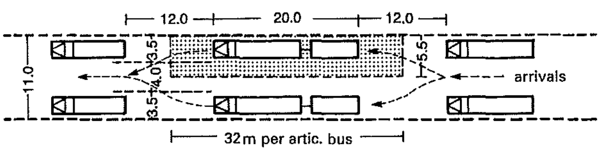
❽ Bus stop

Platform shape	Without passing lane			With passing lane		
	Aa	Ab	Ac	Ba	Bb	Bc
layout of arrival line	parallel	at 45°	at 90°	parallel	at 45°	at 90°
length of platform (m)	24	24	24	36–60	36–60	36–60
width of platform (m)	3	3	3	3.5–4.0	3.5–4.0	3.5–4.0
no. parking places						
a) for buses	2	2	2	2–3	2–3	2–3
b) for artic. buses	1	1	1	1–2	1–2	1–2
area of platform, roadway and arrival lane (m^2) a) per bus	138	176	189	293	296	313
b) per artic. bus	276	340	378	439	444	470

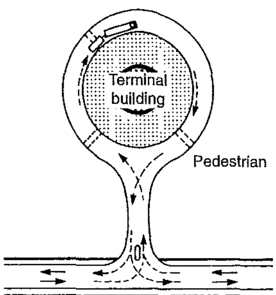
❾ Space required for platforms

Layout of arrival line	Parallel	At 45°		At 90°	
length of parking space (m)	32	12	24	12	24
possible parking for:	1 artic. bus or 2 buses	1 bus	1 artic. bus or 2 buses	1 bus	1 artic. bus or 2 buses
width of one parking space	3.5	3.5	3.5	3.5	3.5
width of arrival lane (m)	4.0	8.0	8.0	14	14
parking area inc. roadway area (m^2) a) per bus	88	135	89	140	91
b) per articulated bus	176		178		182

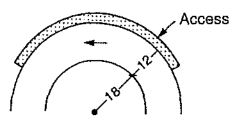
❿ Space required for parking places



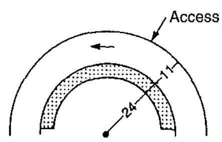
⓫ Layout of parking spaces, parallel to direction of approach



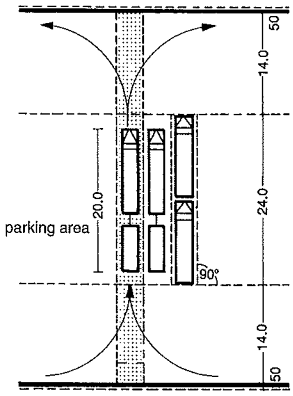
⓬ Platform inside turning loop



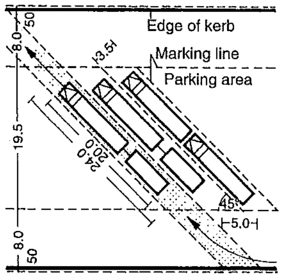
⓭ Semi-circular platform outside loop; no crossing of road necessary



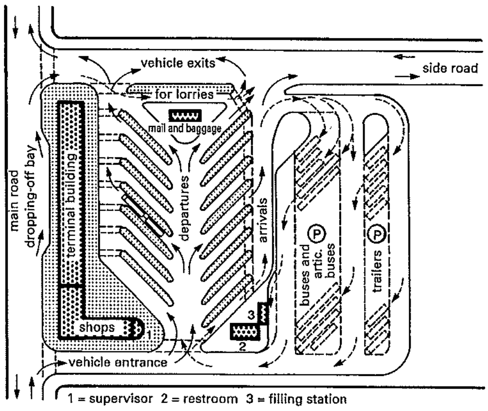
⓮ Semi-circular platform inside loop; accessible only by crossing road



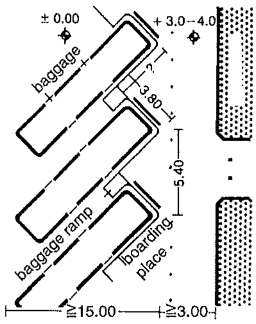
❶ For buses and articulated buses



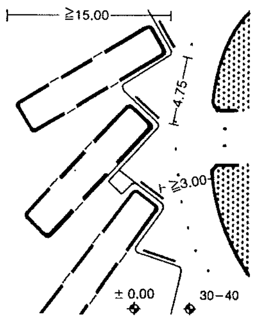
❷ Parking spaces for buses and articulated buses



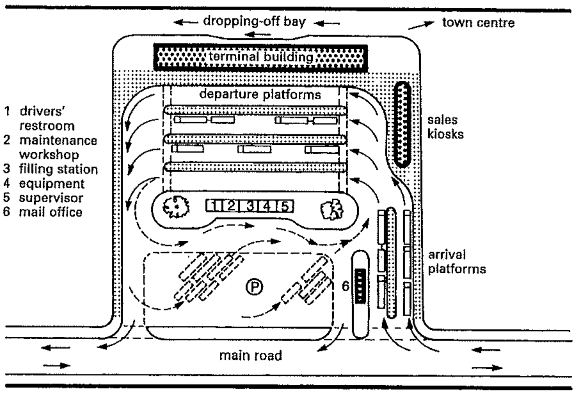
❸ Large drive-through bus station with adjacent parking area



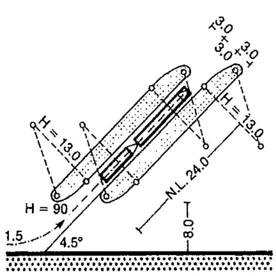
❹ Normal parallel staggering, according to Time-Saver standard



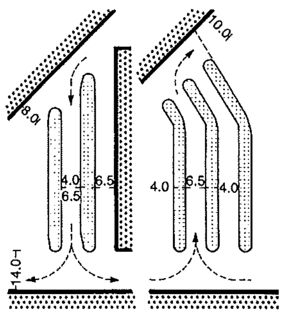
❺ Radial layout extends free space at front



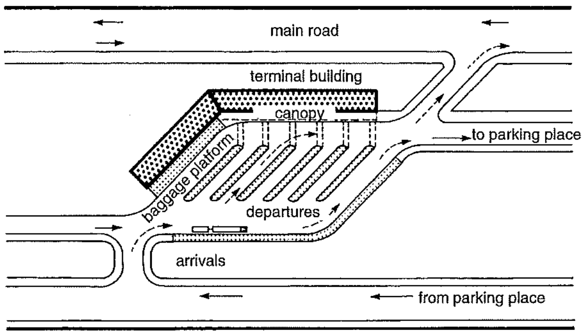
❻ Large drive-through bus station with separate arrival and departure platforms



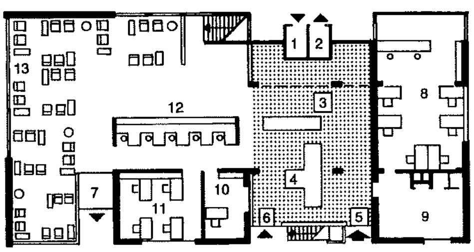
❼ Long platform at angle



❽ Right-angled departure, oblique arrival, oblique departure

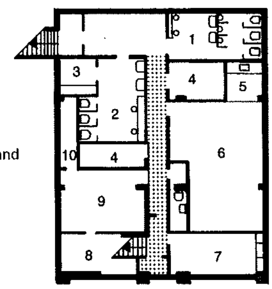


❾ Drive-through bus station with separate arrival and departure platforms, oblique layout and distant parking area



1 entrance for departing passengers
2 exit for arriving passengers
3 concourse
4 baggage despatch
5 entrance for arriving passengers
6 entrance for arriving baggage
7 exit for departing passengers
8 baggage office
9 baggage deposit
10 office manager
11 office
12 information and air tickets
13 waiting room

❿ Ground floor of KLM bus station



1 WC men
2 WC women
3 nursery
4 cloakroom
5 kitchen
6 canteen staff
7 drivers' restroom
8 meter cupboard and storeroom
9 filing room
10 pump room

⓫ Basement → ❿

Transport

PUBLIC TRANSPORT
Conditions, means of transport
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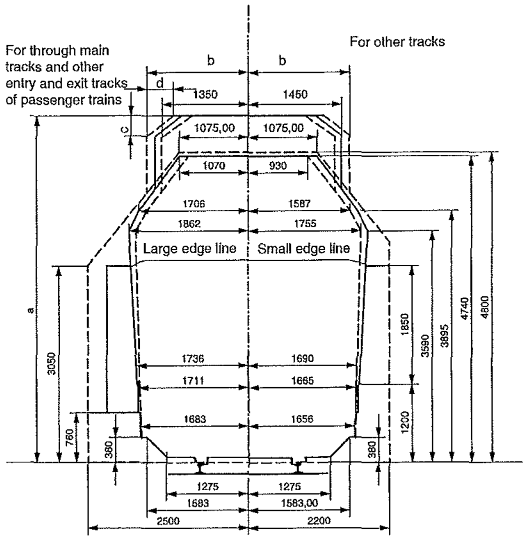
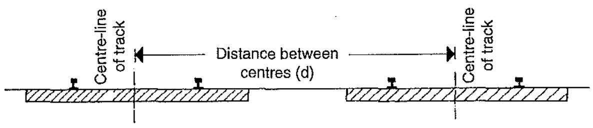


a) working height pantograph = 5.60 m minimum, depending on type of electricity 5.00–5.34 m
b) maximum 1.58 m b, c and d dependent on working height range of pantograph (EBO appendix 1)

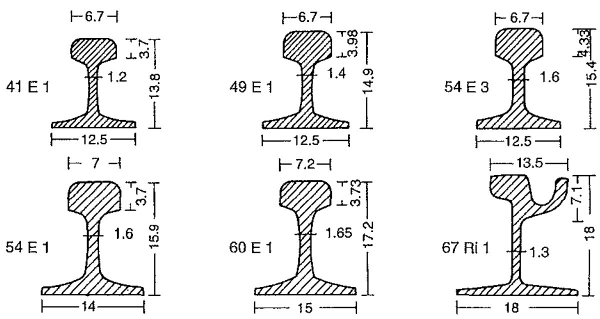
❶ Standard clearance space, according to the Railway Construction and Operation Regulation (EBO), valid on straight and curved lines with radius ≧250 m

The key standard distances (d) between track centre-lines are:

• On open stretches of track	4.00 m (3.50 m on older lines)
– where signals installed	4.50 m
– as safety space after every 2nd track	5.40 m
– newly built stretches, V >200 km/h	4.50 m
• In stations	4.50 m (4.75 m)
– main lines, straight through	4.00 m
– in sets of 5–6 lines	6.00 m
– for brake inspection/test tracks	5.00 m
– in sidings for carriage cleaning	5.00 m

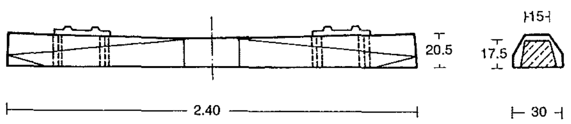


❷ Track spacings

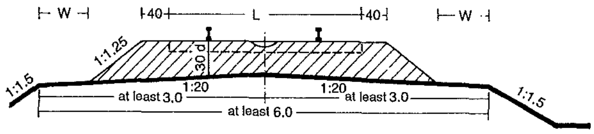


❸ Sections of common types of rail (the first number is the rail weight in kg/m)

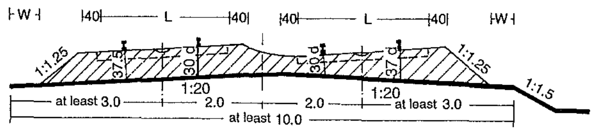
❹ Concrete sleeper B 70



❺ Concrete sleeper B 58



❻ Standard track bed cross-section for single-track lines



❼ Standard track bed cross-section for two-track lines

Standard gauge of German Railways:
gauge (for 71% of the world's railways) 1.435 m
gauge tolerances:
–3/+30 mm on main lines
–3/+35 mm on branch lines
(other gauges: Russia 1.520 m; Spain and Portugal 1.668 m, South Africa 1.067 m, Chile, Argentina, India 1.673 m)

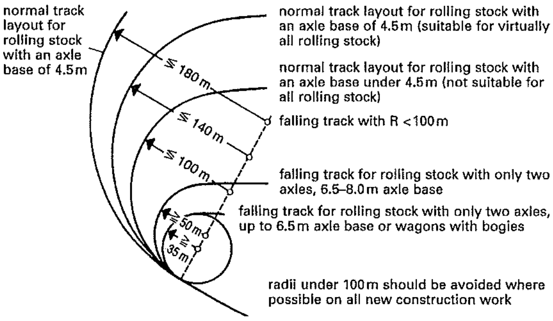
Lifetime of sleepers:

– timber sleepers impregnated with creosote (Rüping process)	25–40 years
– timber sleepers, not impregnated	3–15 years
– steel sleepers	about 45 years
– concrete sleepers, estimated	min. 40 years

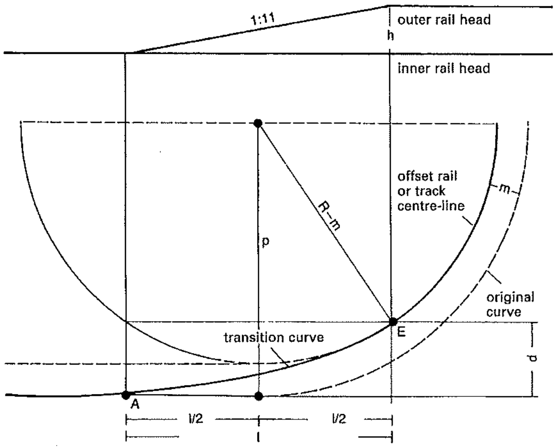
Trench depth in cuttings ≧0.4–0.6 m under ground level
Slope of the trench 3–10% according to the type of consolidation of the trench floor. Groundwater at retaining walls is to be drained through pipes or drainage holes.

