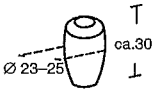
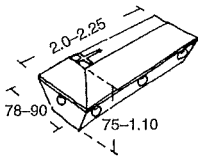
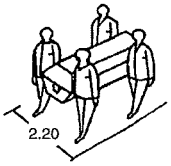


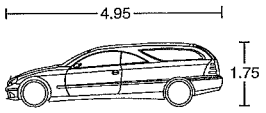
❶ Urn



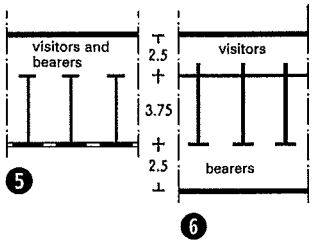
❷ Coffin



❸ Passage width for coffin bearers

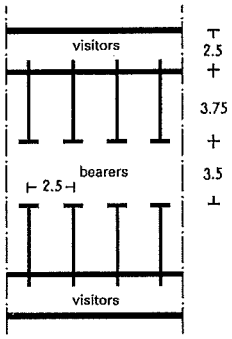


❹ Dimensions of a hearse, width: 1.79 m



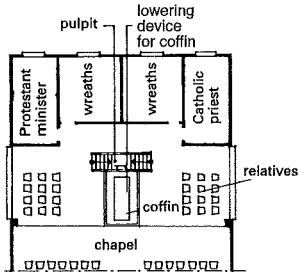
❺

❻

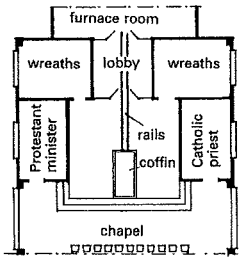


❼

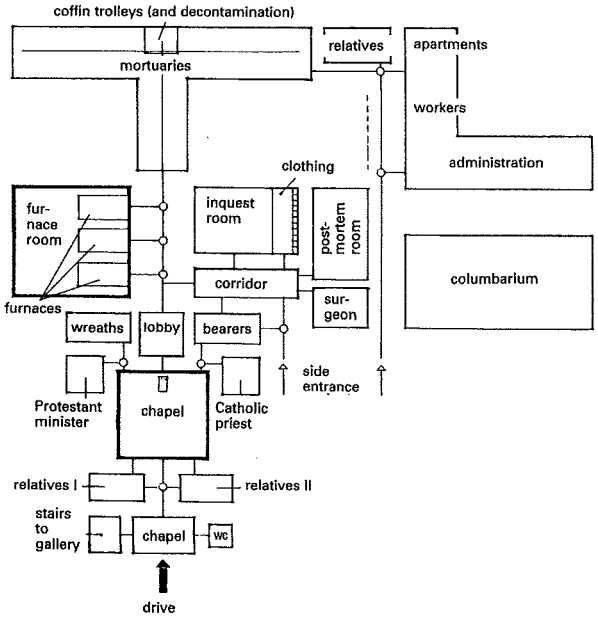
❺–❼ Various common layouts of compartments in the mortuary



❽ Schematic layout of facility with cremation room below chapel



❾ Cremation room behind the chapel and separated by lobbies



❿ Functional diagram of a mortuary with crematorium and ancillary rooms, for a larger cemetery

Urns are containers for the ashes resulting from the cremation of a body. Their dimensions are normally restricted by cemetery rules → ❶. Wall compartments in urn halls (columbariums) are mostly 38–40 cm wide and 50–60 cm high.

Coffins are sized to suit the deceased person. The laying out of the dead takes place in compartments (or cells) in the **mortuary**, which are separated from each other by lightweight half-height walls (composed of sheet metal or plants) → ❺.

In larger facilities, the **compartment passage** for coffin bearers is separated from the **viewing passage** for mourners → ❻, who can see the body through airtight panes until the burial/cremation ceremony. Projecting pillars between the cells avoid the mourners disturbing each other as far as possible → ❻. Newer facilities, however, often have no special passage for mourners, as shown in → ❺ without side passage. **Compartments**: usual dimensions 2.2 × 3.5; 2.5 × 3.75; 3.0 × 3.5 m.

Mortuary: a room where the deceased person is placed until the funeral, situated either at the entrance or in the middle of the cemetery with a passage (3.5–4.0 m wide) for hearses. The temperature in a **mortuary** should be ≧2°C to ≦12°C. Central heating and cooling must be provided to maintain this temperature, above all in summer, with constant ventilation. The floor of the mortuary must be impervious, smooth and easy to clean, and the simplest wall finish is lime wash, which has to be renewed often. Larger mortuaries also require: one room for attendants and coffin bearers of 15–20 m^2 with toilet and washroom.

A location should be provided for the bier (size 2.20 × 1.08 to 3.0 × 1.1 m).

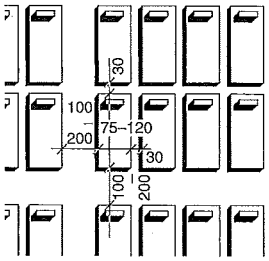
Crematorium: facility for cremating bodies into ashes; example → p. 426 ❷ In the **incineration room**, the coffin is taken from the transport trolley and placed on the carriage, which carries the coffin onto the fireclay grating in the oven. The **combustion chamber** is either in the basement with the coffin being lowered in → ❽, or behind the assembly room and separated from it by a lobby → ❽ – ❿; and → p. 426 ❶.

Transport on the level is most simply provided by manual winches, but the lift is better hydraulically driven. The doors to the lobby or the floor opening then close slowly as the coffin disappears into the lobby or the basement.

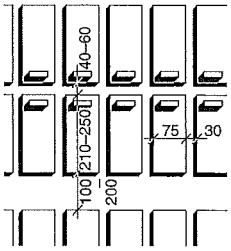
The **cremation** is performed by special ovens fuelled by coke, gas or electricity (consumption about 45 kW for each cremation; height of the two-storey oven 4.3 m) with no production of dust or odour through 900–1000° dry air, so that the flames do not touch the body. The oven is heated 2–3 hours in advance and the cremation itself lasts 1¼–1½ hours. The ashes are collected in a steel box for preservation in the urn. Viewing apertures are provided for monitoring the cremation.

The facilities described above are ideally situated behind the crematorium **chapel**. The size of the chapel varies; typical might be ≦100 seats and 100 standing places, also 1–2 rooms for the mourners (which may be additional to the chapel) and other ancillary rooms → ❿. It serves all denominations (and so requires two rooms for clergymen).

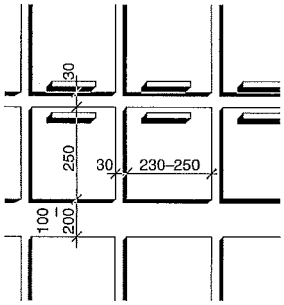
The **administration offices** should be relatively near: one room for the board, 2–3 offices, coffin store, stoker etc. Behind that, a gardener's area with greenhouse, room for the gardener and possibly garden architect, social rooms for employees, equipment room, seed room, WC etc.



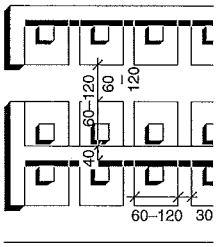
1 Graves in rows, head to foot



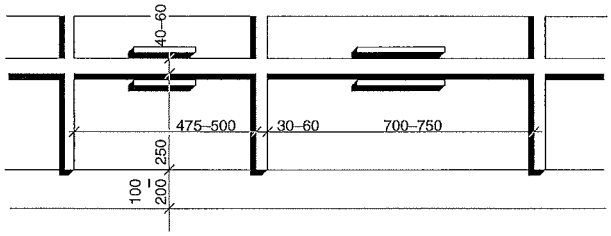
2 Graves in rows, head to head, possibly separated by a small hedge



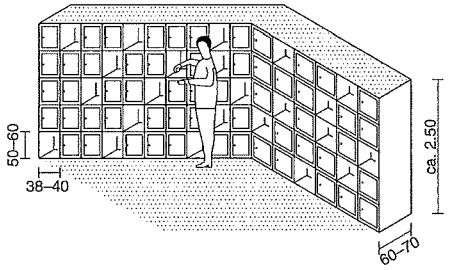
3 Double graves



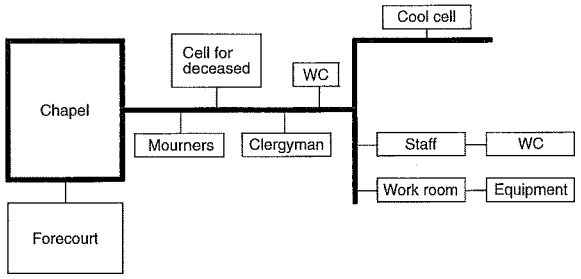
4 Urn burials, separated by a small hedge



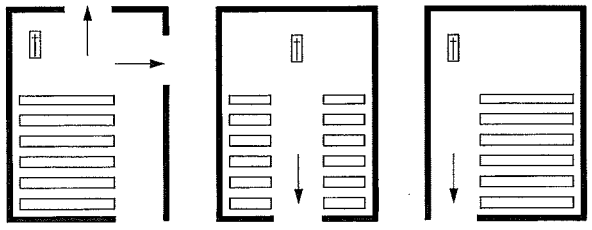
5 Larger family graves: four- or six-place family grave plot



6 View of a columbarium



7 Functional diagram of crematorium chapel and ancillary rooms



8 Crematorium chapel: typical plans

Overall cemetery facilities

Assembly area for mourners, stands for sale of wreaths and flowers, WCs. Groundwater table ≧2.50–3.00 m deep, which may require drainage. A large water supply pipe is necessary for watering.

The best exploitation of space is achieved by straight paths and the division of the cemetery into groups with similar grave sizes, like urns, purchased, children's and adults' graves → 9. Dimensions of the group areas: 30 × 30–40 × 40 m.

Planting with trees and shrubs is often an essential design feature, and some possibilities are tree strips within the cemetery, larger stands of trees as a boundary or outside the plot, high hedges or groups of shrubs to offer orientation.

Graves and gravestones

In an unhedged grave area, there should be only flat or standing gravestones, the size (see following table) and colour mostly uniform.

Grave form	High	Wide	Thick
simple graves	1.0–1.05	40–45	9–10
double graves planted at rear	120–125	50–55	10–12
triple graves at suitable locations	120	150	13–15

Earth burials are located on the main paths, boundary walls and ends of paths. Urn burials are located in the planting belt, urn groves and hedge fences.

Grave depths

Graves for adults in rows: 2.00–2.40 m
Children up to 10 years: 1.50 m
Children up to 3 years: 1.00 m
Grave mounds were formerly 25–30 cm with stone surround; today sloping and 15–20 cm high or quite flat.

The size and period of use of graves in the cemetery regulations are very varied. The following values are a rough guide:

Type of grave	Size [cm]	Space between [cm]	Period of use* [years]
adult graves in rows	210 × 75–250 × 120	30	20–25
graves in rows for children up to 10 years old	150 × 60–150 × 75	30	20
graves in rows for children up to 3 years old	100 × 60	30	15
inherited graves with hedges	300 × 150–350 × 150		40–100
crypts	300 × 120–350 × 150		50–100
urn meadows	100 × 100–150 × 100	60	10–100
prominent places	150 × 150	100	30–100

*depends on the soil

9 Size and period of use of graves

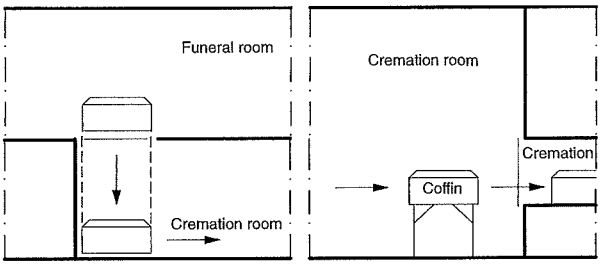
Columbarium

Urns not intended for burial can be stored in a columbarium. This can be a room (hall) or also just a wall with niches for the urns → 6.

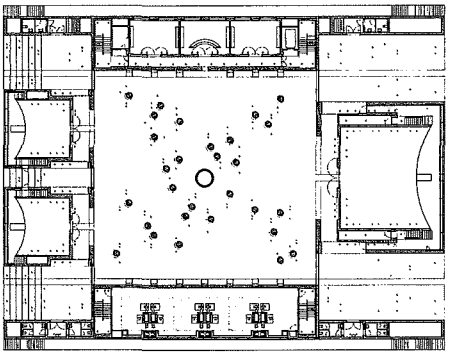
Crematorium chapel

This serves all denominations. If within a cemetery, it will be an important design element in the overall concept. It is normally situated in the middle of larger cemeteries, but in smaller and medium-sized cemeteries it can be at the entrance, or at the edge or end of a main path.

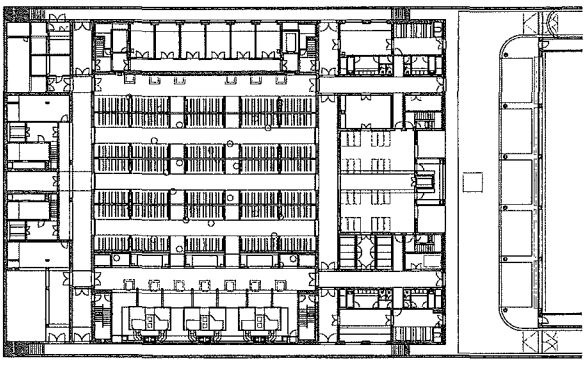
The focus of the chapel is where the funeral service is held. Its form has a significant effect on the course of the ceremony → 7 in conjunction with the other rooms.



1 Vertical and horizontal transport of the coffin for cremation

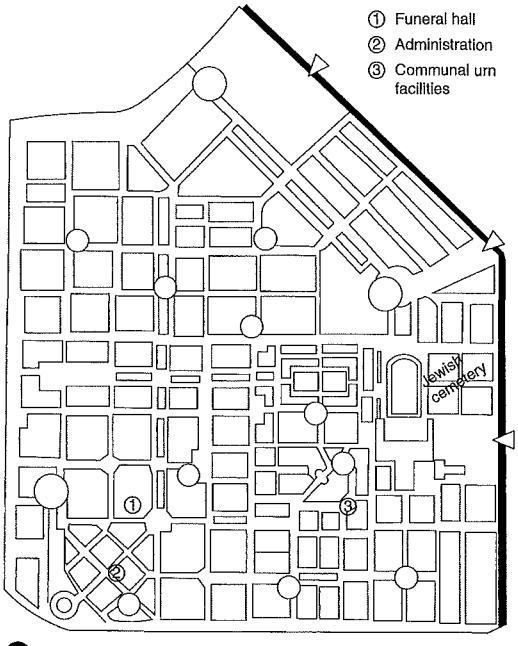


Ground floor with funeral room and enclosed wood area

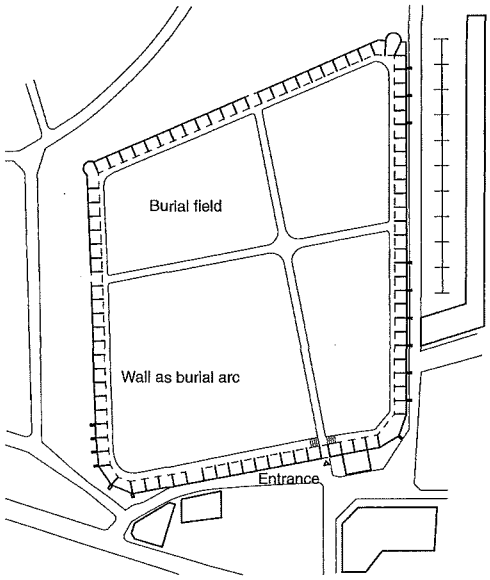


Basement with crematorium

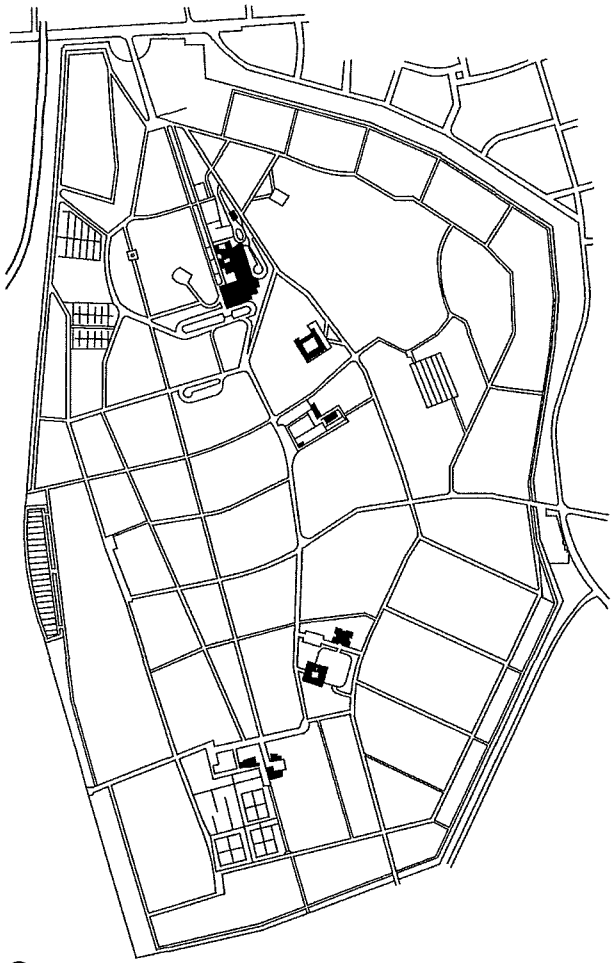
2 Baumschulenweg Crematorium, Berlin Arch.: Schultes Frank Architekten