The longitudinal gradient of open stretches of main line ≦12.5‰, on branch lines and urban railways ≦40‰ and on station tracks ≦2.5‰. Gradients of up to 25‰ are possible on main lines with special approval.

Static wheel load = 9 t. On stretches with sufficiently strong track and supporting structures, higher wheel loads (up to 11.25 t) are possible.



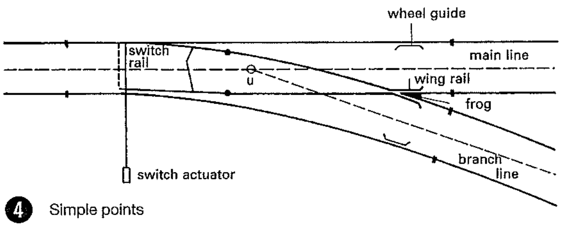
❶ Track radius (turnability) of the connecting tracks



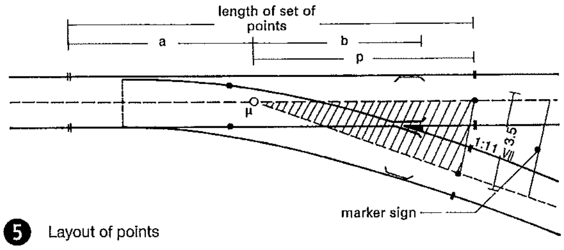
❷ Track cant ramp and transition curve

R	l	m	Ramp gradient
180–200	40	0.370 0.333	1: 320 1: 320
250–350	30	0.1150 0.107	1: 300 1: 400
400–2000	20	0.012 0.008	1: 310 1: 1300

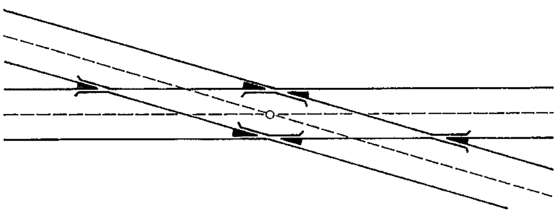
❸ Branch lines and normal sidings (m)



❹ Simple points



❺ Layout of points



❻ Oblique crossing (wheel guide as example diameter ❹ – ❺)

Curved radii (to track centre-line) = R
main lines, direct main tracks .... ≧300 m
station tracks .... ≧180 m
branch lines with main line rolling stock .... ≧180 m
without main line rolling stock .... ≧100 m
sidings used by main line engines .... ≧140 m
sidings not used by main line engines, preferably .... ≧100 m
minimum .... ≧35 m

If 100 m >R ≧35 m, carriages should if possible only be pulled; with radius >130 m not all carriage types can any longer be driven.

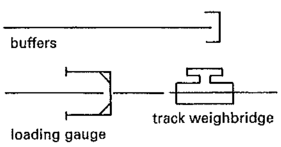
Radii for narrow-gauge railways
for 1.00 m gauge track .... R ≧50 m
for 0.75 m gauge track .... R ≧40 m
for 0.60 m gauge track .... R ≧25 m

For tracks to be used at greater than shunting speed, a transitional section of curve must be installed between the straight section and the circular arc with radius R, with the curvature of the transition curve increasing constantly from 1: ∞ up to 1: R → ❷. Circular curves may have to be canted in order to keep the centrifugal force arising when travelling round the curve within reasonable bounds (≦0.65 m/sec). Canted curves and transition curves should coincide.

For details, see German Railways combined guideline KoRil 820/1.

Points
Sets of points are characterised according to the shape of the rail, the turning track radius and the inclination of the frog, e.g. 49–190–1:9.
only use the points for carriages up to the limit sign → ❺
spacing of the track centreline at the warning sign ≧3.5 m
point length / length of the point blade → ❽
49–190–1:7.5 = 25.222 m/12.611 m
49–190–1:9 = 27.138 m/10.523 m
49–300–1:9 = 33.230 m/16.615 m
normal turntable = D
for axle turntable 2–3 m, for carriage turntable 3.5–10.0 m, for locomotive turntable 12.5–23.0 m.

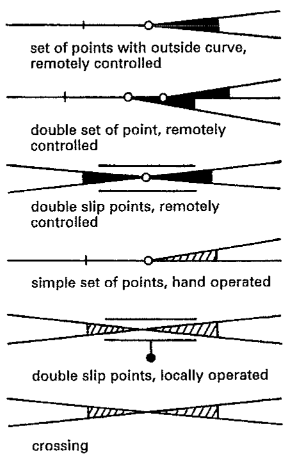
Traversers
Size = minimum axle spacing of the carriage to be pushed + 0.5 m



❼ Drawing symbols

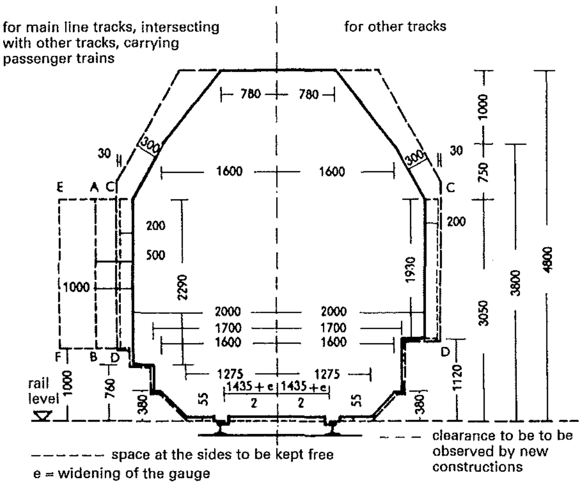
Set of points	Radius (m)	Pitch ratio	Overall length (m)
ABW 49	215	1:4.8	22.100
EW 49	190	1:7.5	30.039
EW 49	190	1:9	27.138
DKW 49	190	1:9	33.230
DW 49	190	1:9r/1:9l	37.661

❽ Dimensions for sets of points



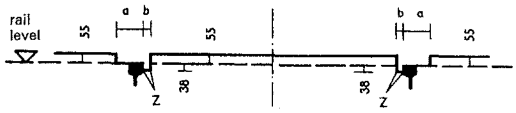
❾ Drawing symbols

Standard gauge railways



A–B for main lines on open stretches for all objects with the exception of fabricated structures
C–D for station sidings and for open stretches of main lines with special structures and signals between the tracks
E–F for fixed objects on passenger platforms

1 Standard clearance profiles (straight track plus curves with radii ≧250 m)

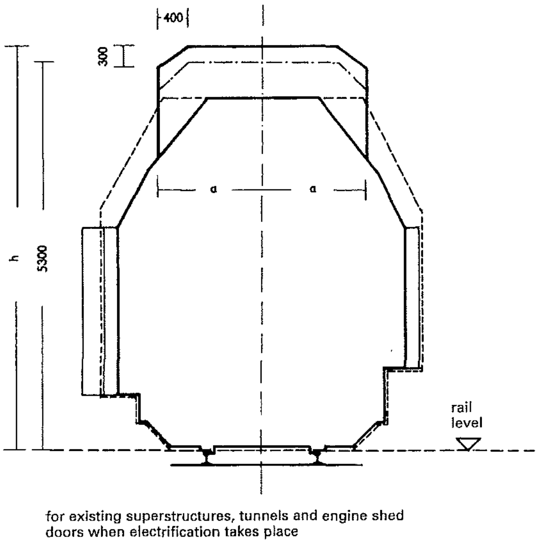


a ≧ 150 mm for immovable objects which are not firmly connected to the rail
a ≧ 135 mm for immovable objects which are firmly connected to the rail
b = 41 mm for devices guiding the wheel on the inside of the front surface
b ≧ 45 mm for level crossings
b ≧ 70 mm for all other cases
Z = corners which have to be radiused

2 Standard structure gauging and clearances at low level

Curve radius (m)	Necessary increase in standard clearance on the	
	Inside of the curve (mm)	Outside of the curve (mm)
250	0	0
225	25	30
200	50	65
190	65	80
180	80	100
150	135	170
120	335	365
100	530	570

3 Necessary increase in the standard clearance for curves with radii <250 m



4 Top limit of clearance for stretches with overhead conductor wire (15kV)

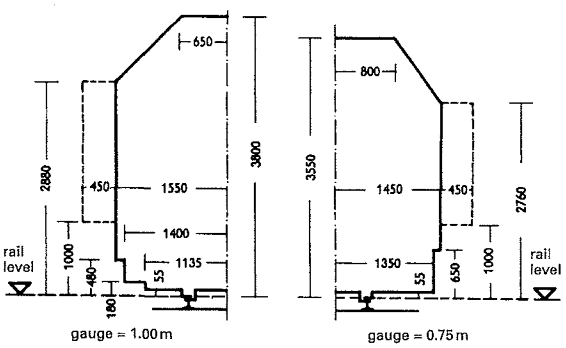
Half the radius of the curve (m)	Dimensions of half the width a (mm)
up to 250	1445
225	1455
200	1465
180	1475
150	1495
120	1525
100	1555

5 Dimensions for half the width of the upper limit of the clearance

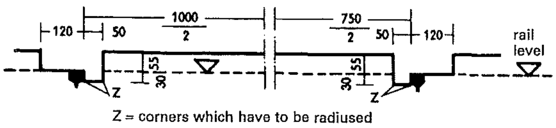
	h
heavy superstructures up to 15 m wide and in tunnels	5500 mm
heavy superstructures over 15 m wide	6000 mm
light superstructures, such as footbridges, sheds including doors	6000 mm
signal gantries and brackets	6300 mm

6 Minimum clearance under structures

Narrow gauge railways



7 Standard clearance profiles, straight line track



8 Standard structure gauging and clearances at low level

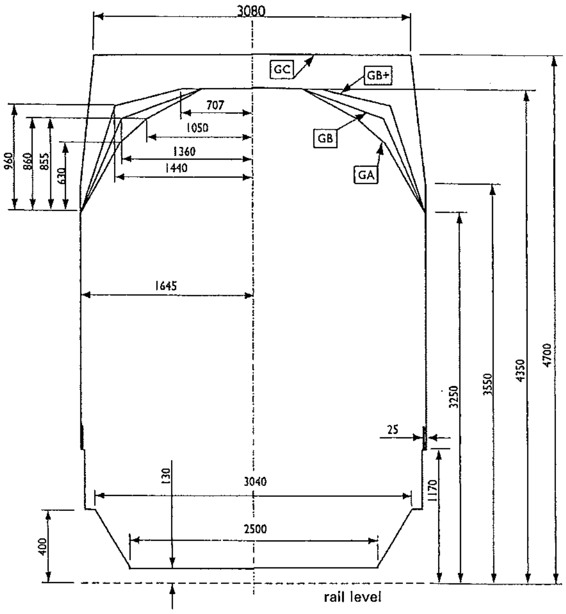
Other dimensions: European standards (Germany)

For entrance doorways the clear width should be ≧3.35m and for new structures ≧4.00 m.

For tunnels, the extra clearance needed beyond the trains' kinematic envelope clearance to the wall for a single-track stretch of line is 0.40 m; for a double-track stretch of line it is 30 cm.

There are minimum distances required between buildings and railway tracks for new structures. These vary according to location. Typical examples are: a fire resistant structure with suitable cladding must be separated by ≧7.50 m from railway land; the corresponding distance for soft covered structures that are not fire resistant is ≧15 m. The latter also applies to structures in which combustible materials are stored.

Platform heights vary from country to country, and can be as small as 0.38 m. However, access to platforms must not involve passengers having to cross the track. This requires tunnels or bridges, which should have a width of 2.5–4.0 m. If there is circulation in both directions, 4.00–8.00 m is desirable. Steps on bridges or in tunnels should be the same width as the bridge or tunnel.