3 Cemetery as geometrical park layout: Gertrauden Cemetery, Halle (Saale)

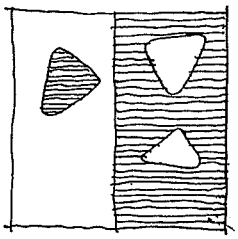


4 Cemetery as walled 'campus': Stadtgottesacker, Halle (Saale)

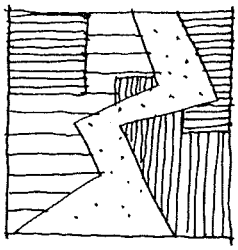


5 Cemetery as the amalgamation of architecture and man-made landscape: Skogskyrkogarden woodland cemetery, Stockholm
Arch.: Gunnar Aspund, Sigurd Lewerentz

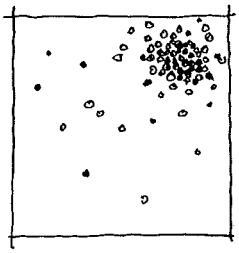
Horizontal aspects



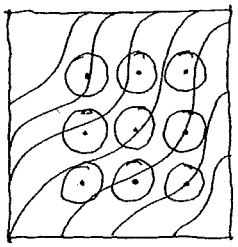
1 Reference and contrast



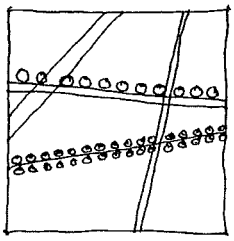
2 Superimposition



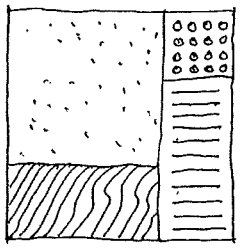
3 Single and heaped



4 Structures

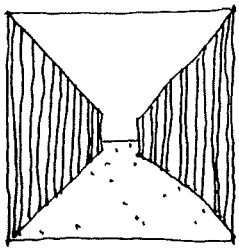


5 Lines and intersections

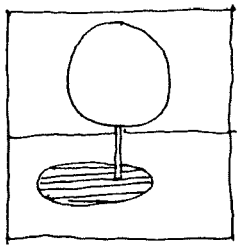


6 Areas of materials

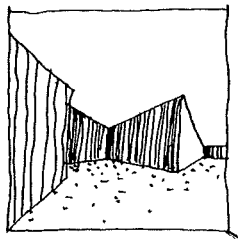
Vertical aspects



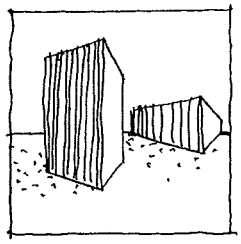
7 Walls



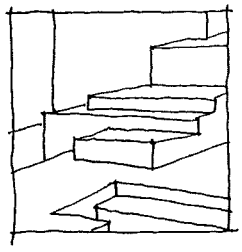
8 Solitary objects



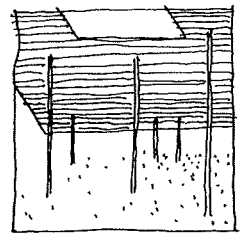
9 Edges



10 Bodies



11 Topography



12 Roofs

The term **landscape design** covers two apparently contradictory elements. Landscape is traditionally thought to refer to undisturbed natural landscapes, and design is evidently artificial. But we must recognise that untouched landscapes are almost absent from large parts of the world, or exist only as a temporarily abandoned terrain subject solely to sporadic attacks.

Built and unbuilt land are today strongly related in a dialectic relationship (we refer to urban landscapes). This has also generated a spatial way of thinking in landscape design, comparable with architectural or town planning design processes.

Aesthetic landscape compositions are no longer based on classical garden designs or providing greenery around the building as a decorative accessory – they are congenial solutions for a space, which form an inseparable unit with buildings or town planning. So it is evident that landscape architects are integrated into the project team right from the start, like structural or services engineers.

The foundations are:

Horizontal aspects

The general structuring of outdoor areas in context with the surroundings is regarded as a horizontal aspect. This is a fundamental organisation following considerations like idea, function, design and form. It can produce horizontal results (paving, lawns etc.) and also vertical (buildings, trees, pergolas etc.).

According to concept, items can be related to each other, repeated or contrasted; or a number of items can be superimposed. Open areas can, for example, continue themes or materials from buildings or provide a contrast. The ideal is to produce a central theme without functional limitations and then develop a design to make it readable.

Vertical aspects

Vertical aspects of concepts for outdoor areas derive from the fundamental horizontal aspects and substantiate them. Not only is the selection of materials important but also the spatial contexts of the immediate surroundings. If there is a dip or a rise in the field of view, this lends the space to different interpretations.

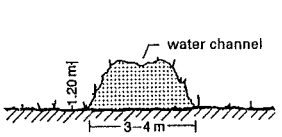
On the peak of a rise or in an open area, a roof, object or shelter can offer an impression of spatial definition. In street environments, trees can reduce the proportions of high buildings to a human scale and create small spaces within large. Vertical aspects, whether built or planted, should be to a sensible scale and integrate seamlessly into the overall concept of landscape architecture.

Form of illustration

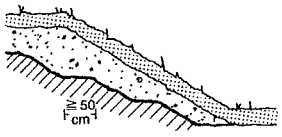
The decision how to illustrate with plans or drawings depends greatly on the stage of the project work. In the preliminary design and actual design phases, hand sketches and drawings can even today still contribute to a project's presentation. At these stages, forms of illustration have a great significance. Quick 2D or 3D sketches can be a great help in explaining open areas at meetings with the client.

In the phases of detailed design and the production of working drawings, the functional depiction of structures and objects is more important.

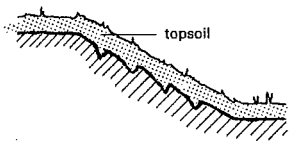
The type of illustration will be aligned with the design concept. A minimalist design will not, for example, include playful depictions of trees and vice versa. This enables the consideration of the 'world' in the design with few limitations. Pictures associated with individual components of the design can be selected and presented to supplement the ideas behind it.



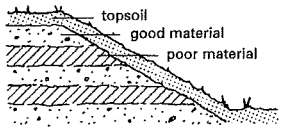
❶ Topsoil pile



❷ Cohesive material in the core with flat stepping



❸ Soil spreading on slightly sloping surfaces



❹ Filling in layers

	Soil class	Description
1	topsoil	upper layer of soil of natural origin or artificially prepared mixture; contains humus and soil life forms in addition to inorganic materials.
2	flowing soil types	soil with consistency of slurry or liquid, of which the high water content can only be reduced with difficulty.
3	easily excavated soil types	non-cohesive soil, soil with d <0.06 mm <15% and d = 63–300 mm <30%; stable organic soil.
4	relatively easily excavated soil types	mixed soils with d <0.06 mm ≧15% and d = 63–300 mm <30%; cohesive soils with slight to medium plasticity.
5	soil which is hard to excavate	soil classes 3 and 4 with d = 63–300 mm ≧30% or d = 300–600 mm <30%; highly plastic clays with I_c ≧0.5.
6	easily excavated rock and comparable types of soil	soil classes 3–5 with d = 300–600 mm ≧30%; jointed, broken, foliated, soft or weathered rock types or correspondingly consolidated soils.
7	hard rock	only slightly weathered, mineral-bound rock types; slag heaps etc., stones (blocks) ≧600 mm.

❺ Soil categorisation

Type		Density (kN/m³)	Angle of repose (°)
Topsoil	loosened and dry	14.0	35–40
	loosened and naturally moist	16.0	45
	loosened and water-saturated	18.0	27–30
	stamped and dry	17.0	42
	stamped and naturally moist	19.0	37
Loam soil	loosened and dry (average value for light soils)	15.0	40–45
	loosened and naturally moist	15.5	45
	loosened and water-saturated (average value for medium soils)	20.0	20–25
	stamped and dry	18.0	40
	stamped and naturally moist	18.5	70
Gravel	(pebbles), medium-graded and dry	18.0	30–45
	medium-graded and moist	20.0	25–30
	dry	18.0	35–40
Sand	fine and dry	16.0	30–35
	fine and naturally moist	18.0	40
	fine and water-saturated	22.0	25
	coarse and dry	19.0–20.0	35
Coarse gravel, wet		20.0–22.0	30–40
Clay	loosened and dry	16.0	40–50
	loosened and wet through	20.0	20–25
	solid and naturally moist (heavy soil)	25.0	70
Dry sand and rubble		14.0	35

❻ Density and angle of repose of various soil types

Design of earthworks

Modelled areas of ground are generally perceived as pleasant and interesting and can have a strong effect on the perception of a space. The human eye looks for viewpoints and fixed objects in an open area. An example of this is the common hilly landscape with meadows, farmland and isolated trees in open man-made countryside. This impression can be achieved with intentionally designed terrain modelling as an addition to vertical structures or plants.

Homogeneously occupied areas (lawns, ground-cover planting of uniform height, paving), with sunken centres in particular, make spaces seem larger. Wavy or hilly ground modelling can also enlarge the impression of space. According to the situation, this can enable economic synergies to be gained through the management of earth quantities.

Definition of soil

Soil is the outermost layer of the earth's crust and is largely formed by organisms. Soil can be generally categorised into **subsoil** and **topsoil**. While topsoil is often dark-coloured and bustling with life and roots, subsoil is often lighter-coloured and rather less weathered, with few living things and roots. The topsoil extends downwards as far as signs are discernible of living things, weathering or roots, often down to solid rock.

A classification of soil can be found in → ❺. Soil types can be roughly identified by appearance, smell and rolling in the fingers.

Preservation of topsoil

This is ensured on building sites by temporary storage in stockpiles → ❶. If these are not in the shade, the tops should be covered (with turf, straw etc.) to prevent excessive drying out. If the storage is to last longer, green manure plants may be planted. Topsoil piles should be turned over at least once a year with the addition of 0.5 kg of quicklime per m^3.

Filling has to be **compacted**, if garden structure, lawn or planting work is to be carried out (particularly important for the construction of paths and paving).

1. Driving over with construction machinery (bulldozer) will mostly compact filling sufficiently.
2. Sluice only good filling material such as sand and gravel.
3. Cohesive material should be rolled in layers of 30–40 cm, always from outside to inside, i.e. from the slope into the middle of the filling area. Gravel also has to be rolled to construct paths.
4. Stamping or ramming is possible for all stable soil types.
5. Only loose, non-cohesive soils can be vibrated for compaction.

All compaction work should take account of the later use. For paths and paving, the soil has to be compacted fully but lawns require 10 cm, and areas for planting 40 cm, of loose soil at the surface.

Slope protection

To avoid erosion, slips, wind erosion etc. Generally, the most stable slopes for all bulk materials are achieved by filling in layers. Profiling of the layer beneath → ❷ serrates the loose filling material into the subsoil and prevents the formation of slip planes.

In the case of higher banks with steeper slopes, the formation of steps → ❸ provides security against slipping (step width ≧50 cm). If the steps are inclined into the slope, then a longitudinal gradient should be provided to permit the drainage of collecting water.

Feature	Reference guideline		
	ZTVE-StB	ZTV-LW	RLW
deviation from the correct level (according to profile):		no requirement	no requirement
– under unbound surfacing	+ 3 cm		
– under bound surfacing	+ 2 cm		
– formation of soil consolidation	+ 2 cm		
– top of noise barriers	is to be maintained in case of settlement		
flatness of formation (deviation under a 4 m straight edge):			
– for applied bound levels	no requirement	< 2 cm	no requirement
– for applied unbound levels	no requirement	no requirement	no requirement
– formation for soil consolidation	< 2 cm	no requirement	no requirement
cross-slope of formation:			
– non-consolidated, not water-susceptible ground	> 2.5%	at least as good as the layers above	normally, as the layers above
– water-susceptible ground	> 2.5%		

❶ Precise requirements for soil formations for earthworks, according to Additional Technical Contract Terms for Earthworks in Road Construction (ZTVE-StB),...for Rural Road Construction (ZTV-LW) and Guideline for Rural Road Construction (RLW) (Lehr → refs)

Scope of application	Soil type	Reference guideline		
		ZTVE-StB		RLW
		Deformation modulus E		
construction classes SV, I to IV acc. RStO	construction classes	120 MN/m²	100 MN/m²	
construction classes V to VI acc. RStO	100 MN/m²	80 MN/m²		
construction classes SV to VI acc. RStO	construction classes	45 MN/m²		
rural roads:				
– very low traffic load or insignificant route or reinforced bearing course		—	—	30 MN/m²
– average traffic load (corresponds to construction class VI acc. RStO)	no statements about soil type	—	—	45 MN/m²
– high load and main route connection (corresponds to VI acc. RStO)		—	—	80 MN/m²

❷ Minimum requirements for the load-bearing capacity of the soil formation. Abbrevs → ❶. (Lehr → refs)

Effect		Process	Area of application						Can influence:								
			Earthworks, road building	Landscape construction	Foundations	Fill material	Formation	Ground for construction	Workability, installation process	Load-bearing capacity	Stability, securing slopes	Surface erosion	Suffusion	Contact erosion	Permeability	Capillarity	Frost susceptibility
Physikal	construction	soil exchange	+	+	0	+	+	+	+	+	+	+	+	+	+	+	+
		geotextiles	+	+	0	0	+	–	–	+	0	–	–	+	+	+	–
		reinforced earth	+	+	–	+	–	–	–	+	+	–	–	–	–	–	–
		drainage	+	+	+	+	+	0	+	+	+	+	+	+	–	–	+
		groundwater lowering	+	0	+	–	0	+	–	+	+	–	–	–	–	–	0
	mechanical	compaction, loosening	+	+	0	+	+	0	–	+	+	+	–	–	+	+	+
		alteration of grading	+	+	–	+	0	–	+	+	+	+	+	+	+	+	+
	thermal/ electrical	heating	–	–	+	–	–	+	–	+	0	–	–	–	–	–	–
		freezing	–	–	+	–	–	+	–	+	+	–	–	–	+	+	+
		electro-osmosis	0	–	+	–	–	+	–	+	+	–	–	–	–	–	+
Chemical		injection: liquids,	–	–	+	–	–	+	–	+	+	–	–	–	0	0	0
		gases	–	–	+	–	–	+	–	+	+	–	–	–	0	0	0
		mixing in: chemicals	+	+	–	+	+	–	–	+	+	+	+	0	0	0	0
		hydraul. binders	+	+	–	+	+	–	+	+	+	+	+	+	+	+	+
		bitum. binders	+	+	–	+	+	–	–	+	+	+	0	+	0	0	0
Biologisch	covering stability	sowing	–	+	–	+	–	–	–	–	0	+	0	–	–	–	–
		laying turf	–	+	–	+	–	–	–	–	+	+	+	–	–	–	–
		tree planting	–	+	–	+	–	–	–	–	0	–	–	–	–	–	–
		propagation, cuttings	–	+	–	+	–	–	–	–	+	–	–	–	–	–	–
	intermediate greening	inert materials	+	–	–	+	–	–	–	0	+	0	0	–	–	–	–
		sowing	0	+	–	+	–	–	0	–	+	+	+	–	–	–	–

Explanation: + normal process / good effect
0 sometimes used / may work
– never used / no effect

❸ Processes for soil improvement and consolidation: scope of application and properties which can be influenced (Lehr → refs)

Soil formation

Soil formation is achieved by the excavation of topsoil and removal of obstructions. It should ensure the following:

1. Correct profile (short and long term)
2. Water run-off
3. Degree of compaction
4. Load-bearing capacity and suitability for transporting

With earth structures the soil formation must comply with certain requirements → ❶, which should be checked in each individual case. Soil in these areas also has to comply with various degrees of compaction according to use.

The individual degrees of compaction are, for example, evaluated with the deformation modulus EV 2 → ❷ and differ above all in the existing subsoil conditions and the planned pavement loading. When a formation for earth structures or roads is described, a differentiation is normally made between coarse and fine soil formation for vegetation areas. For sport grass areas, this fine formation can even demand a precision of max. 30 mm on a 4 m straight edge.

Soil loosening

According to the nature of the subsoil, it can often be subjected to unintended further compaction during and after various construction activities on the site. In particular driving on wet soil has a negative influence on the soil structure. In over-compacted soil, roots remain small and flat. The compacted soil is also particularly susceptible to damage from drying and waterlogging.

Soil is loosened in landscape construction by digging over 30–40 cm deep, or through the use of a pick or machines for loosening. Care should be taken not to cause further compaction with the necessary machines.

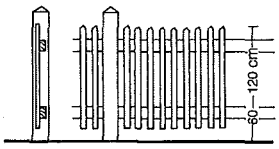
The best-known machines are the subsoil grubber, reversible share grubber and plough. Rotary tillers, which are often also used, should not be employed too often or too intensively as they destroy the soil's crumbly structure and create a soil that can no longer absorb and store water and has to be replaced.

Soil improvement

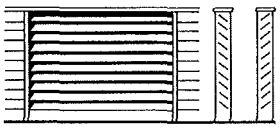
Soil improvement denotes processes to improve the properties of the soil for planting as quickly as possible and improve unsuitable sandy or clay soils through the appropriate measures. The risk of damage due to drought (sandy soils) or waterlogging (clay soils) is reduced if soil containing loam or clay is mixed into sandy soils, or sand is mixed into clay soils. Soil improvement using peat or dung is possible but either not readily available or too expensive. At the moment, well-rotted organic compost from organic waste is recommended for the improvement of all growing soils. The normal treatment is about 10 litres per m² of organic compost with the RAL (German quality assurance) mark. This means a layer 1.0–2.0 cm thick.

This compost is worked flat into the soil, not deeper than 20 cm. This improves the soil structure significantly and works in enough nutrients to start the growth of all plants, meaning that no additional mineral fertiliser is required at the start of planting.

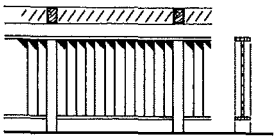
Soil improvement or soil consolidation is also carried out to improve load-bearing subsoils. This is often done through the addition of binder. Firstly, the deficiency of the soil in the relevant property should be determined in light of the intended improvement (to provide a temporary road etc.). The individual processes are shown in → ❸. The term 'soil treatment' is often used in Germany but internationally this is described as 'soil stabilisation'.



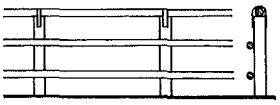
❶ Fence with projecting posts



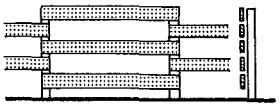
❷ With horizontal bars



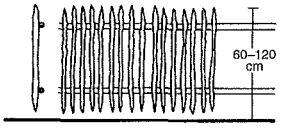
❸ With vertical wooden louvres



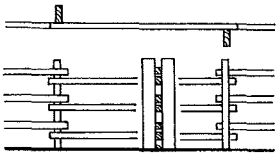
❹ Paddock fence with round wooden rail at the top



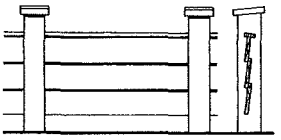
❺ Of overlapping glued boards



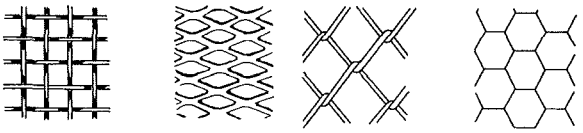
❻ Simple wooden fence



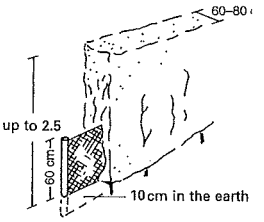
❼ Paddock fence with overlapping posts and rails



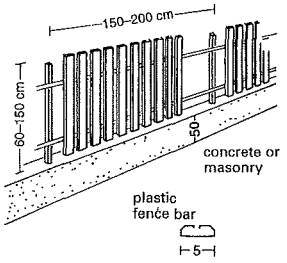
❽ Unfinished, sawn boards nailed to posts



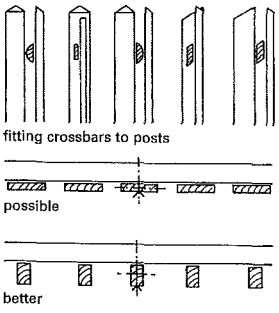
❾ Wire mesh, normal wire spacing 4–5.5 cm



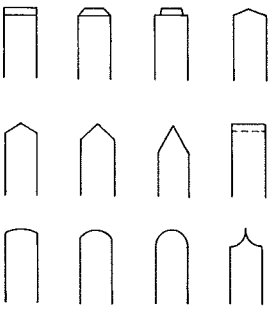
❿ Hedge with wire mesh fence



⓫ Fence of galvanised steel profiles with wooden uprights



⓬ Fixing palings to rails: screwed from behind, thin palings screwed on the face side



⓭ Heads of palings

External works

GARDEN ENCLOSURES
Design aspects
Earthworks
Garden enclosures
Pergola and trellis
Paths, paving, steps
Drainage
Vegetation
Biological engineering
Greenhouses
Ponds and pools
Example

Design aspects of walls and fences

During the planning stage it should generally be noted that walls and fences form vertical optical barriers. This should be used intentionally to create spaces or particular views (visual domains). Individual spaces can be created out of large areas either geometrically or also organically. The selection of materials should consider the overall design concept. For example, paving can be of materials (natural stone, brick etc.) that 'grow out of' their original location, and can be continued into walls to create a tranquil and homogeneous effect. Walls and fencing offer a multitude of design forms and types.

Fences are normally made of wood or metal. Wooden fencing is generally cheaper but not so durable.

Wooden fences are normally used in rural areas or for special requirements (animal pounds etc.). Functional enclosures, like fencing to keep out wild animals, can also be integrated into hedges → ⓾. Wooden posts should always be well protected against soil moisture if at all possible → ⓯.

Metal fences can offer a high-quality and durable appearance. Industrially manufactured metal fencing with panels of wire mesh or metal rods → ⓮ are a compromise between cost and usefulness and are available in builder's merchants or DIY shops.

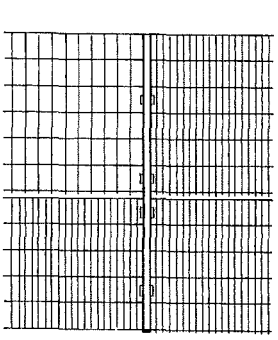
Metal mesh or grilles are more stable than wire mesh fences and can be used to meet security requirements. The spacing of the bars is normally varied with height → ⓮.

High-quality metal fences require design work in advance, and are then made up by a smith/metalworker. The design should include criteria like overall appearance, suitability of the various parts for processing (galvanising, coating) and function. Corrosion-protected metal fences can be concreted into the ground without further treatment.

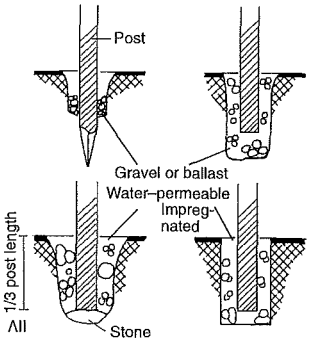
The rights of neighbours/duty to enclose

Regulations about the distance of walls and fences from boundaries are laid down in the Law on the Rights of Neighbours and the individual state building regulations. The normal situation is that every house owner has to fence the right-hand side of their boundary as seen from the road. The joint back is to be fenced communally, i.e. the costs of minimal fencing (wire mesh fence, height = 1.25 m) are to be shared. If a house owner has a sole duty of enclosure, then they must bear the cost of fencing alone and the fencing must stand on their own property. If the enclosure duty is shared, then the barrier must be centred on the boundary. There is a general duty of enclosure when it is usual in the location. Exceptions are regulated in the law mentioned above. Walls and retaining walls (including enclosures) do not require, for example, according to the building regulations in Berlin, building permission unless they exceed 2.0 m in height.

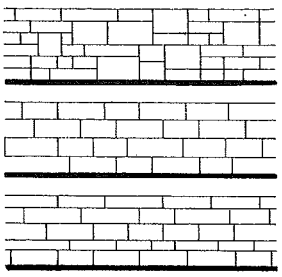
Under English law, ownership of, and responsibility for, walls and fences etc. are specified in the deeds of the property.



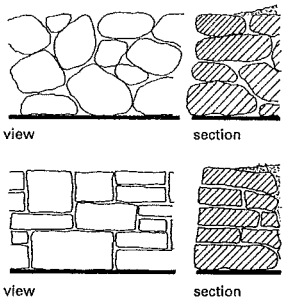
⓮ Grille fence panels



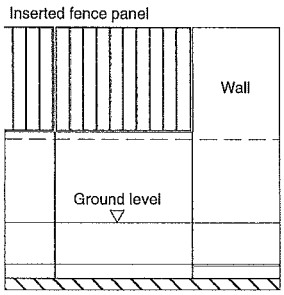
⓯ Burying wooden posts for fences, pillars etc.



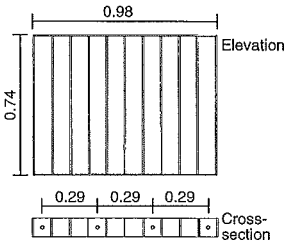
❶ Coursed masonry with various heavy stone courses



❷ Broken and worked stone masonry

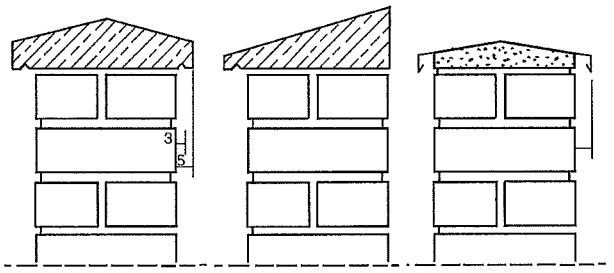


❸ Gap in a wall with inserted fence panel element



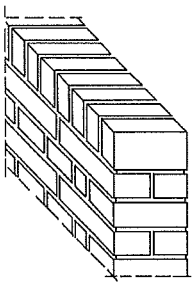
Fence element of flat steel 100 × 8 mm all-welded, galvanised, 3 coats of paint (thick layer, with rust-protective iron mica)

❹ Fence element, detail → ❸

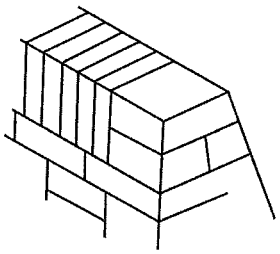


❺ Pre-cast concrete coping stones

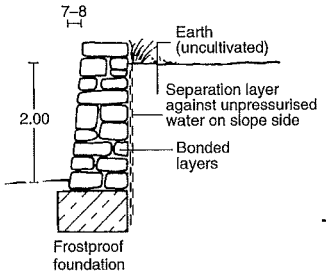
❻ Cladding with zinc sheet (Lehr → refs)



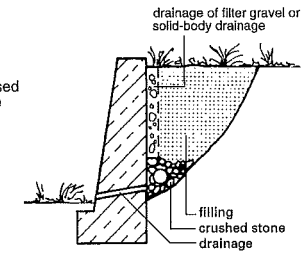
❼ Details of capping courses in brickwork (Lehr → refs)



❽ Details of capping courses in natural stonework (Lehr → refs)



❾ Dry stone wall: drainage measures are necessary according to soil type



❿ Concrete retaining wall (also available as pre-cast elements) → ⓭

Walls are differentiated into retaining walls and freestanding walls. The particular feature of retaining walls is the earth filling to one side → ❾ so the effects of moisture and the longevity of the materials have to be taken into account.

Retaining walls can be self-supporting → ❿, of concrete with facing brick or of dry stone → ❾.

The simplest form of retaining wall is the angled pre-cast concrete wall → ⓫ – ⓬. These walls are structurally reinforced and are available in the trade from a height of 55 cm. They have the advantage of a pre-defined structural design according to loading case. **Freestanding walls** are only subject to damp from the soil through the foundations and are therefore less problematic in the choice of materials. The selection of materials and dimensions of the bricks or blocks is important to enable a face on both sides.

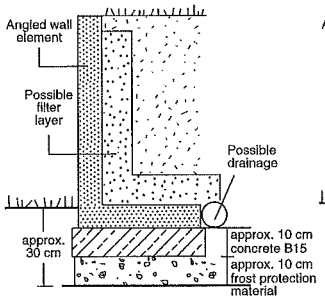
The appearance of the face of walls is very varied according to material → ❶ – ❷ and depends on the possibilities offered by the material (brick, natural stone, broken stone etc.).

Walls over 1 m high should generally be structurally calculated. There are guidelines and standards for each type of masonry (brick, stone etc.). The effect of the pointing on the material should be investigated because otherwise there is a danger of efflorescence.

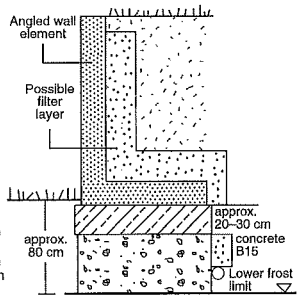
In order to protect the masonry from damp from above, a coping should be provided → ❺ – ❻.

Copings

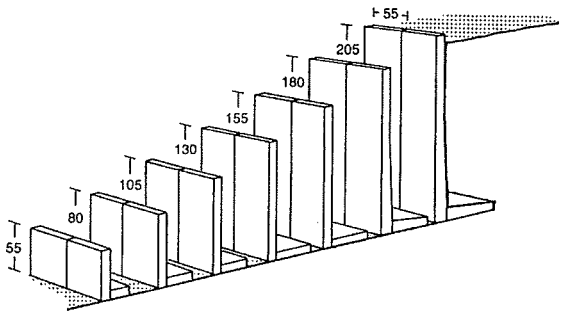
The tops of walls must be protected against rain and snow by covering them with large slabs or stones. The coping element should have a cross-fall of at least 0.5%. Longitudinal joints in the coping are not allowed and butt joints must be at right angles to the wall centre-line. A drip mould should be provided min. 3 cm outside the face of the wall → ❺ in order to keep vertically falling water off the face. For natural stone walls, copings of the same material can be used. Nailed zinc or aluminium coverings are also suitable → ❻.