1 All dimensions are in mm.
2 The kinematic envelope is the cross-sectional profile of a vehicle at any position along its length, enlarged to include the effects of dynamic sway and vertical movement caused by speed, (dynamic effects of) track curvature and cant, track positional tolerances, rail wear, rail head/wheel flange clearances, vehicle wear and suspension performance for the particular track location under consideration. The determination of the kinematic envelope is the responsibility of the operator of the proposed vehicle and shall be in accordance with the Railway Group Standard.

1 UIC (International Union of Railways) reference profiles for kinematic gauges (GA, GB, GB+, GC)

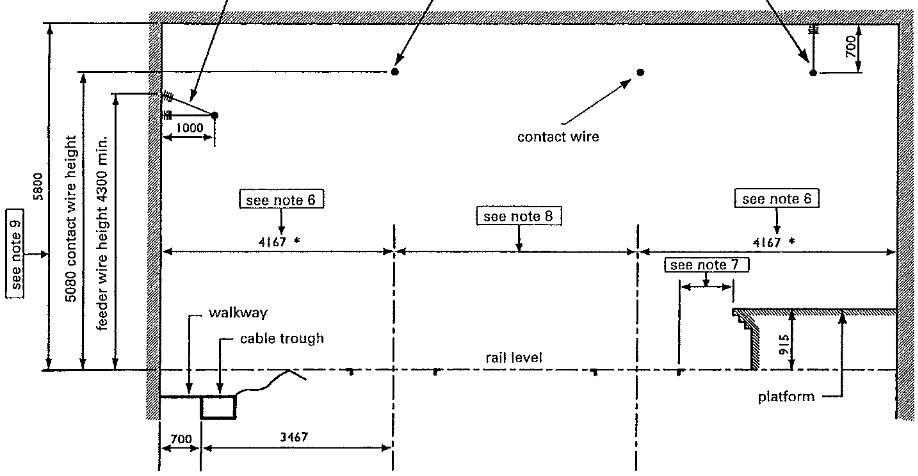
Further information: Safety and Standards Board, Network Rail, London
This information is based on the Railway Group Standard which applied to all new design and new route clearances for railway vehicles and loads from 3 February 1996.

The purpose of this Railway Group Standard is to set down the engineering requirements for the safe passage of rail vehicles and their loads by reconciling their physical size and dynamic behaviour with the opportunities offered by the railway infrastructure.

This standard applies to infrastructure owned by Network Rail and any other infrastructure interfacing with it and affecting its physical clearances (e.g. private sidings or works into which, or out of which, trains will work onto Network Rail lines).

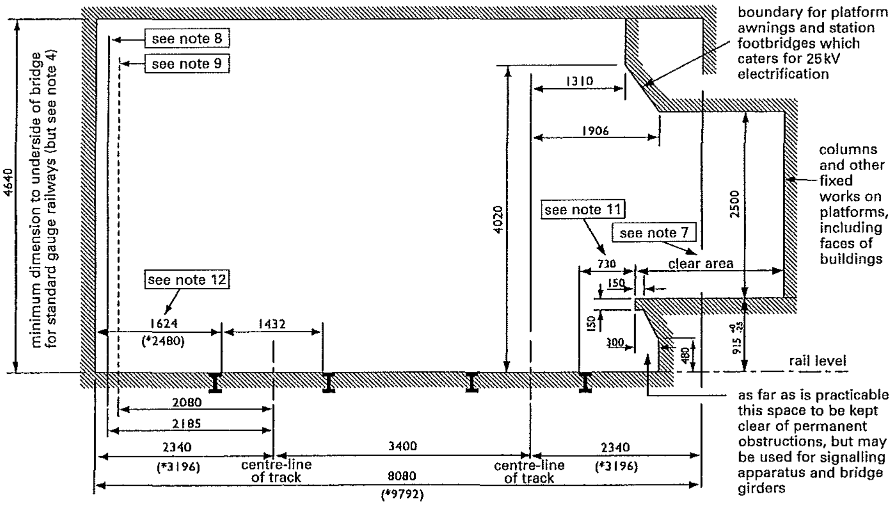
It shall be complied with in the design, maintenance and alteration of the railway infrastructure, in the design and modification of traction and rolling stock and in the conveyance of out of gauge loads.

Standards are constantly evolving as faster trains are developed and heavier loads are transported. The national rail administration should, therefore, always be contacted for the latest standards and details.



1 This drawing is not applicable to viaducts and tunnels.
2 All dimensions are in mm.
3 Track centres for a mixed traffic railway.
4 Applicable only to straight and level track.
5 Refer to GC/TW496 *Requirements for Constructional Work on or near Railway Operational Land for Non-Railtrack Contracts* for the design of supports for structures built over or close to railway lines.
6 It may be possible in tight situations to reduce the dimension marked with an asterisk, but only where alternative access is available, via a route in a petition of safety, connecting with the walkways each side of the structure or where the railway operates on a 'no person' basis, whereby staff are only allowed on the track when special protection measures are in place.
7 Platform clearances are subject to maintenance of HMRI stepping distances and specific requirement shall be calculated from the chosen kinematic envelope with an allowance made for structural clearance.
8 This dimension shall be calculated from the dimensions associated with the chosen kinematic envelope with an allowance made for passing clearance. At the time of calculating the required dimension an assessment shall be made of traffic proposed for the route such that aerodynamic effects can be taken into account.
9 This dimension accommodates full UIC GC reference profile and assumes train speeds up to 300 km/h. Commercial considerations will dictate whether it is necessary to amend this dimension and contact wire height for the actual type and speed of vehicles proposed for the route.

2 New construction gauge (derived from the UIC GC reference profile)



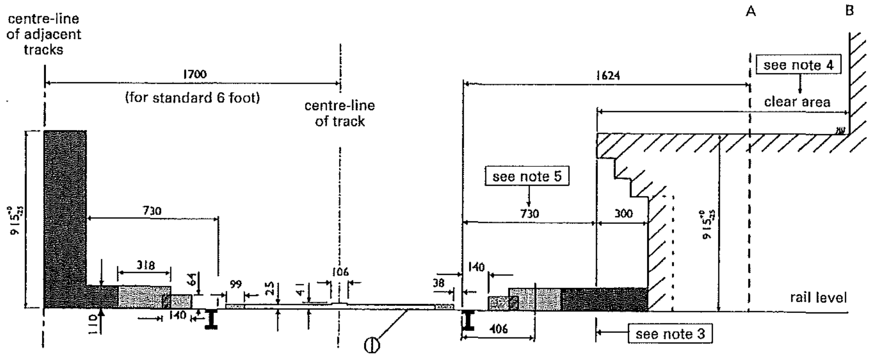
1 This diagram illustrates minimum lateral and overhead clearances to be adopted in construction or reconstruction and for alterations or additions to existing track and structures for line speeds up to 165 km/h (100 mph).
2 All dimensions are in mm.
3 * The dimension to be used when line speed exceeds 165 km/h (100 mph).
4 The clearance dimensions given are valid for straight and level track only and due allowance must be made for the effects of horizontal and vertical curvature, including super-elevation (cant).
5 The standard structure gauge allows for overhead electrification with voltages up to 25 kV. However, to permit some flexibility in the design of overhead equipment, the minimum dimension between rail level and the underside of the structures should be increased, preferably to 4780 mm or more if this can be achieved with reasonable economy. The proximity of track features such as level crossings or OHE sectioning may require greater than 4780 mm.
6 Permissible infringements in respect of conductor rail equipment, guard and check rails, train stops and structures in the space between adjacent tracks are not shown.
7 The minimum dimensions of a single face platform measured from the edge of the platform to the face of the nearest building structure or platform furniture shall be 2500 mm for speeds up to 165 km/h and for speeds greater than 165 km/h the minimum dimension shall be 3000 mm. The minimum distance to the face of any column shall be 2000 mm.
8 Nearest face of all other structures including masts carrying overhead line equipment of electrified railways.
9 Nearest face of signal posts and other isolated structures less than 2 m in length but excluding masts carrying overhead line equipment on electrified railways.
10 Vertical clearances to the canopy above the platform shall be 2500 mm up to 2000 mm minimum from the platform edge or up to 3000 mm where the line speed exceeds 165 km/h. At distances beyond 2000 mm or 3000 mm from the platform edge, as applicable, the minimum headroom shall be 2300 mm.
11 Platform clearances are subject to the maintenance of HMRI stepping distances and specific requirements shall be calculated from the particular kinematic envelope with an allowance made for structural clearance. The minimum lateral dimension is 730 mm and is shown for guidance.
12 Where reasonably practicable these dimensions shall be increased by 300 mm to facilitate the provision of an access walkway in accordance with CC/RT5203 *Infrastructure Requirements for Personal Safety in Respect of Clearance and Access.*

3 Standard structure gauge

Network Rail shall give consideration to passenger safety by limiting the maximum stepping distance from the top edge of the platform to the top edge of the step board or floor of passenger rolling stock.

The following maximum dimensions for stepping distances, calculated from the centre of the bottom of the door opening, shall apply unless dispensation has been sought from HSV/HMRI for site specific cases relating to identified rolling stock. All such cases must be recorded in writing and maintained for future reference.

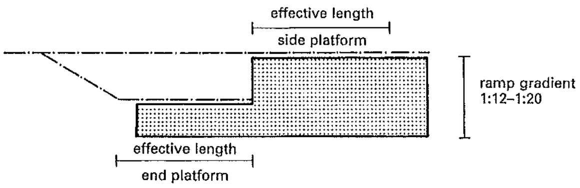
horizontal	275 mm
vertical	250 mm
diagonal	350 mm



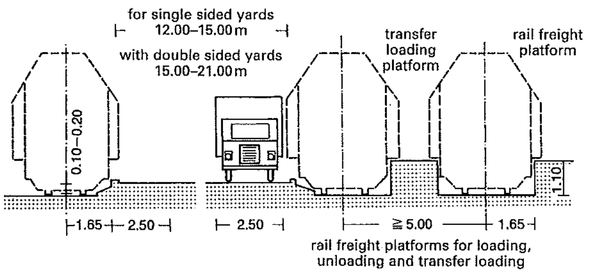
1 All dimensions are in mm.
2 The dimensions shown are for straight alignment and appropriate adjustments must be made for curvature. Except for dispensation which allows station platforms on curves with a radius greater than 360 m to be placed at standard dimensions (as shown), the amount of platform set-back for curves with a radius less than 360 m shall be determined by Network Rail.
3 Bridge girders, dwarf signals and other lineside equipment up to a height of 915 mm ARL may be positioned in the space available for platforms.
4 The minimum dimension of a single face platform shall be 2500 mm for speeds up to 165 km/h and for speeds greater than 165 km/h the minimum distance shall be increased to 3000 mm. The minimum distance to the face of any column shall be 2000 mm.
5 Platform clearances are subject to the maintenance of HMRI stepping distances and specific requirements shall be calculated from the particular kinematic envelope with an allowance made for structural clearance. The minimum lateral dimension is 730 mm and is shown for guidance.

key
A abutments, piers, stanchions etc. (clear of platform)
B columns and other works on platforms
areas for conductor rails and guard boards
areas for guard and check rails only
areas available for dwarf signals, bridge girders and other lineside equipment
unhatched areas so marked are for permanent way, signal fittings and fourth rail electrification

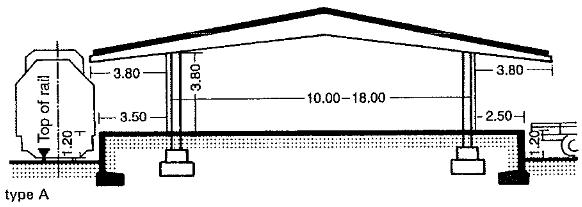
4 Standard structure gauge applicable at and below 1089 mm above rail level (ARL)



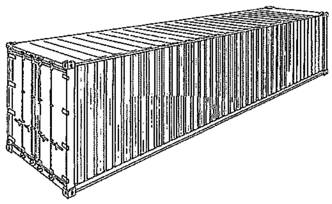
❶ Plan of a loading ramp with head and side ramps with a slope of 1:12–1:20

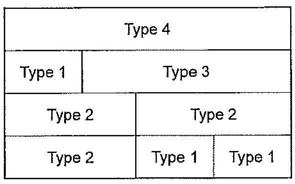


❷ Profile of a loading road (top of rail to road level)



❸ Section through a loading warehouse





❹ Modular system of ISO containers

Code	Container length (mm)	ft' in"
1	2991	10'
2	6058	20'
3	9125	30'
4	12192	40'
A	7150	
B	7315	24'
C	7430	
D	7450	24' 6"
E	7820	
F	8100	
G	12500	41'
H	13106	43'
K	13600	
L	13716	45'
M	14630	48'
N	14935	49'
P	16154	
only USA		53'
only USA*		57'

*only in some states

❺ Codes for container lengths

Container description	External dimensions						Permissible gross mass
	Length		Width		Height		
	mm	ft' in"	mm	ft' in"	mm	ft' in"	kg
1AAA	12192	40'	2438	8'	2896	9'6"	30480
1AA					2591	8'6"	
1A					2438	8'	
1AX					<2438	<8'	
1CC	6058	19' 10.5"	2438	8'	2591	8' 6"	24000
1C					2438	8'	
1CX					<2438	<8'	

❻ External dimensions and weights of common types of 20 and 40 foot containers. The construction size of a 20 foot container is a joint smaller, so that shorter and longer containers can be stacked together.