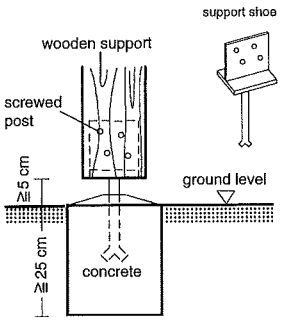
⓫ Simple foundations



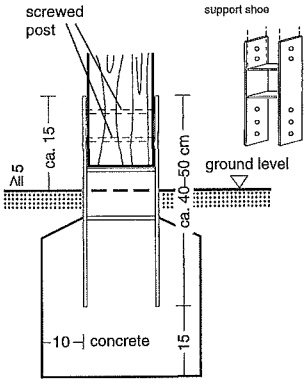
⓬ Frost-proof foundations



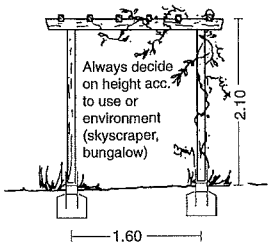
⓭ Retaining wall of pre-cast concrete elements, which are available as standard up to about 4.55 m high



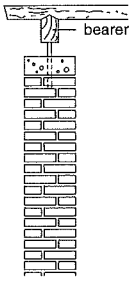
❶ Fixing of posts for fencing and pergolas



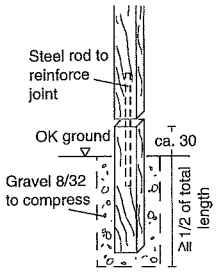
❷ Fixing of posts for fencing and pergolas



❸ Framework for climbing plants; fixing as ❷



❹ Pergola on masonry pillars



❺ Fixing for pergolas and trellises entirely of timber

Design aspects of pergolas and trellises

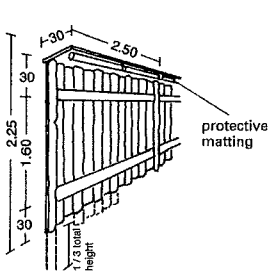
In addition to the selection of a material for the planned **pergola**, its position within the outdoor area needs to be considered carefully. Large pergolas form spaces almost like buildings, and should be justified by their function or particular aesthetic value. Pergolas can lead to special places or viewpoints (linear arrangement), and can be used to divide spaces and/or as a sitting area (point arrangement). Pergolas with climbing plants should be detailed in accordance with the particular characteristics of the intended plant (spacing of supports for climbing or winding plants).

A pergola is a room-forming row of columns or pillars. The verticals can be masonry pillars → ❹ or simple timber → ❷. If timber uprights are used, they should be protected against damp from the ground → ❶ + ❷. The construction generally appears lighter if the overhead construction is thinner or lighter than the verticals. It should be clarified in advance whether climbing plants are to be integrated.

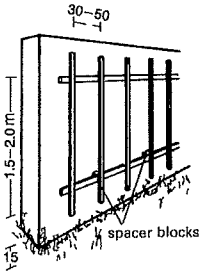
Trellises are supports for climbing plants and can also be used as a visual barrier.

Espalier-trained fruit trees are classically grown against façades. The supports are mostly made of wood → ❻ – ❼, ❿ – ⓮.

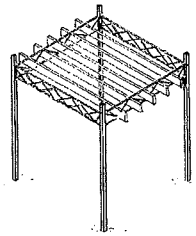
When designing support systems for climbing plants, attention should be paid to the growth height of the intended climbers, as the uppermost wire may, for example, not be reached by the plants. It is generally advisable to consider the architectural effect of the façade without plants. The basic decision is between linear and full-area growth according to local conditions.



❻ Timber wall for espalier trees, detail in the ground as ❷



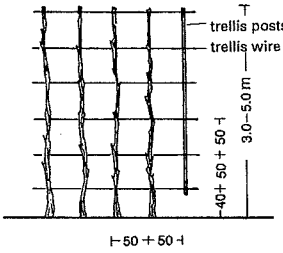
❼ Trellis fixed to a wall, spacing to suit planting



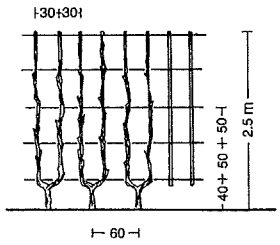
❽ Pergola of steel elements

	Height
cup and saucer vine	4–6 m
ornamental gourd	2–5 m
Japanese hops	3–4 m
morning glory	3–4 m
sweet peas	1–2 m
runner beans	2–4 m
nasturtiums	2–3 m

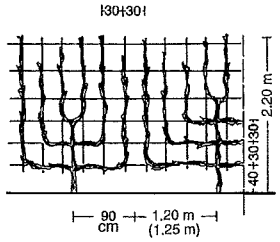
❾ Climbing plants: annual species



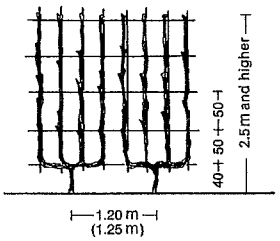
❿ Vertical cordon training



⓫ U-shaped cordon training



⓬ Palmette verrier training (six and eight branches)

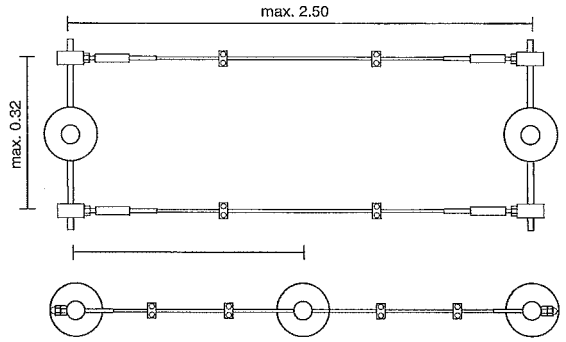


⓭ Chandelier palmette training

Perennial species	Height	Growth	Trellis? x = yes	Leaves	Watering	Flowering: month/colour	Location
ivy – *Hedera helix*	up to 25 m	slow	x needed	winter	-	9–10 greenish	○ – ●
polygonum – *Polygonum aubertii*	up to 15 m	quick	x	summer	+	7–9 white	○ – ●
wild vine – *P. tricuspidata* 'Veitchii'	up to 15 m	quick	x	summer	(+)	5–6 greenish	○ ◕
clematis – *Clematis montana*	up to 8 m	quick	x	summer	+	5–6 white	○ ◕
wisteria – *Wisteria sinensis*	up to 10 m	medium	(x) sensible	summer	(+)	5–6 blue	○ ◕
old man's beard – *Clematis vitalba*	up to 10 m	quick	x	summer	+	7–9 white	○ ◕
hydrangea – *Hydrangea petiolaris*	5–8 m	medium	(x) sensible	summer	-	6–7 white	◕
pipe vine – *Aristolocchia macrophylla*	up to 10 m	medium	x	summer	(+)	5–6 brown	◕ ●
trumpet vine – *Campsis radicans*	up to 8 m	slow	x	summer	+	7–8 orange	○
crimson glory vine – *Vitis coignetiae*	up to 10 m	medium	x	summer	(+)	5–6 greenish	○ ●
grape vine – *Vitis vinifera*	up to 10 m	medium	x	summer	+	5–6 greenish	○ ●
honeysuckle golden flame – *Lonicera heckrottii*	3–4 m	medium	x	summer	(+)	6–9 yellow-red	◕
hop – *Humulus lupulus*	4–6 m	quick	x	summer	-	5–6 greenish	◕
Italian woodbine – *Lonicera caprifolium*	up to 5 m	medium	(x) sensible	summer	+	5–6 yellow-red	◕
climbing roses	up to 5 m	medium	x	summer	-	6–8 varied	○ ◕
winter creeper – *Euonymus fortunei*	2–4 m	slow	x	winter	(+)	6–8 greenish	◕ ●
clematis – clematis hybrids	2–4 m	medium		summer	+	6–9 varied	○ ◕
winter jasmine – *Jasminum nudiflorum*	up to 3 m	slow		winter	+	1–4 yellow	○ ◕

○ = sunny location ◕ = semi-shadow e.g. north wall ● = shadow

⓮ Overview of some climbing and winding plants (see also p. 434)



❶ Support system of metal wires for greening walls (Stahl → refs)

Trellises or other support systems for climbing plants can be used for the decoration of walls or also in the vegetable garden (where it is important to keep the plants within reach for picking). Various methods have proved successful → ❸ – ❼.

Fan and espalier training of fruit trees → ❽ – ❾ is found in farm gardens or, more often, in private fruit and vegetable plots. In commercial fruit plantations, trees are planted in patterns → ❿ – ⓬ to optimise economic success.

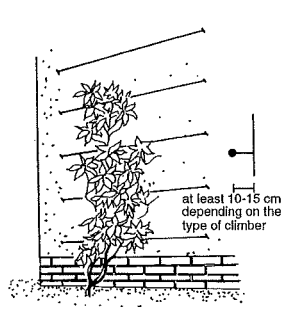
Green walls, formed of plants that cannot support themselves, require climbing aids. Such support systems are made of wood for small areas but larger areas, above all at heights, use metal wires → ❶. The spacing of the wires should be suited to the intended plant. In addition to the growth height, the type of plant (with tendrils, winding etc.) should be investigated.

Growth heights of 2–20 m are possible. Some plants, especially twining and winding plants such as Celastrus (staff vine), can squeeze and damage trees or downpipes.

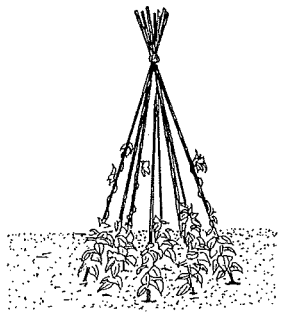
The spacing of the horizontal wires should be between 20 and max. 50 cm according to species. Spanned wires should be plastic-coated to protect the plants from frost damage.

The greening of walls can sometimes have legal significance: for example, fire walls require special permission and should generally not be planted as this could spread a fire. The greening of a wall should generally be agreed with the owner. If, for example, the neighbour's wall is to be greened, this should be agreed in a contract.

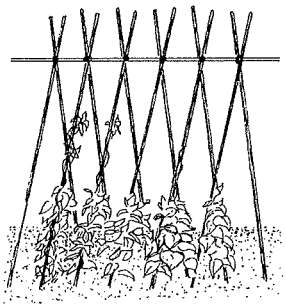
Supports for climbing plants are generally excepted from approval procedures. The relevant building regulations should be complied with, and listed building regulations or local regulations concerning the appearance of buildings may also be applicable.



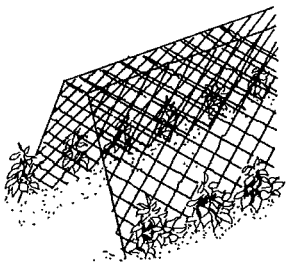
❷ Horizontal supports



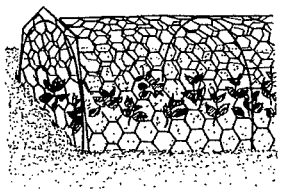
❸ Wigwam method for 8–11 plants



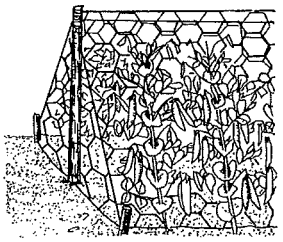
❹ Tent method



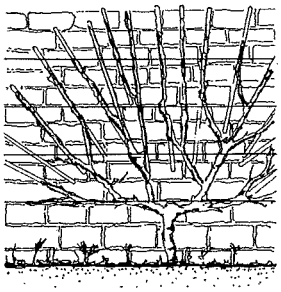
❺ Double grating of wire mesh



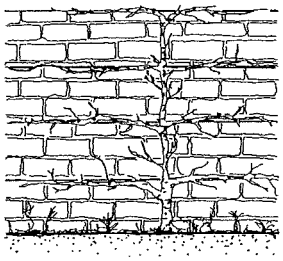
❻ Wire mesh protection against birds



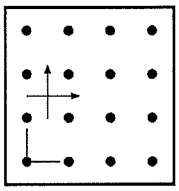
❼ Wire mesh support for peas



❽ Fan: only two branches at an angle of 45° to the ground are allowed to grow and the fan is formed from their shoots in the spring.

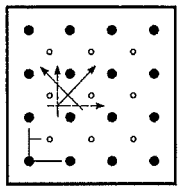


❾ Espalier: the central trunk of an espalier is trained vertically and the side branches at right angles to the left and right.



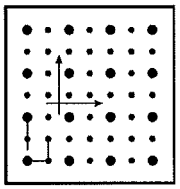
Spacing	Trees per ¼ ha
4×4 m	156
6×6 m	69
10×10 m	25

❿ Square pattern planting



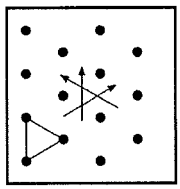
Spacing	Trees per ¼ ha	
	Standing trees	Fillers
4×4×(2) m	156	156
6×6×(3) m	69	69
10×10×(5) m	25	25

⓫ Square pattern planting with fillers



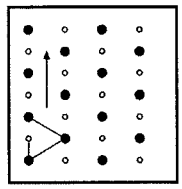
Spacing	Trees per ¼ ha		
	Standing trees	1st filler	2nd filler
6×3×3 m	69	69	103
8×4×4 m	39	39	58
10×5×5 m	25	25	37

⓬ Square pattern planting with double fillers



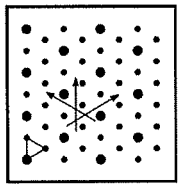
spacing	trees per ¼ ha
3×3×3 m	320
4×4×4 m	178
6×6×6 m	80

⓭ Triangular planting equilateral



spacing	trees per ¼ ha	
	standing trees	fillers
1.5×3×3 m	320	320
2×4×4 m	178	178
3×6×6 m	80	80

⓮ Triangular planting with fillers



spacing	trees per ¼ ha		
	standing trees	1st filler	2nd filler
3×3×3 m	80	80	160
4×4×4 m	44	44	88

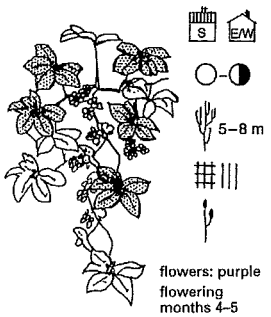
⓯ Triangular planting with double fillers

❿ – ⓯ Planting system according to De Haas; and see p. 437 ❸ – ❺

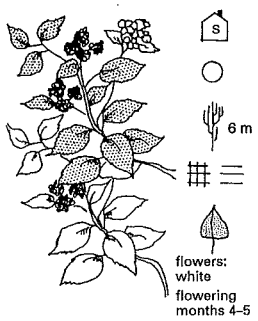
PERGOLA AND TRELLIS

Examples of Plants

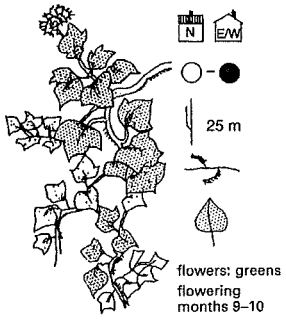
favourable area
sunny, half shade, shady
growth: slow, medium, fast
climbing aid: wood, wires, steel mesh
deciduous, evergreen
crevice holding roots
holding roots with suckers