Today rail-borne freight transport is a part of international goods transport. In order to remain competitive with road transport, rationalised loading and unloading systems (combined transport) have been developed.

Loading ramps

These can be head or side ramps situated in or next to stores or logistics warehouses. The length is approx. 700 m in order to load and unload entire trains. Clear opening width of entry doors ≧3.35 m or for new buildings = 4.00 m. Inside buildings the railway structure gauge (p. 408 → ❶) and the clear profile and swept curves for HGV traffic (p. 461 and p. 398) should be considered. Loading ramps: see also Supply and disposal (pp. 461–462).

Side ramps, at which goods wagons are unloaded and loaded through outward-opening doors, may not be higher than 1.10 m. The height must not exceed 1.00 m if the outward-opening doors of passenger carriages may also have to be opened. Otherwise, side ramps for the loading and unloading of wagons may, except on main lines, be up to 1.20 m above the top of the rail. Details of safety distances (for workplaces) according to GUV-VD 30.1 are also to be complied with. Storage and logistics warehouses should be designed for the goods to be handled. Goods are normally transported on pallets, as these are easier to load. For logistics reasons, Europool pallets (abbreviated to **Europallet**) are mostly used (→ p. 269). They are standardised according to UIC Bulletin 435-2 of the International Union of Railways.

Combined transport

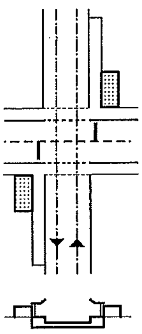
Combined transport denotes the transport of the goods in one and the same transport unit (exchangeable container, container, semi-trailer) or it can be transported in the same road vehicle with one or more transport methods. Starting with shipping, containers have become universal for the transport of unit goods and are also increasingly used for bulk materials. They enable short handling times between the various means of transport on water, road and rail.

The logistics centre is described as a combined or inter-modal transport terminal and is mostly part of a freight centre. Portal cranes stack the containers automatically for intermediate storage and load them onto other vehicles.

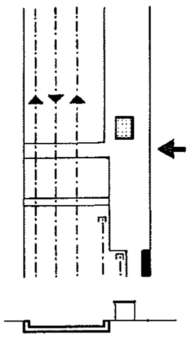
Containers

Containers used for international transport are predominantly ISO containers with a width of 8 ft (2.44 m) and a length of either 20 ft (6.06 m) or 40 ft (12.19 m), with the abbreviated descriptions: TEU (Twenty-foot Equivalent Unit) and FEU (Forty-foot Equivalent Unit). Other lengths → ❺. Standard containers are 8 ft 6 in high (2.59 m), and 'High-Cube' (also described as HQ 'High-Quantity') containers are 9 ft 6 in (2.90 m). The dimensions are chosen so that containers can also be transported in most countries by truck or rail. In European land traffic, containers with a width of 2.50 m or 2.55 m are used (inland containers). Containers are so robustly constructed that they can be stacked up nine high (load-bearing capacity min. 4 fully loaded containers).

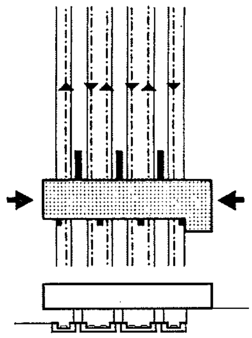
There are various special types of containers, like refrigerated containers for perishable freight, tank containers for liquid and gas loads, car containers for car transport and living containers for temporary accommodation. Another combined transport possibility is the loading of complete trucks or road trailers onto special wagons. This 'rolling road' or piggyback transport requires only a ramp at the end of the track, because the trucks can drive onto the train under their own power.



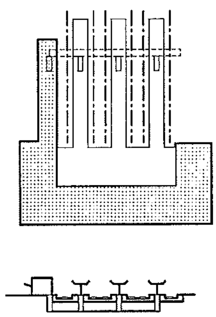
❶ A stop at an existing level crossing to change side of platform



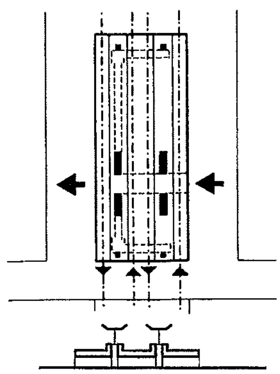
❷ Access for passengers over the tracks, only possible for small stations without trains passing through



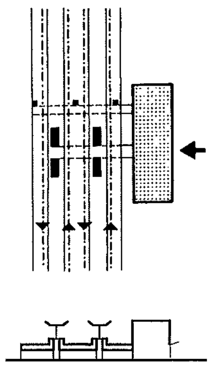
❸ Station building over the tracks. Bridge for passengers and luggage.



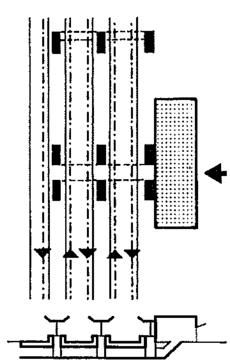
❹ Station building of a terminus, ideally at track level. This is suitable only for stations with no through traffic at all, because otherwise too much track area is needed



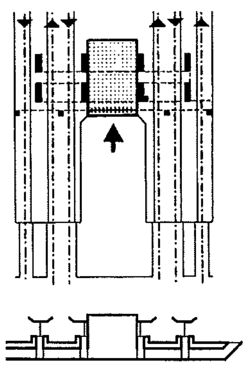
❺ Station building centrally located below the tracks. Short routes, good waiting area lighting, otherwise as before



❻ Station building below track level. Tunnel for passengers and luggage. Popular and effective layout with level access



❼ Station building at the side at track level. Tunnel for passengers (with slope)



❽ Station building below and between the tracks, generous forecourt, short routes, otherwise as before

Stations can be halts with a platform located next to a line without points, or stations with at least one point so the trains can bypass the station or turn. Stations are described according to the layout of the tracks and the location of the station building (depot).

1. Through station (most frequent layout, e.g. Cologne main station, Hannover main station) → ❻.
2. Terminus (e.g. Leipzig or Munich main stations) → ❹.
3. Multi-level station (e.g. Osnabrück main station, Berlin main station)
4. Island station (station building between the tracks, e.g. Halle/Saale main station) → ❽.

The approach line to the station through the city can be at street level, on banks with roads passing underneath or in cuttings or tunnels with the streets passing over. The route alignment leads to the location of the station → ❶ – ❻, with a low-level arrangement being the most acceptable variant for urban planning (e.g. the design for Stuttgart 21, conversion of the terminus to an underground through station while still using the old station building).

Design basics
The following principles apply to new building and also refurbishment (in order according to importance):
1. Operational safety and accident prevention
2. Feeling of security and well-being
3. Simple orientation
4. Simple building maintenance
5. Brand recognition/formation
6. Attractiveness of form

Stations should be designed to achieve the shortest possible walking distances to other forms of transport. Urban rail and underground stations should be under the station building if possible. Local public transport should be available as near as possible to the platform. It should be possible to park long term and taxis and private cars should be able to draw up.

The station building contains areas leased to external leaseholders (normally shops or services) in addition to the services operated by the railway company, like a TravelCentre, a ServicePoint, waiting areas, a lounge (at large stations) and luggage storage.

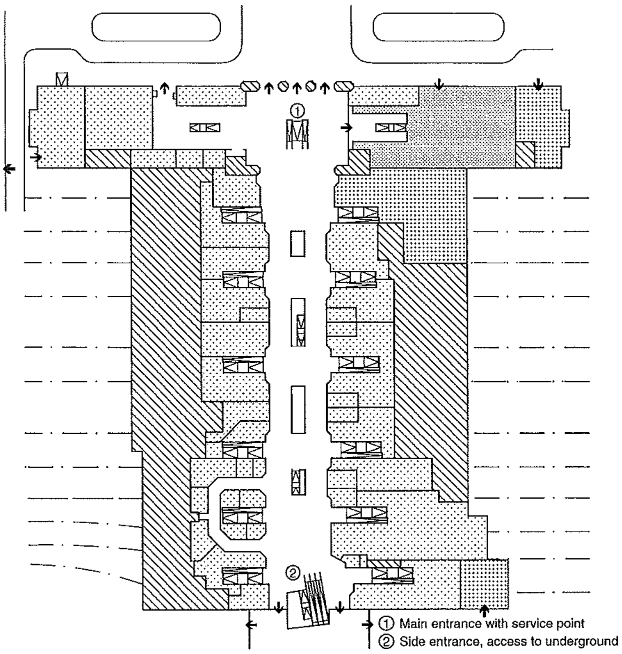
Pedestrian underpasses and bridges
The minimum width of underpasses and bridges is 2.50 m. Larger widths should assume a multiple of the walking width of 0.80 m. The clearance height should be at least 2.50 m, but has to be only 2.25 m under supplementary installations.

Accessibility
If more than 1000 passengers per day catch a train, then at least one barrier-free access (i.e. convenient for disabled passengers) should be provided. Ramps are always available and maintenance-free. Lifts should be pass-through (Roll-On Roll-Off principle) with glazed cabins. The minimum size is regulated by the state building regulations. It should also be possible to transport prams, pushchairs, luggage trolleys and cycles without problems. Access to the platform is permissible only along the platform with a 1.5 m × 1.5 m waiting area in front of the lift.

Tactile and colour-contrasted guide strips should be provided on the floor. On the platforms, these mark potentially dangerous areas. At stairs and ramp handrails, the platform numbering should be applied in Braille.

Transport

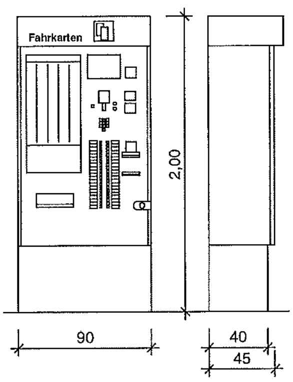
RAILWAYS
Tracks
Freight transport
Stations
Station buildings
Platforms
Platform furniture



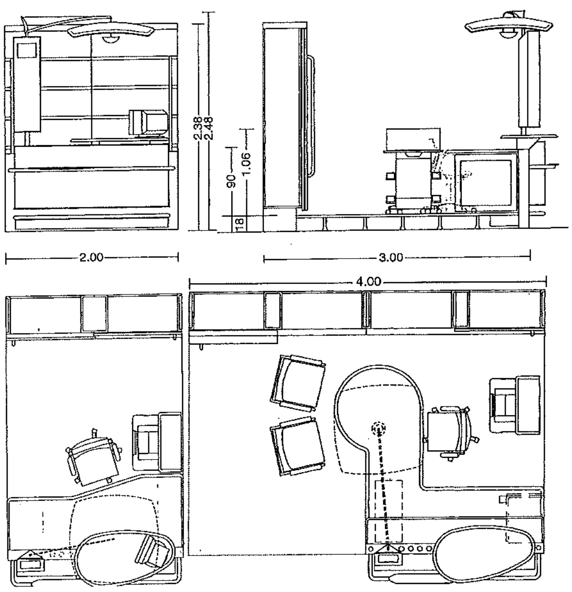
❶ Station aisle, Hannover

Travel service of DB	DB lounge TravelCentre
Station service of DB	Luggage storage Courier service Federal border police Station mission
Service providers	Tenant areas Café Sanitary (WC/showers) Travel requisites
Store & building services	

❷ Station aisle, Hannover – key



❸ Dimensions of free-standing ticket machine; can also be installed.



❹ Modular fitting out system for the TravelCentre (DB → refs)

Station buildings (German Railways uses the term reception buildings) serve to connect the railway network to other means of transport. The services offered in-house by the railway company are limited to essentials like sales of tickets and tours, information and taking care of luggage. Other services and shops are operated by leaseholders in the station area → ❶ – ❷.

TravelCentre

The TravelCentre is for personal advice and the sale of tickets. The fitting out is modular on a metre grid, and the smallest unit, a counter, is 2 m × 3 m. The elements are delivered completely pre-installed. The adjustable legs enable adaptation of the installation and compensation for the height difference between the seated staff and the standing passengers. The system can be completed with various supplementary elements → ❹.