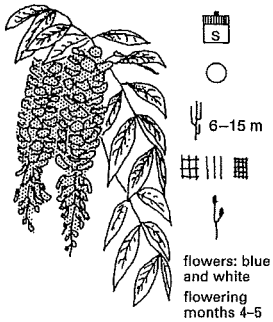
1 Akebia



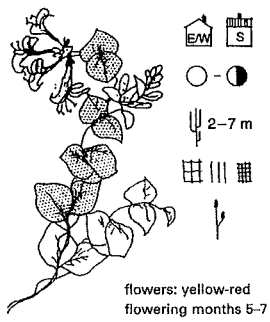
2 Bramble



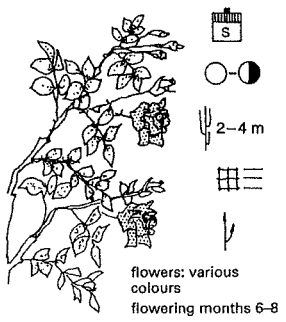
3 Ivy / *Hedera helix*



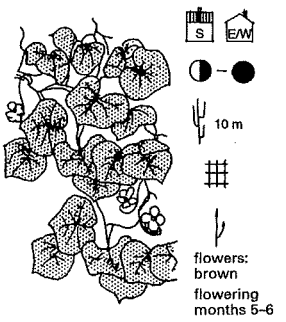
4 Wisteria / *Wisteria sinensis*



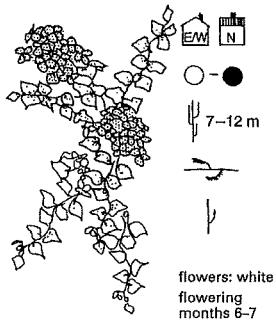
5 Honeysuckle / *Lonicera caprifolium*



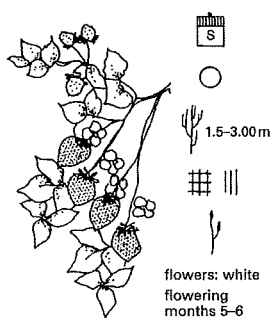
6 Climbing rose



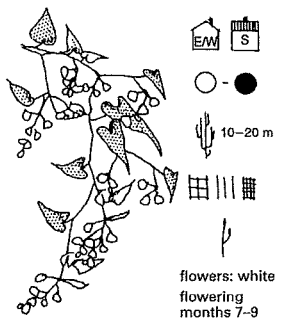
7 Pipe vine / *Aristilochia macrophylla*



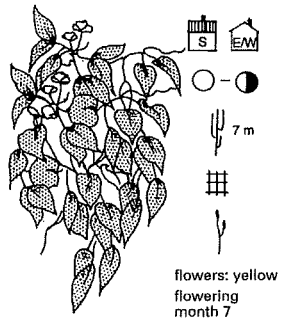
8 Hydrangea / *Hydrangea petiolaris*



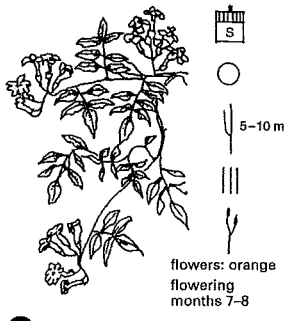
9 Climbing strawberries



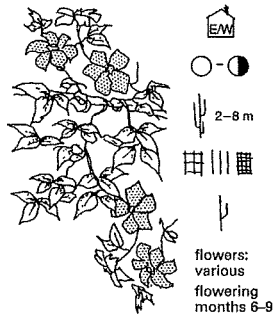
10 Silver lace vine / *Polygonum auberti*



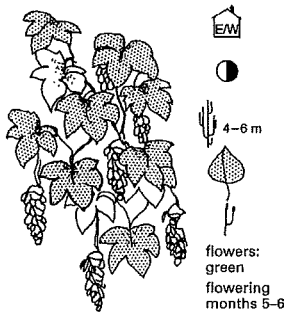
11 *Actindia chinensis*



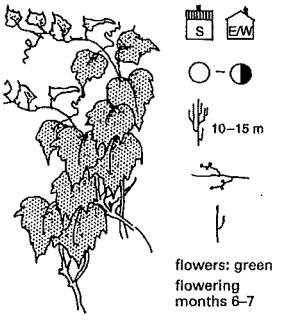
12 Chinese trumpet vine/*Campsis radicans*



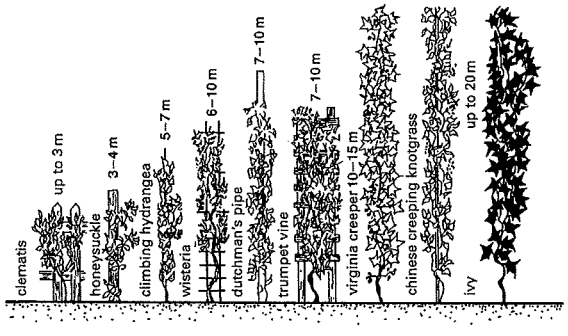
13 Clematis



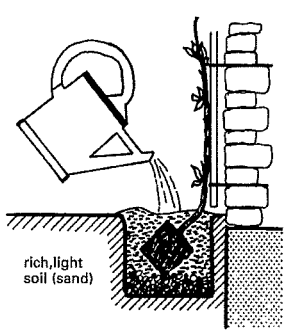
14 Hop / *Humulus lupulus*



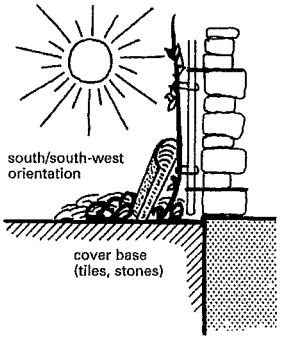
15 Virginia creeper / *Parthenocissus spec.*



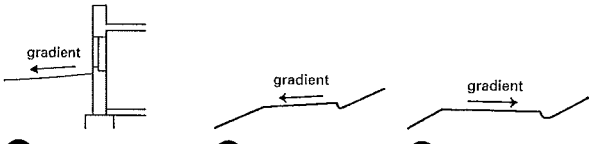
16 Climbing plants and their growth height



17 Watering

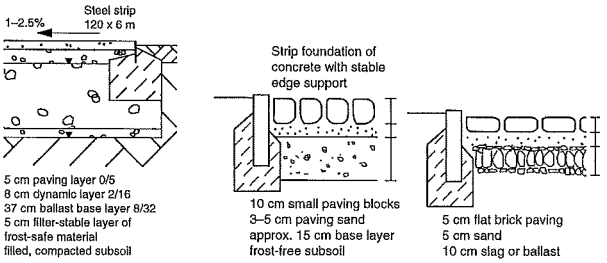


18 Clematis need cold feet and a warm head

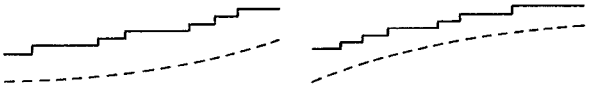


❶ Fall away from house ❷ Footpath on slope ❸ Vehicle road on slope

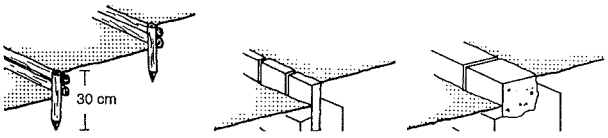
❹ Large-slab path at raised level (avoids dirt collecting) ❺ flush in a grassed area ❻ Slab spacing = length of stride
Thickness ≧3 cm



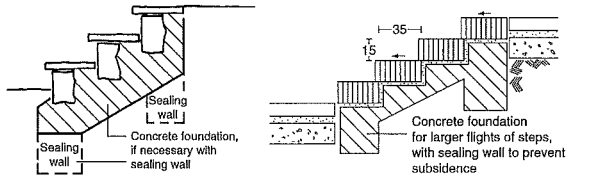
❼ Waterbound road construction ❽ Small cobble paving, expensive but durable ❾ Bricks laid flat



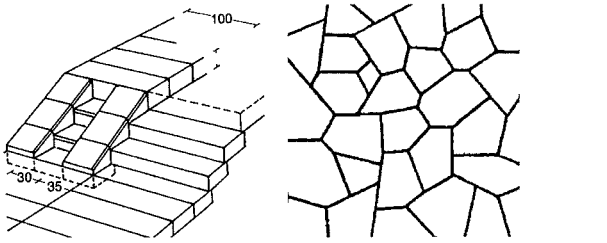
❿ Comfortable walking: concave slope ⓫ Uncomfortable walking: convex slope



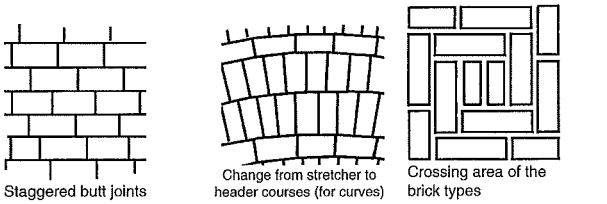
⓬ Staircase with billet steps: short-term solution according to timber type ⓭ Vertical stone plates ⓮ Stones finished on two sides



⓯ Steps with stone slabs and underlay blocks ⓰ Natural or reconstituted stone blocks in mortar bed



⓱ Ramp and block steps in concrete ⓲ Polygonal pattern for natural stone paving (Niesel → refs)



⓳ Variants of brick paving (Niesel → refs)

For the design of paths and paved areas, questions of proportion are important and the selection of materials is decisive. Firstly, the correct dimensions for path width, free paved areas and enclosed spaces need to be determined according to the use and surroundings. The human being should always determine the scale.

Then the colour and type of paving material should be chosen in connection with the overall design, and the surrounding buildings or roads. Light-coloured, large-format paving appears generous. With special edging or structuring, segments can have the effect of rooms. The general rule is to make a function or use easily read from path widening or paved areas.

Paved areas in gardens can be surfaced with the most varied materials. Areas to be driven on are normally paved with asphalt, concrete, or concrete or stone paving. A surface for vehicles (e.g. fire service access) can be created by rolling broken stone and permitting grass to grow on it. For less frequently driven areas, paving slabs, waterbound macadam or timber paving can also be used. Road building is subject to specialist regulations, which define the surfacing in accordance with local ground conditions. In principle, this can be with binder (special construction), without binder or waterbound (standard construction). Waterbound construction → ❼ – ❾ should be carried out with entirely permeable layers including open joints.

Roads with heavier traffic should be constructed with a hard edge to act as an abutment → ❼ – ❾. Clear areas where no vehicles can gain access can be covered loosely → ❹ – ❺ or with concreted back supports. The technical regulations concerning sufficient camber → ❶ – ❸ should be complied with. There should always be a fall away from buildings: in public areas, a minimum fall of 2.5% is required. The various laying patterns → ⓲ + ⓳ should always be suited to the material being used.

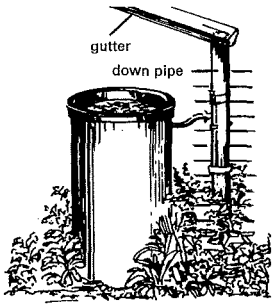
For all paving, the surface treatment is important for the function and design. For natural stone, flamed, consolidated, sawn, sandblasted or split surfaces are usual. The slip-resistance of paved surfaces in external works is important.

Design aspects of steps

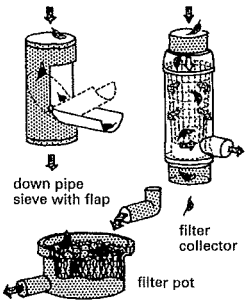
Steps overcome height differences: they are therefore always significant as a vertical design aspect and require detailed matching to the overall theme. Flat and wide steps with low risers appear softer, more spacious and stronger in design. The steeper and narrower the steps, the more functional the impression.

In addition to the dimensions of the steps, the material and colour should also be selected in harmony with the external works design. The possibilities range from expensive natural stone materials with high-quality processing to simple timber steps in woodland. The other important accessories to steps, like handrails, should also be well matched to the design in order to present the end result as a homogeneous finished product. One good idea is to continue the paving leading to and from the steps like a carpet in the form of similar steps. The cheeks of the steps should always be considered with the proportions and function of the overall work

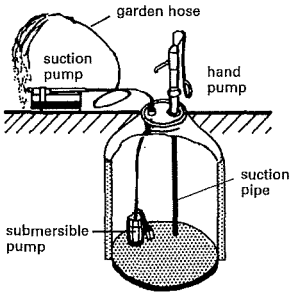
Steps should always be laid out according to the step length rule (2 × h + b ≦65). Steps have a fall to the front → ⓰ in order to prevent ice formation. According to the size of the steps, additional measures can be necessary to secure the foundations → ⓯ – ⓰. Handrails should normally be provided if there are more than three steps (the exact details are given in the state building regulations). It can be sensible to have ramps integrated into the steps, particularly at house entrances and access routes to bicycle storage → ⓱.



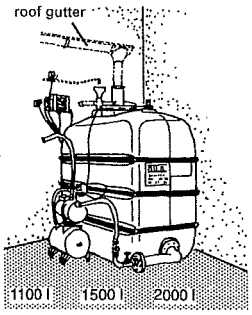
1 Rainwater butt for garden watering



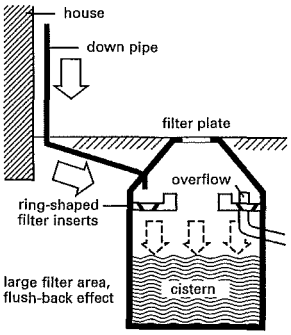
2 Filter upstream of the rainwater tank



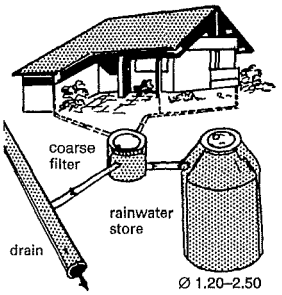
3 Rainwater tank for garden watering



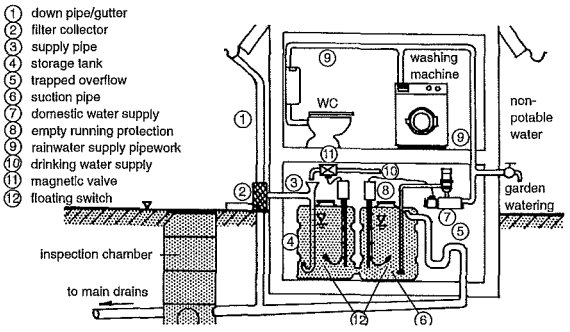
4 Rainwater utilisation system



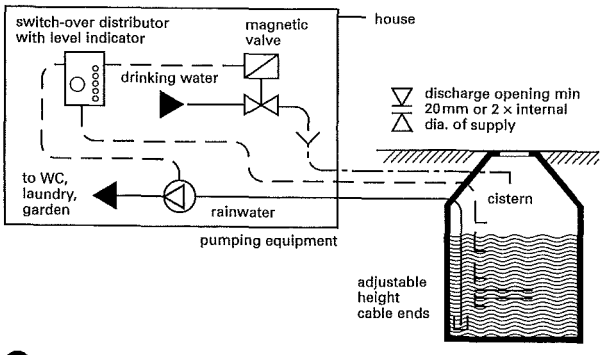
5 Principle of a cistern



6 Rainwater tank up to 12 500 litres



7 Rainwater system



8 Drinking water refilling system → 7

Design for drainage

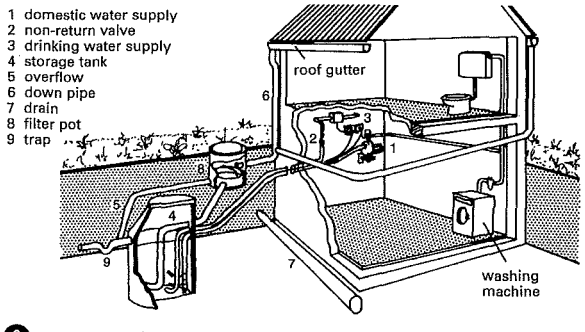
Normal drainage installations like box gutters or floor gullies allow room for design in their material (metal, cast iron) and form (grating, slot gutter etc.), and the effect of these choices should not be underestimated. Above all the positioning should be planned exactly, e.g. fitting into the pattern of slabs.

Complete system solutions (rainwater management) can be implemented as a design idea. Modelled landscape with integrated percolation basins or rain gardens, where water collects in a dip and soaks away, water areas to accept the drainage and ditches with corresponding planting can all enable nature-like or more formal design. The topography of the terrain should be closely considered. Attractive water landscapes can be combined with the necessary provision of drainage functions. Technical facilities like French drains, cisterns etc. should be kept in the background if feasible.