A sufficiently large area should be provided for waiting customers with a free space in front of the counter. If there is more than one counter, organise one centralised queue if possible. Ticket machines are also provided to relieve the workload at the counter → ❸.

ServicePoint

The ServicePoint is the central source of information between customer and service staff and is the direct point of contact for travellers. In order to cover the different requirements and local conditions, a product family has been developed with three basic types:

1. Singular type ServicePoint: free-standing in the reception building, various sizes, modular, different layouts for 1–4 employees (for two workplaces LWH: 3.00 m × 5.00 m × 3.50 m).
2. Integrated type ServicePoint: within a façade or inside the station building, adjacent to the TravelCentre, for 1–4 employees (LWH: 2.00 m × 2.60 m × 3.10 m for one workplace, with each further workplace elongating the fixture by 1.70 m.)
3. Mobile type ServicePoint: a rolling stand for flexible use in the station building and also on platforms, for one employee each (LHB: 0.90 m × 0.80 m × 2.30 m). These sizes are at the design stage and could still alter.

Stairs

The usable stair width should be a multiple of 80 cm (walking passage width) but at least 2.40 m clear. The stair width can also be determined from the expected passenger numbers according to the formula:

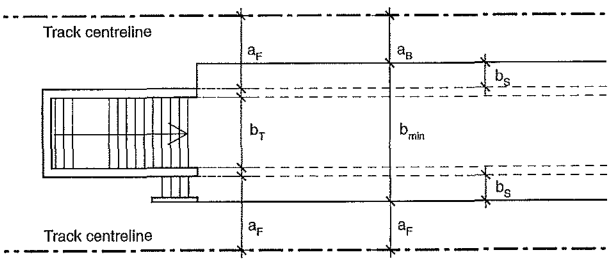
$$b_{Tn} = \frac{n_p}{v \times d \times t} + w$$

n_p	no. passengers at peak travel time	
v m/s	average walking speed	= 0.65
d people/m^2	pedestrian traffic density	= 1.0
t s	time to clear the platform	= 120–180 s
w m	walking width in the other direction	= 0.80 m
	for local and urban traffic	= 0.60 m

Stair dimensions, see → p. 120 ff. The waiting space in front of the stairs should be 1.5 times the stair width. The first and last steps must, and all other steps should, be provided with a 6 cm wide contrasting strip.

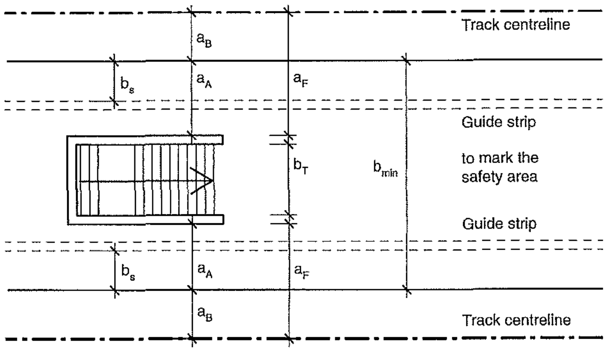
Escalators

From a passenger density of more than 3000 people per hour or, with a difference in levels of 8 m, more than 500 people, escalators should be provided. The minimum width should be 1 m in order to be able to transport luggage trolleys → p. 126 ff.



Platform width $b_{min} = b_T + 2_w + 2(a_F - a_F)$

- a_F Minimum distance of fixed objects (e.g. columns) from the track centreline
  on the platform = 3.00 m
  at the end of the platform = 2.50 m
- a_A Distance between platform structures and platform edge taking into consideration barrier-free access width and the danger area b_S
  next to short structures (e.g. columns) min. $a_A = b_S + 0.90$ m
  next to longer structures with min. 1 entrance min. $a_A = b_S + 1.20$ m
- a_B Distance of the platform edge from the track edge
- b_{min} Minimum width of the platform
- b_S Width of the danger area
  V ≦ 160 km/h b_S = 2.50 m – 1.65 m (for straight tracks)
  160 > V ≦ 200 kmh b_S = 3.00 m – 1.65 m (for straight tracks)
- b_T Clear width of stairs or ramps between the strings
- w Width of the stair string (including cladding)



❶ Platform widths and danger zones

Platform classification	A	A1	A2	A3	B	B1	B2	C	D
Platform standard length	405 m	370 m	320 m	280 m	210 m	170 m	140 m	120 m	60 m

❷ Platform lengths (A express, B local, C and D less significant halts). A full Inter-City Express (ICE) high-speed train needs 405 m and a half ICE train 210 m

Widths

Platforms can be described, according to their location, as central platforms (between two tracks) or side platforms (with only one platform edge). The width of a platform is essentially derived from the number of passengers. The decisive factors are the waiting zone, the walking route width of 0.80 m and the width of the safety zone, which is determined from the permissible highest speed of trains passing through → ❶. The details of distances to the track bed always relate to the track centre-line.

The minimum widths are:
Side platforms = 2.50 m – 1.65 m + 2 × 0.80 m = 2.45 m
Central platforms = 2 × (2.50 m – 1.65 m) + 2 × 0.80 m = 3.30 m

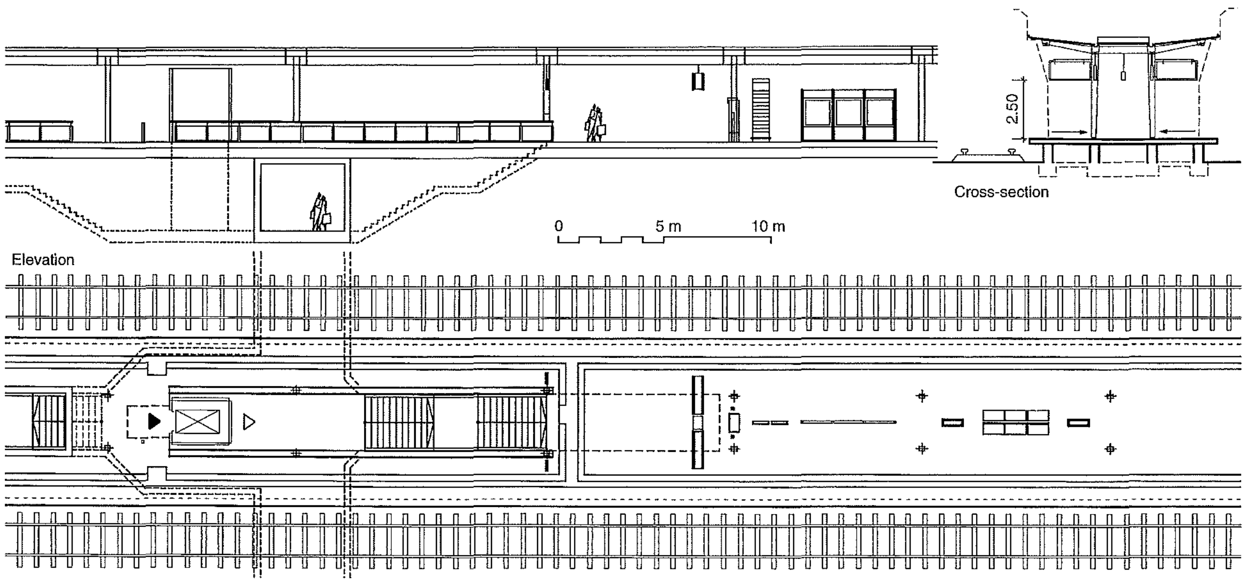
Platform heights and lengths

The heights of platforms are related to the top of rail level. Common values are 76 cm, for local transport also 55 cm, and for urban rapid transit 96 cm. Old platforms may still be 38 cm high. The heights and lengths of platforms depend on the expected operational schedule → ❷. These lengths can be extended to meet local requirements for signalling equipment.

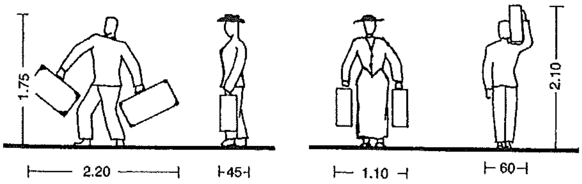
Platform roofing

Three standard types of platform roofing are available for selection according to the status of the station and cost of building. Systems which need only a short construction time in the danger zone and place less stringent requirements on their foundations (frame construction on the table principle) are good, because they disrupt scheduled services only for a short time. These closures have a high cost for safety staff, the securing of the overhead wire system and closing tracks.

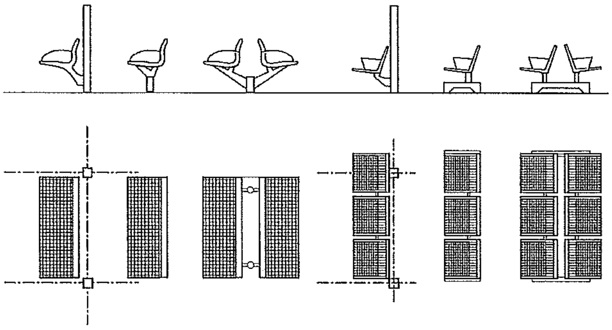
Roof construction is based on a multiple of the 30 cm grid (standard 9 m) of the platform paving. The clear height should be min. 3.25 m in order that a free height of 2.50 m remains under the suspended information system. Attention should be paid to the necessary queuing and waiting areas and the specified distances to the track. The design of structures and of elements hanging from the roof construction needs to take into account the additional loading from buffeting by passing trains.



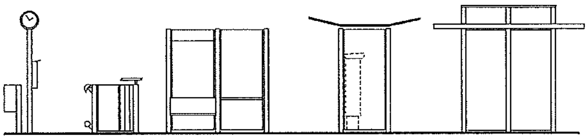
❸ Standard platform with 'Zwiesel' type roof, plan and section



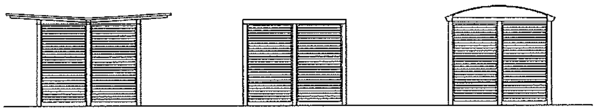
❶ Space required by passengers



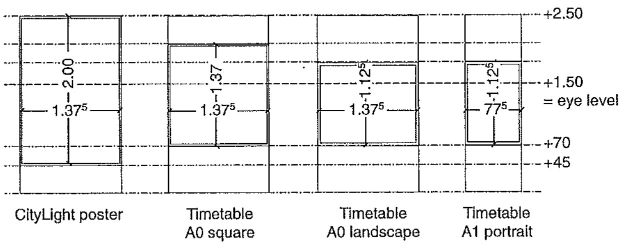
❷ Seating variants, free-standing and weather-protected (DB → refs)



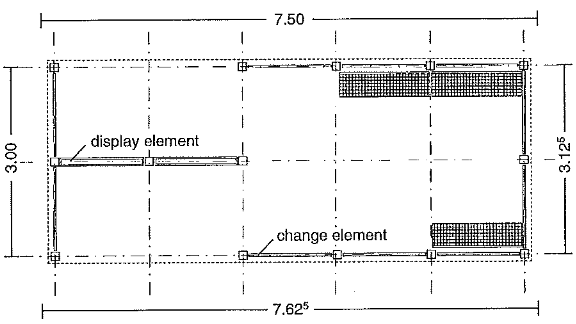
❸ Platform furnishings according to Raster22



❹ Variants of roofs for weather protection



❺ Display cases for various poster and timetable formats. In back-lit display cases, the gap to the paper dimensions is made up with transparent surrounds. The vertical dimensions should enable short people to read the posters (DB → refs)

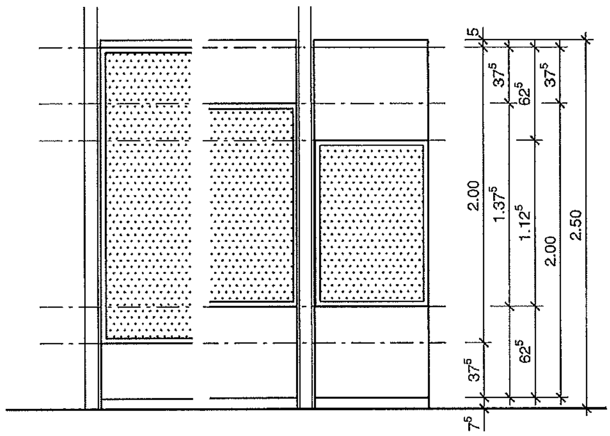


❻ Weather and wind protection type T-in-U for central platforms (DB → refs)

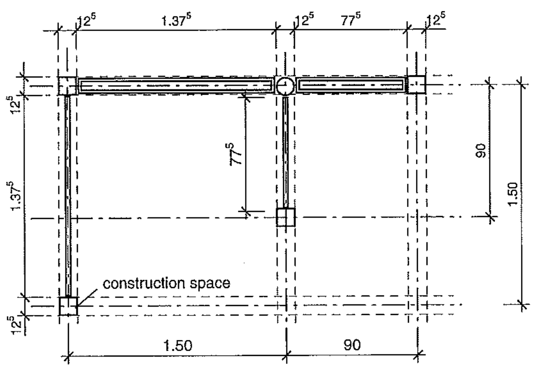
The federal railway authority (EBA) is the approval body for structures built on areas dedicated to the railway. Small buildings under 100 m^2 require no building permission. It is normally obligatory to select structural and fitting out elements from a listed product portfolio, which has been optimised and tested with regard to safety, maintenance expense and corporate design.