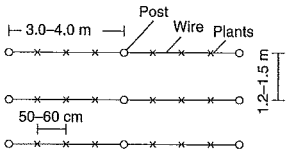
Rainwater management is urgently suggested for ecological and economic reasons in order to preserve the natural rainwater cycle as far as possible. Optimised rainwater management means that no rainwater drains into the sewers. The basic principle of rainwater management is to avoid, reduce or at least greatly delay surface water running off into the drains where it arrives or in the immediate vicinity. The following measures can contribute to this: soakaways, permeable paving, rainwater exploitation (water harvesting) and roof planting

Drainage is generally differentiated into linear or point drainage. Depending on the surfacing, surface falls should be provided to drain surface water appropriately at all times of year. It should be ensured that no surface water is drained to susceptible structures, buildings or onto neighbouring properties. The precipitation is collected in gutters or gullies and then mostly run into gully traps in the underground drainage pipes or to soak away in infiltration facilities. The hydraulic capacity of the inlets and thus the collected area should be calculated according to Guidelines for Street Layout – Drainage (RAS-EW). The approximate rule is:
– for yard gullies: up to approx. 200 m^2 collected area
– for road gullies: up to approx. 400 m^2 collected area
– spacing of the road gullies not less than 40 m.

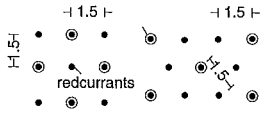
Infiltration measures (surface infiltration or rain gardens, French drains). In addition to underground drainage, water can also be removed by surface drainage through terrain modelling and infiltration. Either constructional features (French drains, infiltration in dips in the ground, infiltration trenches) or grass areas with topsoil covering (rain gardens) are used. The first step is to determine the soil composition and the infiltration capacity of the ground (kf value) in connection with the local precipitation. The guideline is Association for Water, Wastewater and Waste (ATV) 138.



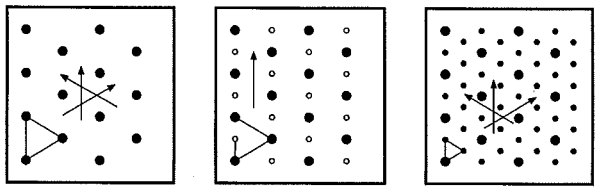
9 Rainwater collection system with filter pot and external tank



1 Spacing for planting raspberries



2 Gooseberries and redcurrants together in squares



spacings	trees per ¼ ha
3×3×3 m	320
4×4 ×4 m	178
6×6×6 m	80

3 Triangular planting, equilateral

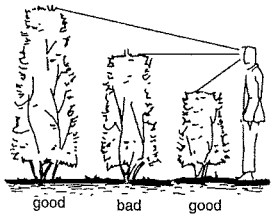
spacings	trees per ¼ ha	
	standing trees	filiers
1.5×3×3 m	320	320
2×4×4 m	178	178
3×6×6 m	80	80

4 Triangular planting with fillers

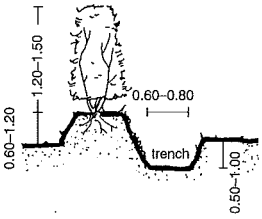
spacings	trees per ¼ ha		
	standing trees	1st filler	2nd filler
3×3×3 m	80	80	160
4×4×4 m	44	44	88

5 Triangular planting with double fillers

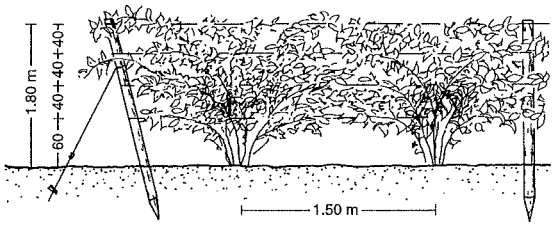
3 – 5 Planting system according to De Haas; and see p. 433 ⑩ – ⑮



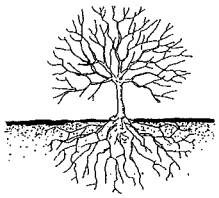
6 Hedge heights



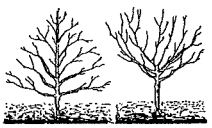
7 'Quick-set' hedge in North Germany



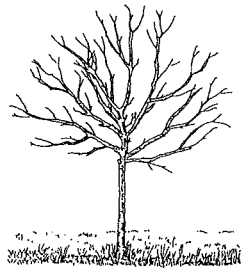
8 Wire support for brambles



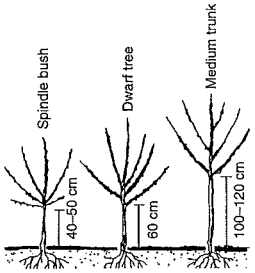
9 They mirror each other above and below ground: the tree and the root system



10 The pyramid is the basic 'Christmas tree' shape and is preferred to the goblet shape because the branches are kept very short and thus less likely to break under the weight of fruit or snow. The goblet has an open form with the branches trained outwards to let more light into the crown.



11 Large tree while still young. Allow the trunk and two or three branches to grow in order to achieve the desired form



12 Tree shapes for small gardens

Design with vegetation

Design with vegetation, which includes plants, trees, bushes, grasses and lawn or meadow plants, is extremely varied. Nonetheless, all landscape design should place the complete concept before the plant selection. Modern landscape architecture understands itself as an open-air architecture, into which the plants have to integrate as an important part of the overall design scheme. Horizontal and vertical spatial characteristics (trees, shrubs etc. in height and form) play an important role before the selection of plant genus, species or type.

Once the spatial units have been decided, the exact choice of plants can be made according to aspects like growth form, leaf form and colour, blossom colour and date, autumn colour and suitability for the location (soil, light). Economic considerations concerning care and maintenance also have to be included. The selection of the correct planting is an elementary part of good landscape design, with the stimulus and challenge that this element always changes with the time of year and with successive years.

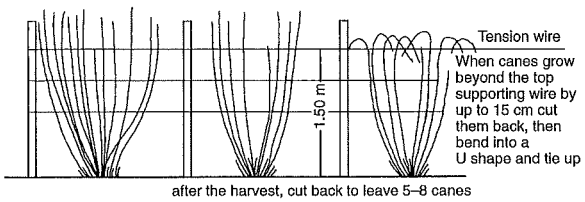
Plants

Under the general terms perennial herbs, grasses, ferns, geophytes (bulb plants) and woody plants, there are countless varieties of plants. In general, the botanical names are used to name plants and these are normally derived from Latin and Greek. The botanical name is composed of plant family, genus, species and variety (e.g. family Araliaceae: *Hedera helix* 'Arborescens' – common ivy). Together with the quality grading by the Association of German Tree Nurseries (BdB) of the plants and their abbreviations, the countless varieties can be exactly named and ordered. Particular forms of growth (hanging – pendula or column-shaped – fastigiata) can often be understood from these names.

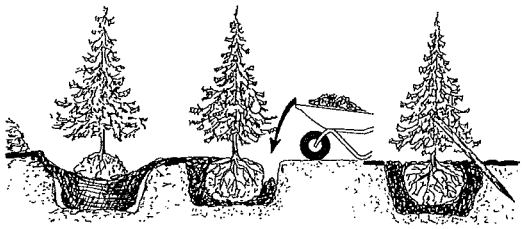
Plant quantities differ greatly depending on the plant family, genus and species. Different plant spacings apply for productive plants → ❷ – ❺ than for general landscaping. Overall, the objective (fast growth of the plant) should be observed. Perennials and small ground-cover plants are planted at 6–12 plants/m², solitary wood plants at 0.5–2 plants/m² and a single-row hedge is usually planted with 3–5 plants/running metre.

When **plants are delivered**, attention should be paid to permitting only a short time span between the uprooting at the nursery and planting. Storage should not exceed 48 hours. Delivery includes all ATV requirements and also planting. If intermediate storage is unavoidable, then the plants should be protected against drying out, overheating and frost. Some possible measures are stacking them roots to roots, spraying with water and covering the roots with soil or tarpaulins. A storage place out of the wind and the sun is best. They should be wrapped up only if there is no chance of early planting.

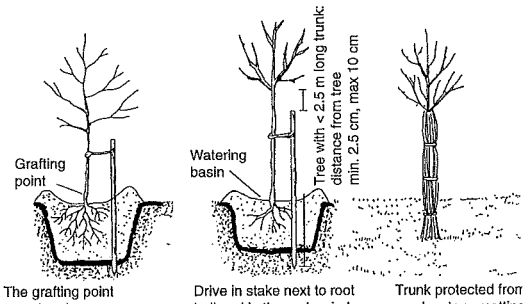
The best **planting time** is generally the autumn and early part of the year; for fruit trees late autumn. In landscapes with early frosts, planting can be as late as October, or in mild regions until November.



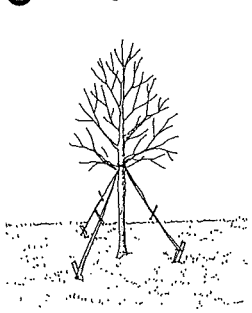
13 Raspberries



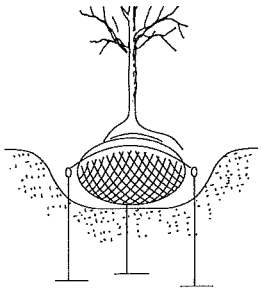
❶ When planting a conifer, the root ball cloth must be removed. With small trees the support stake is installed at an angle.



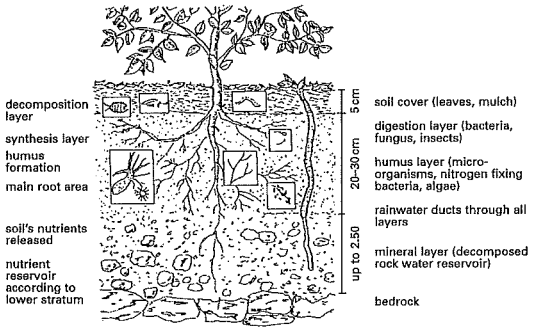
❷ Anchoring trees



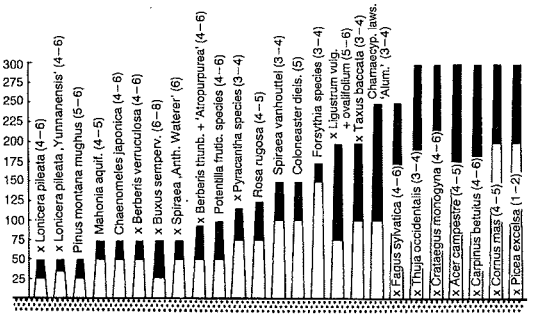
❸ Anchoring trees



❹ Subsoil anchoring for trees with solid root balls



❺ Every layer of humus is full of life. Each spadeful has its occupants



❻ Growth heights of trimmed and free-growing hedges (plants marked x are particularly suitable for trimming) with number of plants required per running m

Planting is regulated in detail in the relevant standard. Planting holes should be dug with a width of 1.5 times the root ball. The topsoil should be separated while digging and replaced at the top again after planting. Trees and larger bushes should be protected against wind damage after planting, for example by **staking** → ❷ – ❹. The stakes should be outside the root ball if possible and always set against the prevailing wind direction. Debarked, round stakes are usual. Plants are removed from pots or small containers (for perennials and ground-cover plants) and put directly into the ground with a planting spade. Planting methods vary according to type of plant.

Distances of plants from boundaries of neighbouring properties, as given by the Law on the Rights of Neighbours, are to be complied with. Hedges up to a height of 2.0 m should be planted at a distance of 0.50 m, or if over 2.0 m in height at 1.0 m, measured from the side surface, small trees at a distance of 1.50 m and large trees at 3.0 m. (measured from the centre of the trunk). There are exceptions and special rules for particular types of neighbouring areas (public roads, woodland etc.).

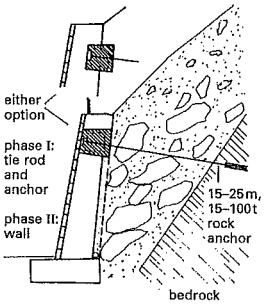
For gardening professionals, the **care of plants** counts contractually as extra work. Woody plants are normally acceptable when they show signs of new shoots in the last third of June, and for perennials when they have sprouted, budded or produced roots. Area (ground-cover) planting is acceptable when no more than 5% of the plants have died but there is a continuous appearance despite this. Annual and biennial flowers, flower bulbs and tubers, and all other plants are acceptable immediately after planting unless additional care has been agreed.

In addition to the sowing of lawns, expensive turf lawns (thin-cut lawn mats) can also be used. For lawn areas, a fertile soil layer of at least 10 cm should be prepared. Grass generally grows at temperatures above approx. 8°C and stops growing at approx. 30°C. A newly sown lawn can be used after about six weeks. A **selection of sowing types** and sowing quantities (lawn for walking, playing, meadow etc.) is given in RSM (Standardised Seed Mixtures) 2008 from the FLL series.

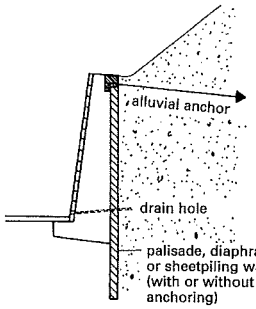
The **care of lawns** counts contractually as extra work. Sowing work is acceptable when a cover of approx. 75% is reached. Landscape grass areas are acceptable with a projective ground cover of approx. 50%. Turf and rolled lawns are acceptable when the growth of roots into the soil is recognisable.

Standards	Trans-plants	Trunk circumference (cm)	Trunk height (cm)	Crown width (cm)	Standing distance (cm)	Max. standing time (yrs)	Other
light standard	2	8–10 10–12	≧180		wide	4	bundles of 5
standard 3 x v	3	10–12	≧200		extra wide	4	
		12–14					
		14–16					
		16–18					
		18–20					
		20–25					
standard 4 x v and often solitary standard	≧4	16–18	total height 300–400 400–500	60–100	extra wide	4	wire balls or container, number of plantings indicate wire balling
		18–20		100–150			
		20–25		150–200			
		each 5 cm		200–300			
		up to 50 cm		400–500			
		each 10 cm		500–700			
		from 50 cm		700–900			
				900–1200			
				+ 300 cm			
avenue tree			TC up to 25 cm		extra wide	4	
			≧220 cm				
			TC from 25 cm				
			≧250 cm				

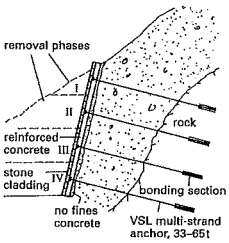
❼ Requirements for sorting and bundling of standard trees (Lehr → refs). TC: trunk circumference



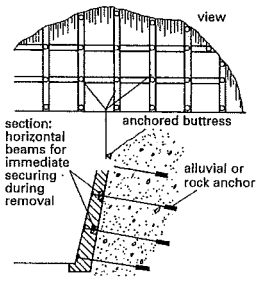
❶ Revetment wall for slope in loose ground with advance support through anchored rail (scheme Badberg II – Badgastein)



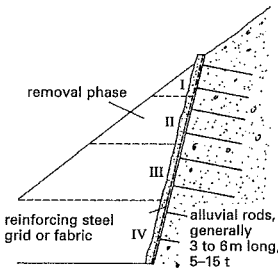
❷ Revetment wall with piled, diaphragm or sheet pile wall (with or without anchoring) in loose ground



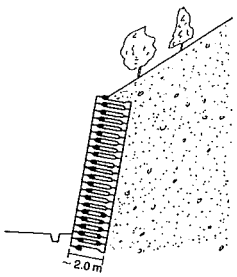
❸ Slope support in loose ground: staged excavation from top to bottom and immediate support with masonry elements and rock bolts (Brenner autobahn)



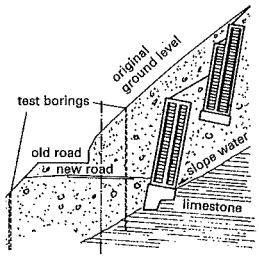
❹ Primary slope support in loam-bound or partially consolidated loose material through anchored beam grillage