Raster22®

DB Station&Service AG has developed the product-independent Raster22 (Grid22) for weather protection systems, wall elements, display cases and seating furniture. This is a dimension and interface system (90 and 150 cm) derived from the paving slab module of 30 cm. 12.5 cm construction space is provided for columns and connection elements, so that the remaining fields of 77.5 or 137.5 cm can be filled with installed elements like wall panels or display cases. The dimensions of the display cases are derived from the maximum size of a CityLight poster of approx. 200 × 136 cm. The vertical dimensions are taken from the grid dimension of the route guidance elements of 12.5 cm. This grid system enables construction elements from various manufacturers to be combined and simplifies the design of connections and foundations. Two product families of seating furniture are available, a bench and an individual seat system. Various types of fixing and seating made of 4 mm wire (weather- and vandalism-resistant), or plywood rails for indoors, offer various possible uses.



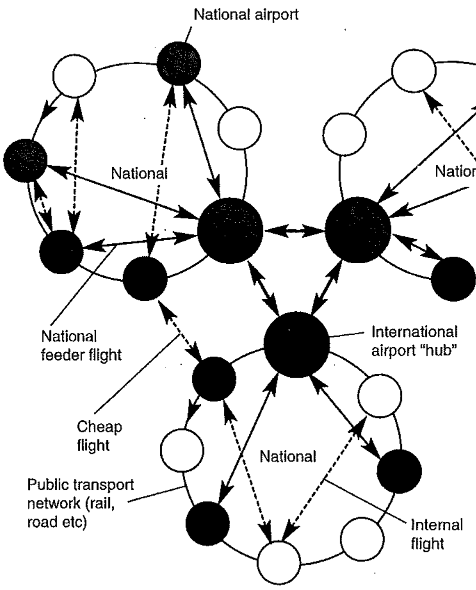
❼ Raster22 vertical module



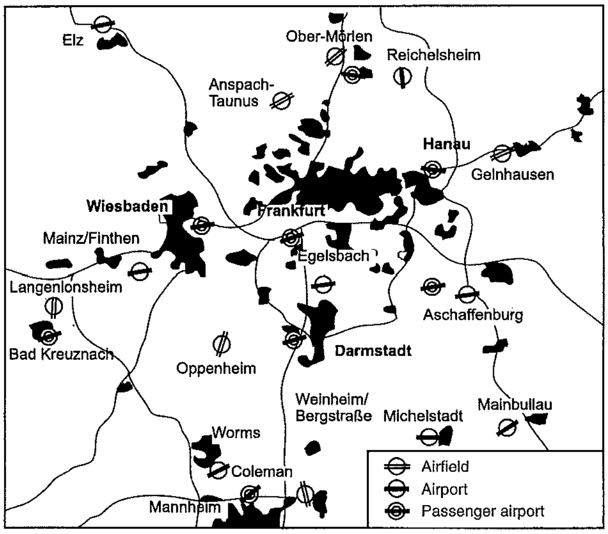
❽ Raster22 plan module (DB → refs)

Transport

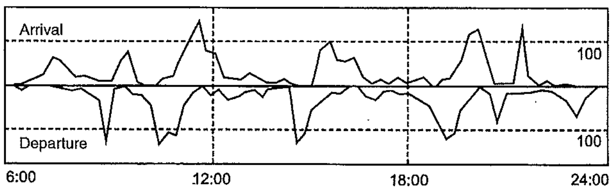
RAILWAYS
Tracks
Freight transport
Stations
Station buildings
Platforms
Platform furniture



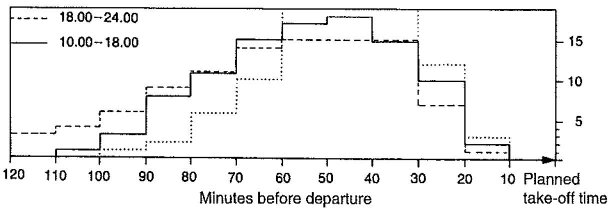
❶ Aviation as part of the inter-modal transport network



❷ Airport density (example: Rhine-Main area)



❹ Node system at a major airport (hub): no. flights / time of day



❺ Arrival time of passengers before a scheduled flight

The aviation market

The wave of privatisation in aviation (airlines, airports, etc.) has created a complex market with hard competition. The **passenger transport** segment (business and holiday flights, either scheduled or charter) is differentiated from the **air freight** sector, and each is split into the geographical segments Germany, Europe and outside Europe. Highly varied business strategies are pursued by the airlines with the main differences being **speed** (flight times, flight durations, rapid transfers) and **price** → ❶. For example, the **'Hub-and-Spoke'** model: major 'international' airports (hubs) are connected by large planes and the spokes are represented by the regional connections to national airports. In order to reduce waiting time for transfers, flights are bundled at certain times of day into **'nodes'** → ❹.

The **'cheap flight'** model: these use low-cost airports (few runways) and cheap slots (unfavourable flight times) and are flown with medium-sized planes.

The traditional income source for airports, their take-off and landing fees, are becoming ever less significant in contrast to rent received for commercial and office space at the airport. This development is having a great influence on modern airport design and architecture.

ICAO Convention	The **design basis** for the construction and operation of airports is the provisions of annex 14, volume 1 of the Convention of the **International Civil Aviation Organisation** (ICAO) as the basis for national laws. The International Civil Aviation Organisation (ICAO) is a specialised agency of the United Nations responsible for the planning of civil aviation. Over 180 countries belong to the ICAO. Germany is represented by a permanent delegation from the federal ministry of transport, building and housing. The tasks of the ICAO include the standardisation and safety of aviation, the development of infrastructures and the production of recommendations and guidelines. The ICAO also allots the ICAO codes.
Public planning law	(National) **public planning law** includes **approval conditions** for the construction of airports. This normally affects large-scale projects with regional significance, for which a **regional planning procedure** with additional conditions (e.g. environmental impact assessment, landscape impact and mitigation) is required → p. 56.
Aviation noise law etc.	Because of the environmental nuisance produced by an airport (noise, emissions, etc., see below), the construction and operation are subject to many further **environmental laws.** (e.g. **airport regulations, aviation noise law).**

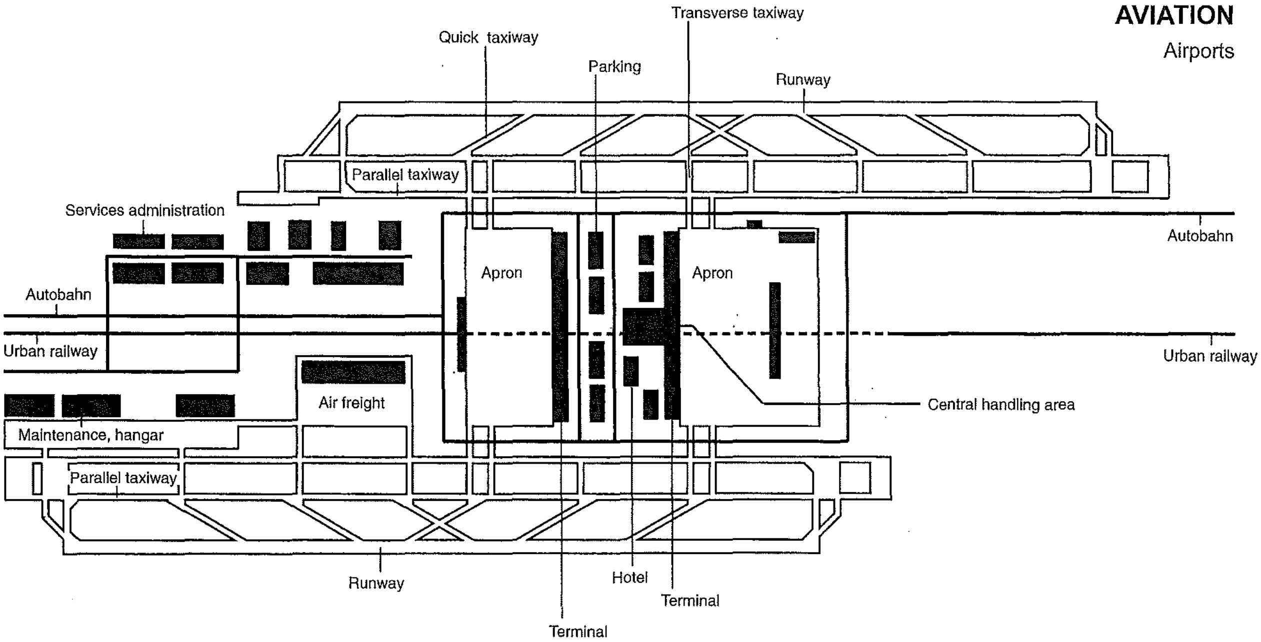
❸ Planning basics

Environmental aspects

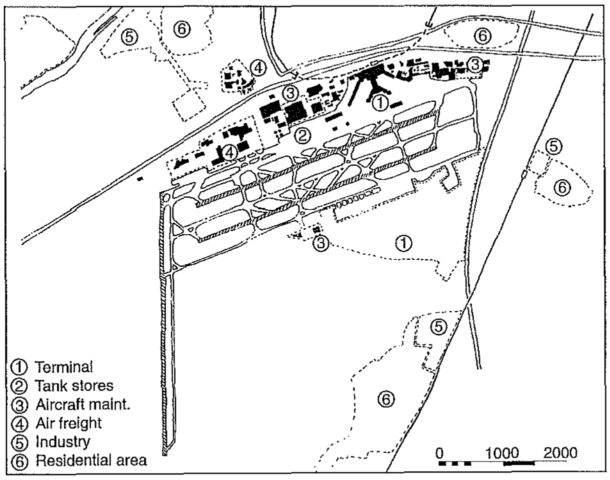
As part of the planning and approval process, the design of an airport has to consider many aspects of environmental protection (environmental impact assessment, landscape impact and mitigation plan, etc.). In addition to the transport connection, the noise nuisance from the airport is a central evaluation criterion, with corresponding thresholds. The area on the ground where the take-off or landing of a plane produces a certain level of noise specific to the plane is called the noise carpet.

In addition, the daily operation of an airport is connected with a range of environmental problems. This particularly concerns **noise reduction** (e.g. through night flying restrictions, noise-related fee structures, construction sound insulation measures), **groundwater protection** (e.g. through rainwater retention basins to control the surface water run-off from airside paving, sparing use of environmentally harmful chemicals (de-icing agents for planes and runways), **energy-** and **environmental management** and **waste management**).

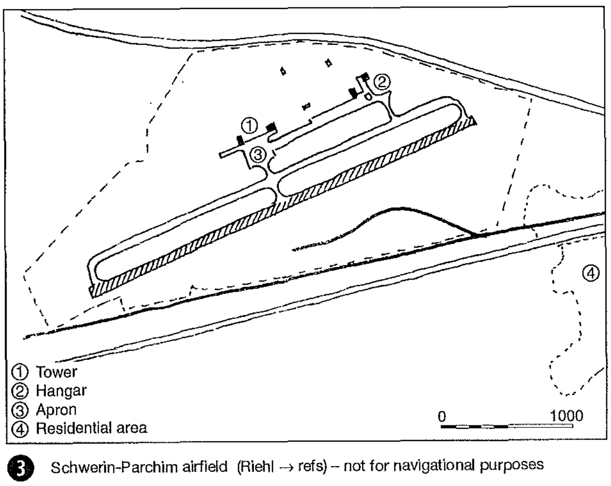
Convention of the International Civil Aviation Organisation (ICAO), annex 14, volume 1
Aviation Law
Building Law (BauGB)
Airport regulations
Aviation Noise Law



1 Scheme of an airport showing functional areas, based on Munich airport, approx. scale 1:4000 (Flughafens München → refs)



2 Frankfurt am Main airport (Riehl → refs) – not for navigational purposes



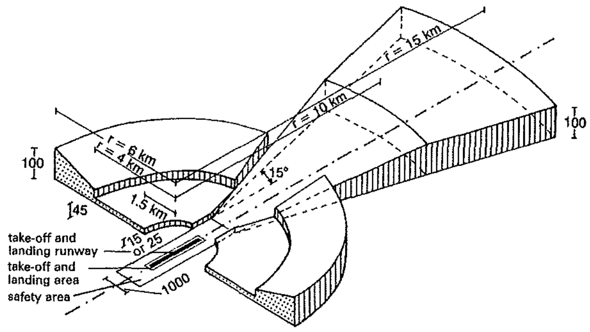
3 Schwerin-Parchim airfield (Riehl → refs) – not for navigational purposes

Categorisation of airfields
The term airport, according to Aviation Law, is a general term for:

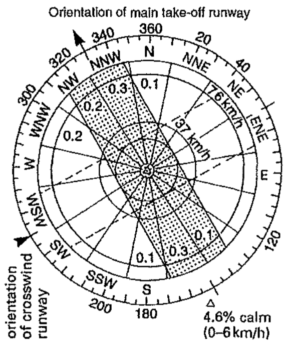
- airports (with surrounding area subject to additional building regulations)
- airfields (perhaps with a limited surrounding area subject to additional building regulations)
- glider airfields, heliports

Airports and airfields are divided into transport and special airports and airfields, either accessible for every aviator or serving special purposes (e.g. airfields belonging to companies or flying clubs).