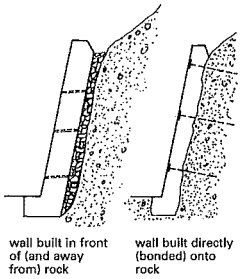
❺ Slope support in loose ground: staged excavation from top to bottom and immediate support with shotcrete with reinforcing mesh and rock bolts



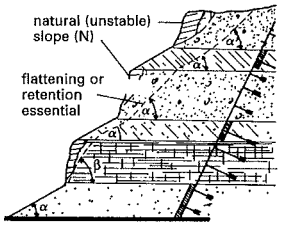
❻ Spatial grid retaining wall (Krainer wall) of concrete (Ebensee system)



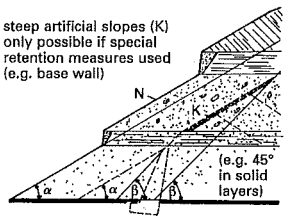
❼ Krainer wall installed in steps provides sufficient room for the new road. The landscape remains green



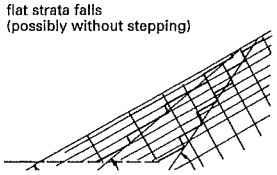
❽ Types of rock cladding as revetment or masonry (after L. Müller 1969)



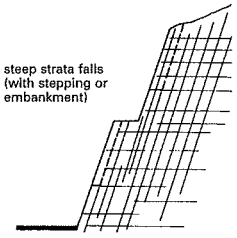
❾ The design of slopes (and support) in strata of variable stability



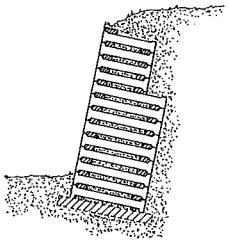
❿ → ❾



⓫ Rock slopes determined by the geology and jointing



⓬ → ⓫



⓭ Krainer wall

	Length [cm]	Width [cm]	Height [cm]	Weight [kg/unit]
stretcher LE	250	30	10	168
end stretcher ELE	280	30	10	188
half end stretcher EHLE	155	30	10	108
half end stretcher HLE	125	30	10	88
header B 130	90	15	25–32	118
header B 180	130	15	25–32	68
spacer block A	30	15	25–32	20
distance block D	20	10	10	6

⓮ Ebensee Krainer wall → ❻ + ⓭

Design in the application of biological engineering

Biological measures in engineering are mostly biologically oriented answers to construction requirements, like the support of slopes or riverbanks. They are therefore to be seen as part of the overall planning and to be designed accordingly. It should be clarified whether such measures should be intentionally visible or concealed as far as possible.

Experience of the application of biological measures can enable banks and slopes, which otherwise would have required retaining walls, to be part of the vegetative scene. The overall design idea and the corresponding choice of materials should always influence the implementation of the functional necessities.

The use of biological solutions to support slopes can be divided into the support of slopes and of riverbanks.

Supporting slopes

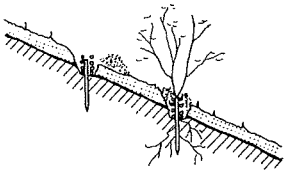
It is necessary to support steep slopes, but the ideal is to create slopes with rounded transitions to flat terrain and planted with grass, perennials or trees.

When slopes are designed steeper than the natural angle of repose, they should be supported with turf, fascines, paving or masonry. At a slope greater than 1:2, turfs should be nailed with timber pegs. Turfs can also be stacked to hold up steeper slopes with inclinations of 1:1.5 to 1:0.5.

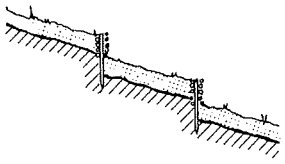
Fascines (bundles of sticks) are suitable for supporting steep slopes where plant cover would become established only with difficulty. They can be living or dead. The latter (willow stakes hammered in) require subsequent planting with deciduous woody plants.

To support large cuttings, as in road building or properties on a slope, elaborate measures are necessary → ❶ – ❻.

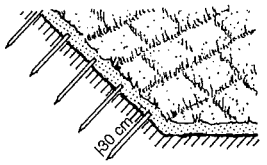
Anchored beam grillages are of various types, e.g. consisting of horizontal, pre-anchored beams with standing posts. The panels in-between are sprayed with shotcrete → ❹.



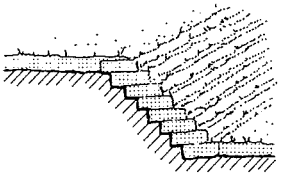
1 Living fascines



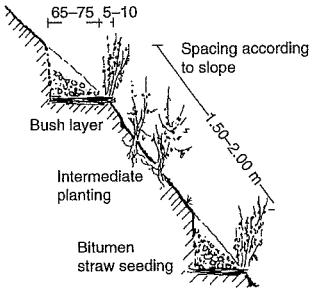
2 Dead fascines



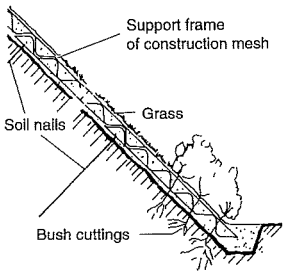
3 Pegged turfs support the slope ≧1:2



4 Support with stacked turfs



5 Bush layering, pioneer planting and bitumen straw seeding for the support of woodland slopes and embankments



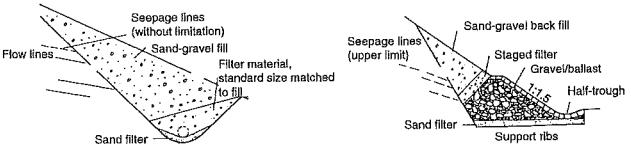
6 Support of a slope surface with anchored steel mesh, Weber system

Planted retaining walls create room for usable properties, roads and paths. Considerable height differences can be overcome. Depending on the system and the slope, high walls can also be built with ground anchors → 6.

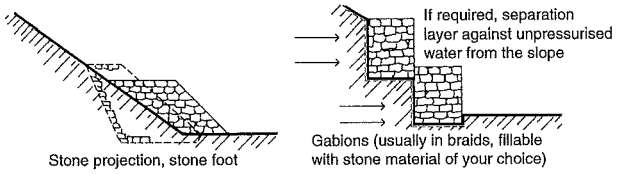
Supporting riverbanks

While, in the design of slope support, earth pressure and gravity are the forces to be considered, the design of riverbank support also has to take into account the effect of water and wave impact. The optimal riverbank protection is a natural vegetation profile next to the flowing water → 10 and healthy root systems prevent the bank being damaged by wave impact.

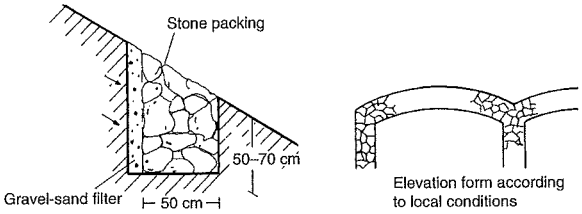
There are many methods of protecting against erosion, particularly the area above and below the waterline, which is most subject to wave impact, e.g. bundles of willow fascines, rhizome edgings or brush mattresses are possible.



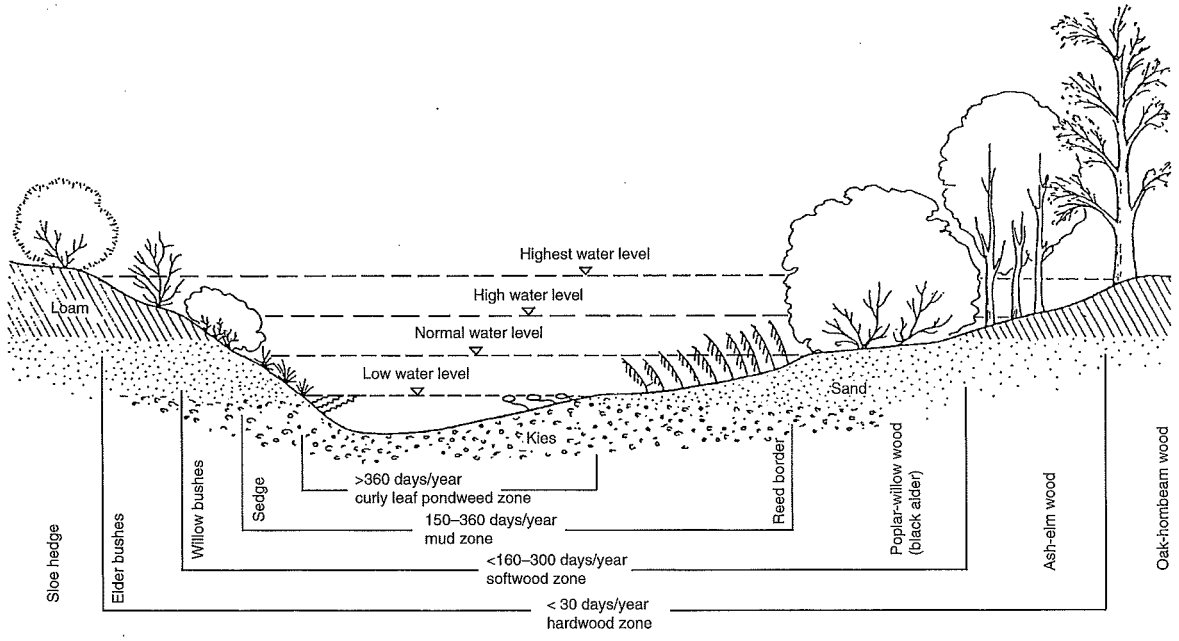
7 Drainage and support of a river slope with stone and ballast bodies



8 Slope support with stone, coarse gravel or broken ballast



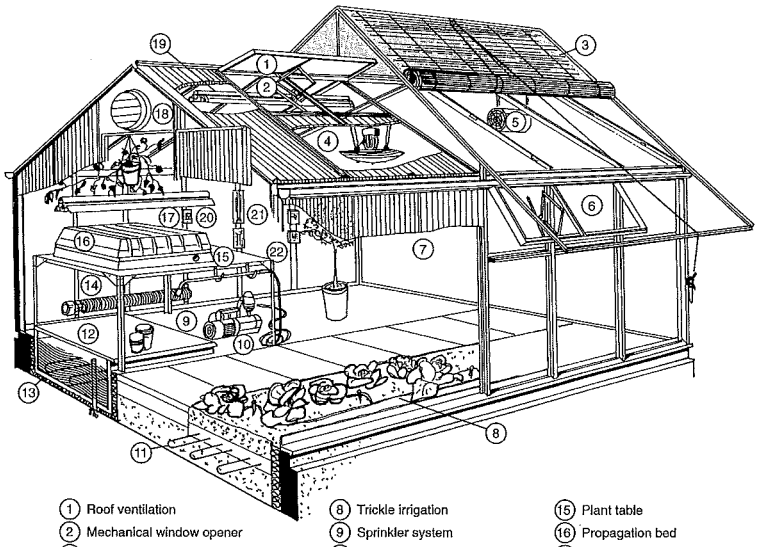
9 Stone ribs to drain and support cutting slopes



10 Vegetation profile of a river bank (Bittmann)

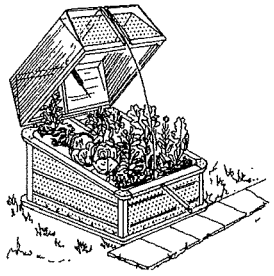
GREENHOUSES

The ventilation of a greenhouse should be designed so that, when it is opened, the temperature is almost the same as outside. To achieve this, it is necessary that about 20% of the roof area opens as a ventilation band or a single casement. Sun protection can be necessary if there is insufficient natural shading outside to create a bearable climate under strong sunshine. The sun protection can be mounted inside or outside, but the effect of external sun protection is greater when the distance between it and the glass is large enough → ❶ and ❿ – ⓫.

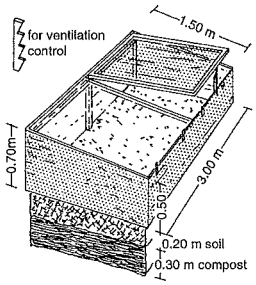


① Roof ventilation
② Mechanical window opener
③ Exterior blinds
④ Air humidifier
⑤ Air circulation fan
⑥ Side ventilation window
⑦ Double layer plexiglass
⑧ Trickle irrigation
⑨ Sprinkler system
⑩ Water pump
⑪ Underground heating cable
⑫ Watering tank
⑬ Insulation
⑭ Heating
⑮ Plant table
⑯ Propagation bed
⑰ Incubation lighting
⑱ Automatic mechanical ventilation
⑲ Greenhouse lighting
⑳ Humidity controller
㉑ Air humidity sensor
㉒ Thermostat

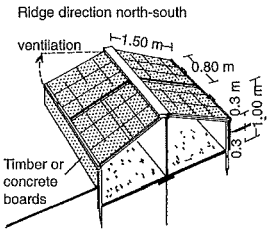
❶ Greenhouse with effective equipment and air-conditioning



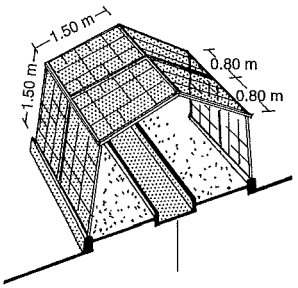
❷ Banked bed with solar hood



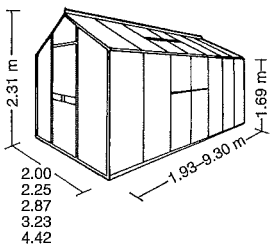
❸ Self-built cold frame



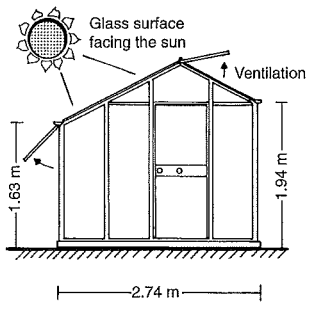
❹ Small greenhouse



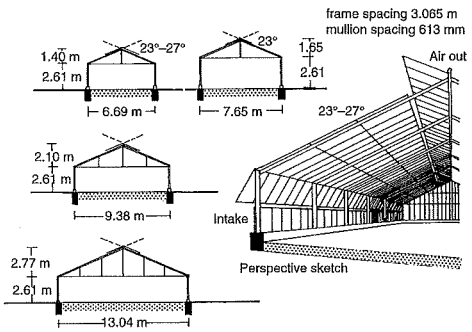
❺ Dutch greenhouse



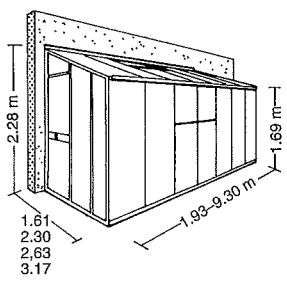
❻ Standard greenhouse



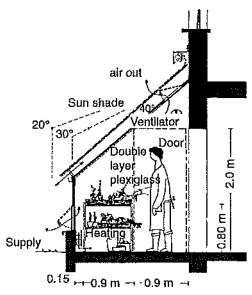
❼ Hothouse



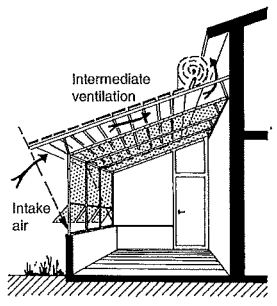
❽ Greenhouses with 23–27° roof pitch



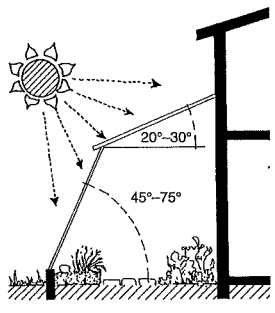
❾ Lean-to greenhouse



❿ Lean-to greenhouse



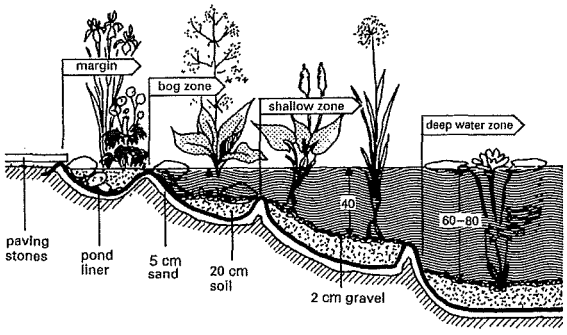
⓫ Exterior blinds with full intermediate ventilation