Design parameters for an airport → 1
Runway system: the number and arrangement (spacing) of the take-off and landing runways determines the possible number of movements per unit of time → p. 420.
Terminal: (handling, check-in and customs building) the capacity of the handling system for passengers and baggage or the freight flow per unit of time is determined by the following parameters: connections to ground transport (main line trains, urban rail, car parking, length of approach roads); passenger handling (number of check-in counters); baggage handling (number of counters and capacity of the transport system); and the organisation of passport control, security controls, access controls before boarding (size of waiting rooms, number of gates) → p. 421.
Apron: the term apron includes parking ramps for planes with the associated taxiways, roads and parking areas for handling vehicles. The apron connects the runways and taxiway system with the terminal and is functionally closely related to it. Apron and terminal should be designed together → p. 422.
Additional buildings: various additional functions are essential for the operation of an airport, and have to be included in the overall layout: administration, maintenance, fire service, airfreight, etc.
Service areas: (non-aviation) the strategic assignment of commercial and service areas (hotels, restaurants, parking, shops, etc.) to the actual functional areas of the airport is of increasing significance in the design of an airport → p. 421.
Ground transport network: the comfortable, reliable and punctual connection of an airport to the ground transport network (inter-modality) is of decisive importance for the functioning of an airport.

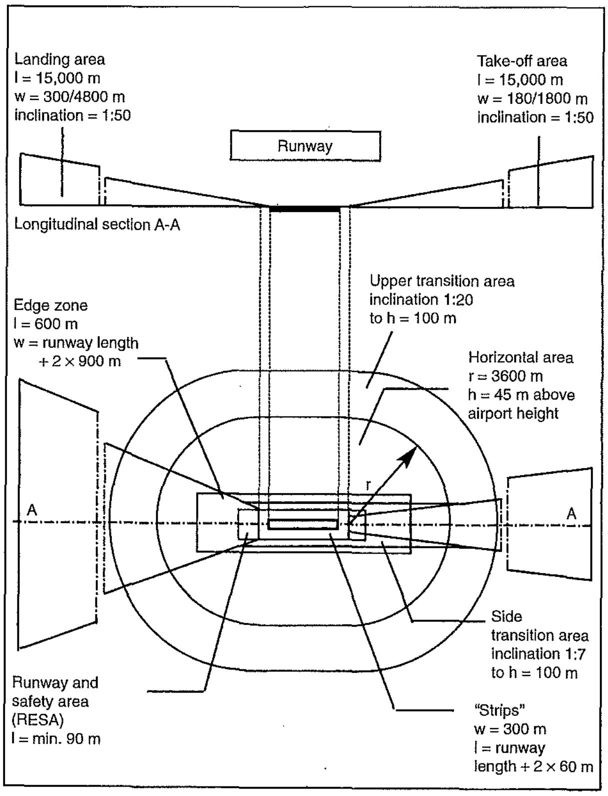


❶ Area of additional building regulations for an airport with an instrument landing runway (Aviation Law)



Wind direction	7–24 km/h	26–37 km/h	39–76 km/h	Overall
N	4.3	1.3	0.1	6.2
NNE	3.7	0.8	—	4.5
NE	1.5	0.1	—	1.6
ENE	2.3	0.3	—	2.6
E	2.4	0.4	—	2.8
ESE	5.0	1.1	—	6.1
SE	6.4	3.2	0.1	9.7
SSE	7.3	7.7	0.3	15.3
S	44	2.2	0.1	6.7
SSW	2.6	0.9	—	3.5
SW	1.6	0.1	—	1.7
WSW	3.1	0.4	—	3.5
W	1.9	0.3	—	2.2
WNW	5.8	2.6	0.2	8.6
NW	4.8	2.4	0.2	7.4
NNW	7.8	4.9	0.3	13.0
still	(0–6 km/h)			4.6
total				100.0

❷ Layout of a runway according to wind direction (example)



❸ Obstruction limitation areas of runways with instrument operation (through the example of precision lanes according to ICAO, annex 14 code 3/4)

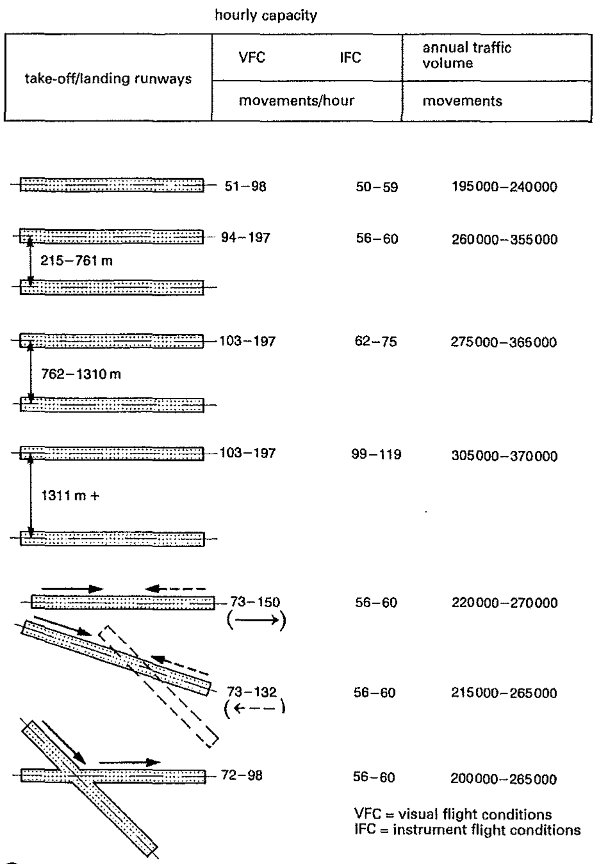
Runways (abbreviated RWY) are for the acceleration of planes for take-off and for slowing after landing. The direction, length/width and number are determined by various factors:

The **direction** is determined by the local wind and topographical conditions. The intention should be that the airport can be flown into 95% of the time. A high frequency of strong crosswinds can make necessary a second runway for taking off and landing → ❷.

The **number** depends on the traffic volume; a parallel arrangement with a spacing of more than 1310 m is beneficial to enable simultaneous taking off and landing, thus achieving full capacity → ❹.

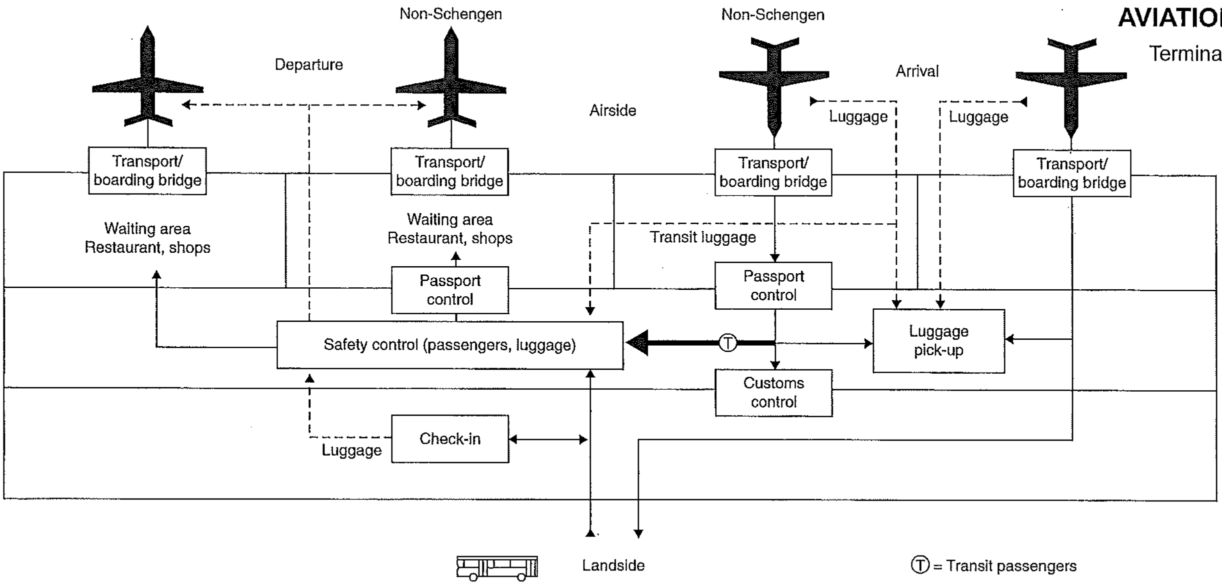
The **length/width** depends on the type of the aeroplane's design and the predominant local climatic and topographical conditions, like temperature, air pressure (analogous to elevation), terrain gradient etc. (large airports have a runway of up to 4000 m length and 40–65 m width). At both sides and as an extension of the runways, the Aviation Law prescribes **areas with additional building regulations** → ❶. The aviation authority issues approvals for building projects in these areas. In addition, **obstruction limitation areas** → ❸ are specified, within which there are limitations to building structures.

Runways are described according to their compass direction (in tenths of a degree), and if parallel with an additional R (right), L (left) or C (centre). Marking and lights code the individual sections, centre-line, width and load-bearing capacity of the runway. The taxiway systems of an airport are designed so that the runway can be cleared as fast as possible after landing (quick exit taxiway) and the take-off position can be reached as quickly as possible.

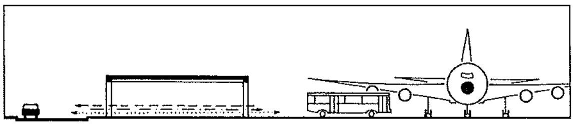


❹ Possible capacity of various runway systems (according to: ICAO Airport Design Manual)

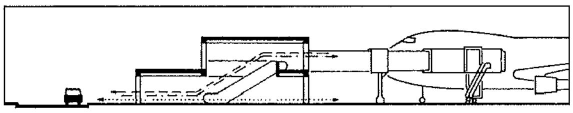
Transport



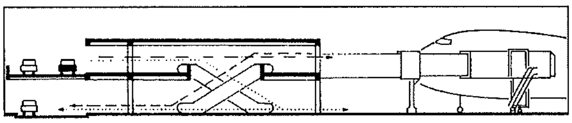
❶ Functional scheme of a terminal (theoretical representation)



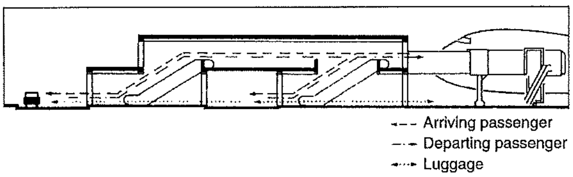
❷ Ground-level road and single-floor terminal on the same level



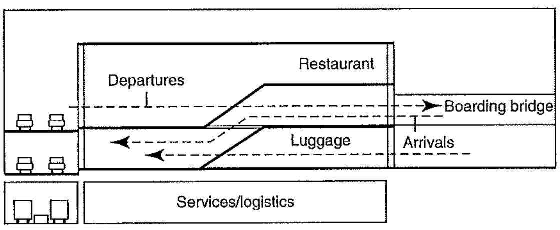
❸ Ground level road / two-storey terminal



❹ Road on two levels / two-storey terminal



❺ Ground-level road / two-storey terminal



❻ Road on two levels / urban rail link and three-storey terminal with service floor

In the design of a terminal, complex technical and functional interactions → ❶ (separation of the public and the secure areas, organisation and dimensioning of the handling areas, movement and waiting zones, conveyor systems with multi-storey routes) have to be balanced with many other prerequisites. The size and variety of requirements give the design some of the character of town planning.

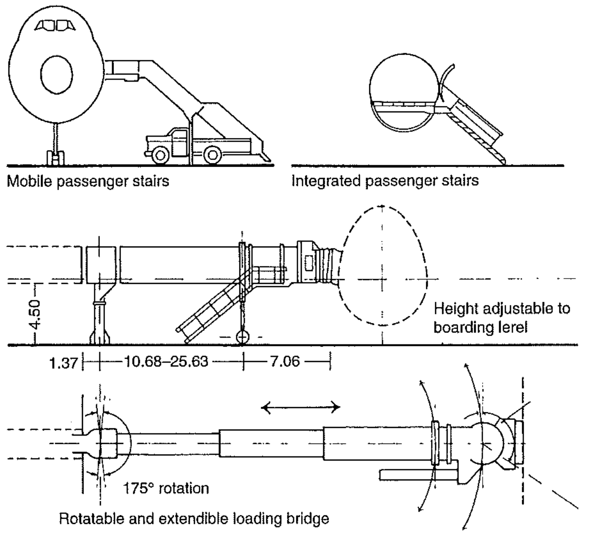
Handling

Handling of passenger traffic covers all customer contact and services, from checking in through security controls until boarding the plane. Handling is performed in specified stages → ❶ and is undertaken by the airline itself or by an outside company acting as handling agent. The principle of handling is to make sure that **no unchecked passenger or unchecked piece of baggage can gain access to a plane and that there is no contact between checked and unchecked passengers.**

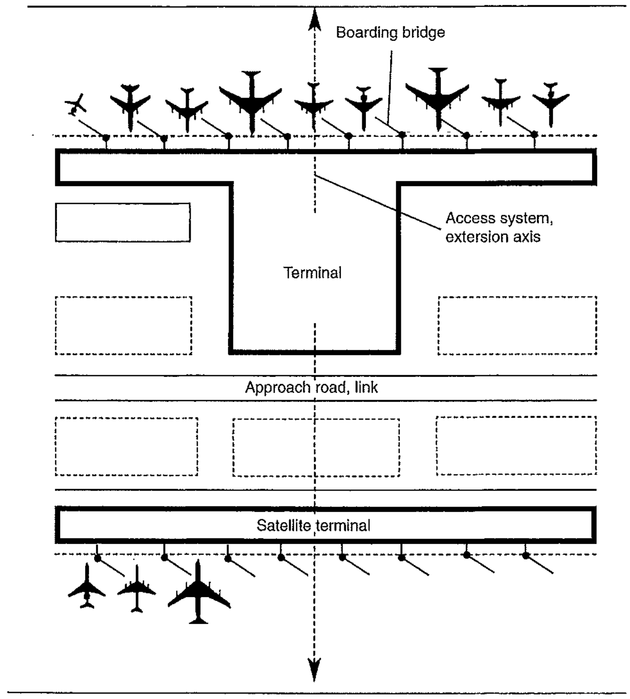
A further important principle is the separation of national and international (or 'Schengen'/'non-Schengen') passengers. The increasing variety of security levels (various source and destination countries and the transit traffic of passengers within an airport) leads to a multitude of parallel routes and security controls with corresponding lobbies (and waiting times). The handling and transit speed is an important factor in the success of an airport in international competition and the routes should therefore be quick and short.

Non-aviation

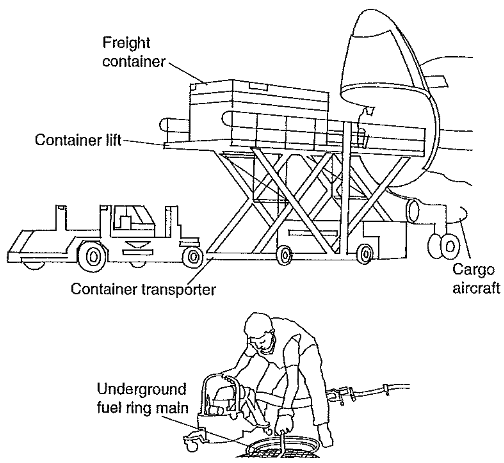
Non-aviation includes all commercial activities at the airport which are not directly associated with flying (hotels, congress centres, shopping, restaurants, etc.). The turnovers in the non-aviation sector at major airports are larger than charges for taking off and landing. The organisation of a terminal therefore has to balance functional procedures (short routes and transfer times) against strategically positioned service and shopping areas, as well as, to an increasing degree, hotels, congress centres and other secondary facilities.



❶ Passenger steps and loading bridges



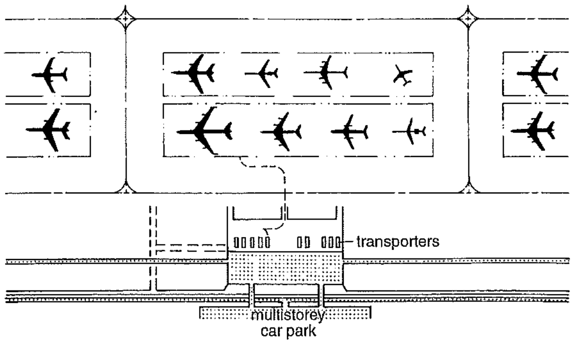
❷ Linear concept with satellites



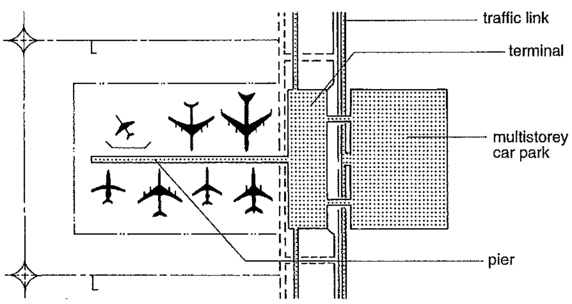
❺ Handling vehicles and machinery on the airport apron

Terminal concepts
Terminals differ according to the arrangement of the gates, their linking to each other and to the building. In addition to the capacity and the areas required, the **possibility of extension** is an important factor in the selection of a terminal concept. **Modular concepts** have become increasingly common in airport design in recent years: **linear concepts** with **satellites** are usual, which means that a linear main terminal building is connected underground or over bridges to satellite units that are also linear → ❷. Access from the building into the planes is normally direct along jet bridges (passenger boarding bridges) → ❶.

A cheaper but lower capacity variant (waiting areas) is offered by **transporter concepts** → ❸, where the passengers are indirectly transported from building to plane on buses. There are also pier concepts with central reception buildings → ❹. When there are two or more piers, however, sufficient room must be provided in-between for at least two planes to taxi in and out, which leads to corresponding distances.



❸ Transporter concept



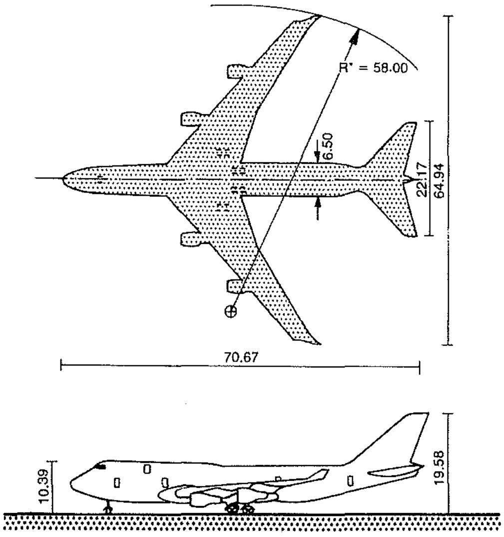
❹ Pier concept

Apron
The apron provides parking spaces for the planes and the associated movement areas (apron taxiways), roads for handling vehicle traffic and parking areas for handling vehicles. The assignment and dimensioning of operational roads on the apron is of great significance for efficient and safer running of the airport. Roads on the apron enable direct and safer connection between the apron and other operating areas of the airport and there should be a minimum of crossings with taxiing planes or other operational functions. Apron roads can be run in front of or behind the planes or next to the ends of the tarmac. If they pass under loading bridges, this imposes a certain clearance profile on all handling vehicles. As a result of the extensive mechanisation and containerisation in aeroplane handling, sufficient space must be provided for handling vehicles and machinery.

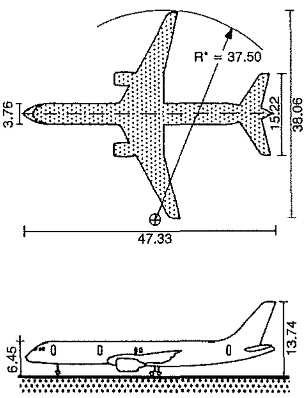
The convention of the International Civil Aviation Organisation (ICAO), annex 14, classifies aeroplanes into **categories**, with letters A– F.

Category A	small and leisure planes (Piper, Cessna etc.)
Category B	RJ 100
	Canadair RJ
	ATR 72
	F 50/F 100
Category C	Airbus A 319/ A 320/ A 321
	Boeing B 737
	MD 80
Category D	Airbus A 300/ A 310
	Boeing B 767
	MD 11
Category E	Airbus A 330/ A 340
	Boeing B 747/ B 777
Category F	Airbus A 380

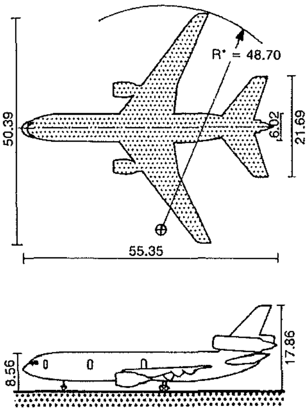
7 Types of planes in categories A–F



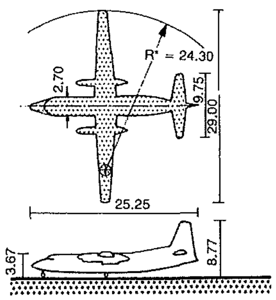
1 B 747-400



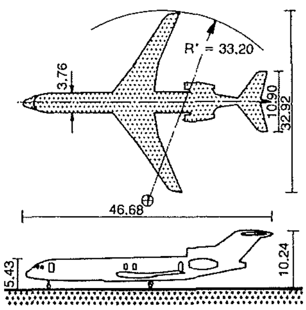
2 B 757-200



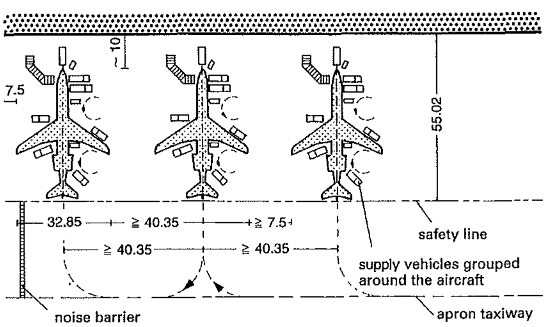
3 DC 10-30



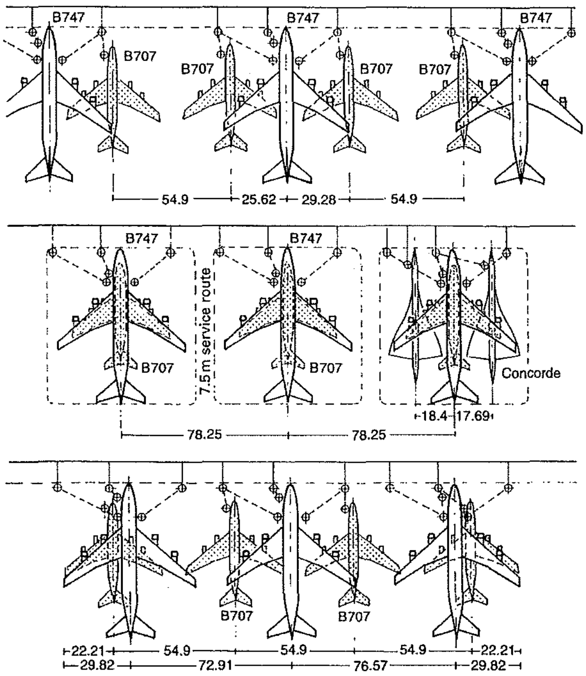
4 F 50



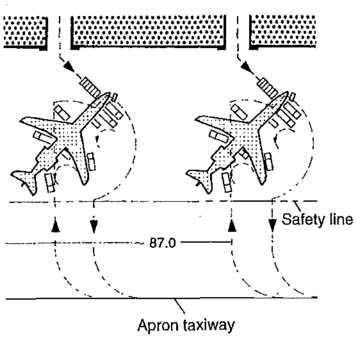
5 B 727-200



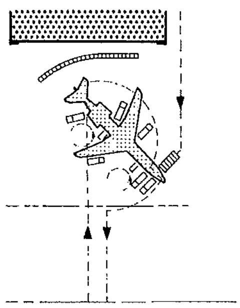
6 Parking position nose-in



8 Parallel parking layout



9 Oblique nose-in parking layout



10 Oblique nose-out parking layout

Transport

AVIATION
Basics
Airports
Runways
Terminals
Apron
Aeroplanes

Convention of the International Civil Aviation Organisation (ICAO), annex 14