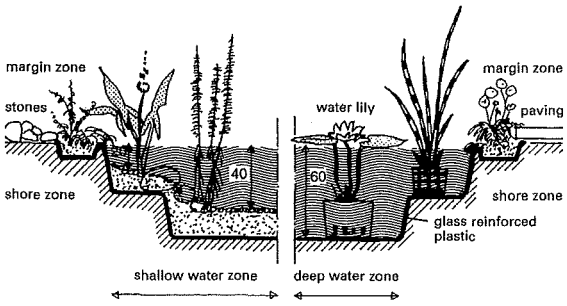
⓬ Optimal angles for glass surfaces

PONDS AND POOLS

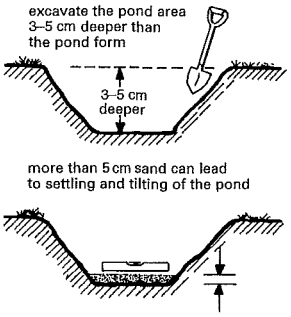
Garden Pond



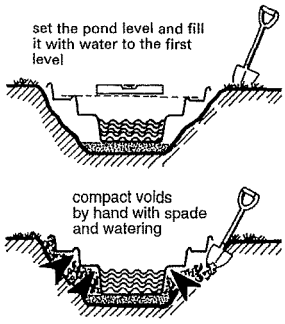
❶ Foil pond planting in a stepped arrangement



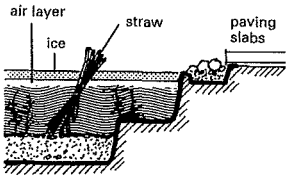
❷ Suitably shaped pre-fabricated pond



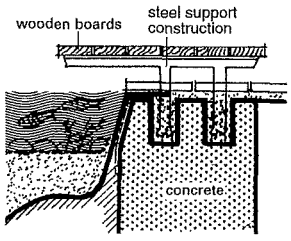
❸ Excavation of a garden pond



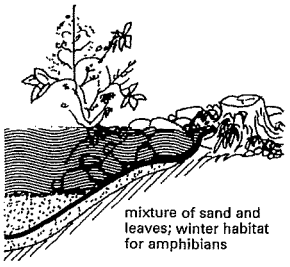
❹ Compacting voids at sides well with excavated earth



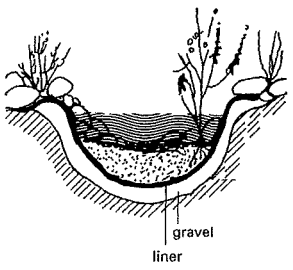
❺ In case of frost, use straw bundles or aeration stones



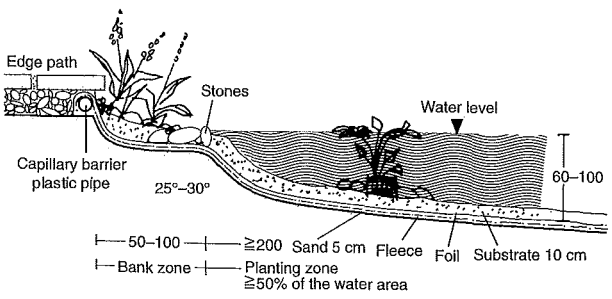
❻ Cantilevered platform



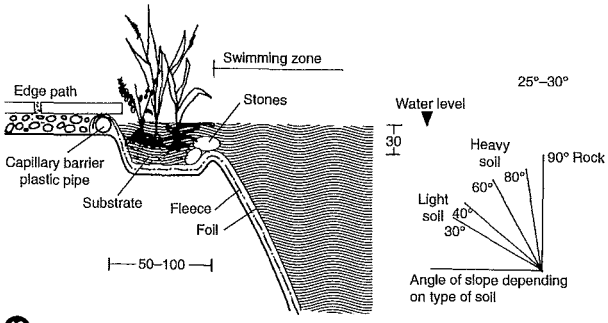
❼ Edge zone



❽ Stream cross-section



❾ Edge detail



❿ In small garden with heavy soil

Ponds should integrate harmoniously into gardens. The correct location is of decisive significance for the flourishing of plants and life forms. Most bog and water plants require plenty of sunlight, approx. 4–6 hours per day, and the preferred location is near terraces and seating.

If the plants, water and sand have been provided in the appropriate quantities, then a biological equilibrium arises after about 6–8 weeks and the water should become clear. The ratio of water surface area to water quantity must be right (about 400 litres per m^2 of water surface). The garden pond then becomes a habitat for insects and plants.

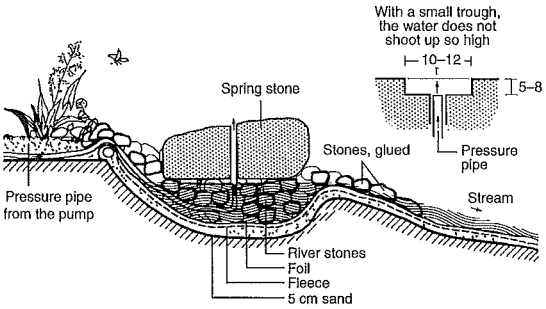
The planting of the pond is done before topping it up with water, which is added carefully. Planting time: from May to September. In order to achieve a harmonious overall picture, tall plants should be planted individually in the water garden at half-height and with a spacing of 30–40 cm. Low plants at the edge should, in contrast, be set only in groups. Spacing from plant to plant: 20–30 cm.

The first planting with **underwater plants** is sufficient with five plants per m^2. The plants multiply quickly. Plants in containers can be brought to the correct water level by planting higher or lower. They can be planted in baskets, containers or directly into special earth. Pre-fabricated ponds provide planting baskets at the correct depths and prevent the gravel or planting earth slumping or slipping → ❷ – ❺.

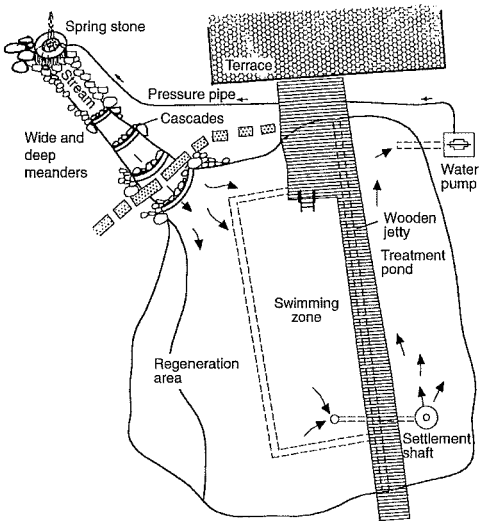
The pond should be appropriate for the size of the garden. Ideal is a water area of 20–25 m^2, but as little as 3–5 m^2 offers a habitat for many species. Wetland, shallow-water zones → ❶ – ❷ and waterlogged borders help to expand the pond area and create a more natural balance. Generous water zones 5–20 cm deep and another area at least 80 cm deep are necessary for insect larvae and newts to overwinter. The deep zone serves as an escape zone for the creatures.

The pond should stay full in the winter in order to prevent frost heave. Fish, frogs and amphibians survive the winter only if anti-ice devices and aeration stones are used.

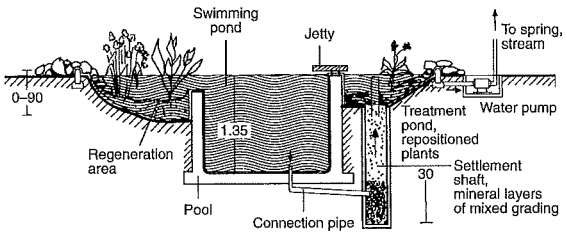
The edge area should be well thought out with regard to cleaning, capillarity → ❹ – ❺ and required use → ❻ – ❽. The advantage of a natural pool in comparison with conventional pools is low maintenance cost (no cleaning, pump) and its ecological value (biotope effect, allergy-free, as no chlorine is needed). On the other hand, turbidity or temporary formation of algae have to be accepted in some weather conditions. These problems normally disappear fairly quickly without any action. A stream can be part of the pool, 8–10 m being ideal → ❶ – ❷. About 15 m³ of water runs over the stones and cascades per hour and is oxygenated.



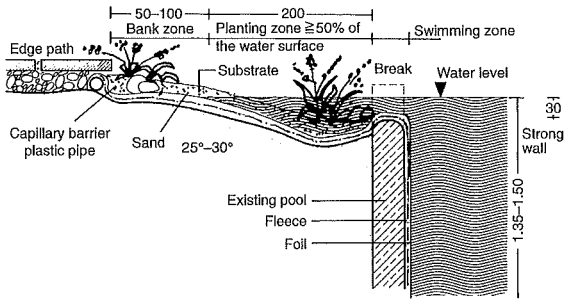
❶ Spring stone → ❷



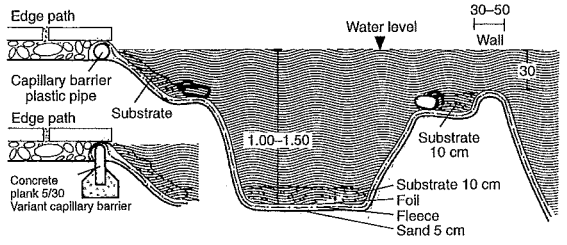
❷ Plan of natural swimming pool → ❸



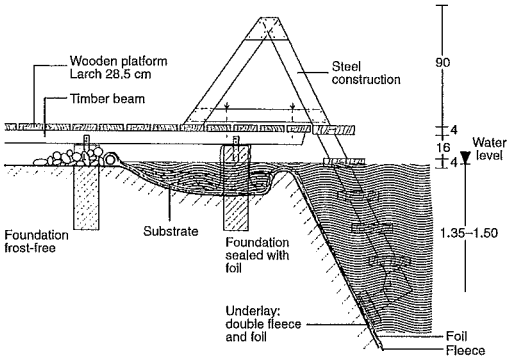
❸ Cross-section of natural swimming pool → ❷



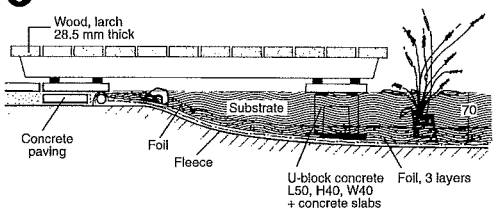
❹ Existing swimming pool converted into a natural pool



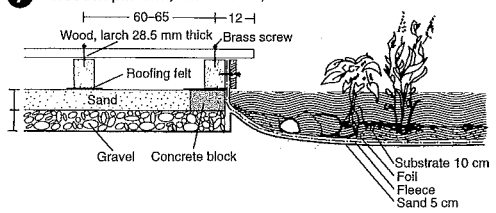
❺ Water treatment zone/hole



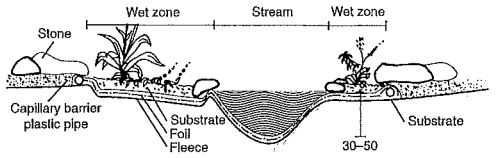
❻ Platform and access



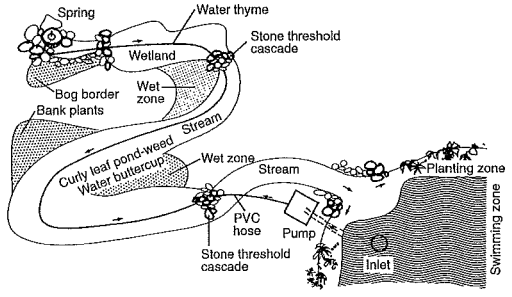
❼ Wooden platform, water island, sun deck



❽ Pool edge layout, wooden platform



❾ Watercourses → ❿

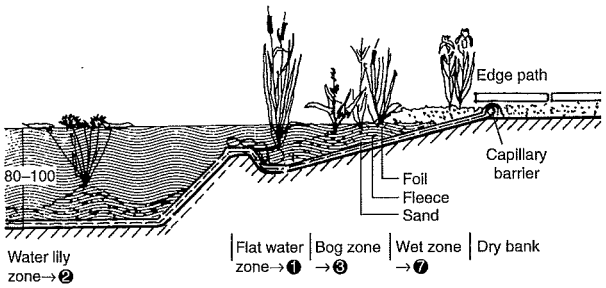


❿ Watercourse with wide and deep meanders and bubbling cascades → ❾.

PONDS AND POOLS

Water Plants for a Natural Swimming Pool

Ecological natural swimming pools require a self-cleaning zone of water plants, which should take up about ⅓ of the total area.



❺ Planting depth

English name	Botanical name	Flowering months	Flower colour
sweet flag	*Acorus calamus*	VI–VII	green-yellow, brown
European water plantain	*Alisma plantago-aquatica*	VI–VII	whitish-pink
lesser water plantain	*Baldellia ranunculoides*	VI–X	brown
flowering rush	*Butomus umbellatus*	VI–VIII	pink, white, red
Cypress sedge	*Carex pseudocyperus*	VI–VII	yellow
reed sweetgrass	*Glyceria maxima 'Variegata'*	V–VII	green
common mare's tail	*Hippuris vulgari*	VII–VIII	insignificant
golden club	*Orontium aquaticum*	V–VI	gold-yellow
water knotweed	*Polygonum amphibium*	VI–VII	pink
pickerel weed	*Pontederia cordata*	VII–VIII	blue
curly-leaf pond-weed	*Potamogeton crispus*	VI–IX	not noticeable
water buttercup	*Ranunculus lingua*	VI–IX	yellow
arrowhead	*Sagittaria sagittifolia*	VI–VIII	white-pink
common tule	*Scirpus lacustris*	VII–VIII	brown
branched bur-reed	*Sparganium erectum*	VII–VIII	green-white
common bulrush	*Typha angustifolia*	VI–VII	black-brown

❶ Shallow-water zone, water depth 10–40 cm → ❺

cape pond-weed	*Aponogeton distachyos*	VII–X	white
frogbit	*Hydrocharis morsus-ranae*	VI–VIII	white
yellow water lily	*Nuphar lutea*	VI–VIII	yolk-yellow
water lily	*Nymphaea hybrids*	VI–IX	acc. type
fringed water lily	*Nymphoides peltata*	VI–VII	gold-yellow
floating pond-weed	*Potamogeton natans*	VI–IX	white
common water crowfoot	*Ranunculus aquatilis*	VI–IX	white
water soldiers	*Stratiotes aloides*	V–VII	white
water chestnut	*Trapa natans*	VI–VII	white, unobtrusive

❷ Water lily zone → ❺

bog arum	*Calla palustris*	VI–VII	white
marsh marigold	*Caltha palustris*	IV–VI	yellow
Gray's sedge	*Carex grayi*	VI–VIII	green heads
variegated horsetail	*Equisetum variegatum*	—	no flowers
common cottongrass	*Eriophorum angustifolium*	V–VI	white
bog spurge	*Euphorbia palustris*	IV–V	yellow
swordleaf rush	*Juncus ensifolius*	VII–IX	brown heads
tufted loosestrife	*Lysimachia thyrsiflora*	V–VI	yellow
American skunk cabbage	*Lysichiton americanus*	IV–V	yellow
water mint	*Mentha aquatica*	VI–VIII	pale violet
bogbean	*Menyanthes trifoliata*	V–VI	white–soft pink
monkey flower	*Mimulus cupreus*	V–X	red
water forget-me-not	*Myosotis palustris*	VI–IX	light blue
watercress	*Nasturtium officinale*	IV–VI	white
sensitive fern	*Onoclea sensibilis*	—	no flowers
European speedwell	*Veronica beccabunga*	V–IX	deep blue

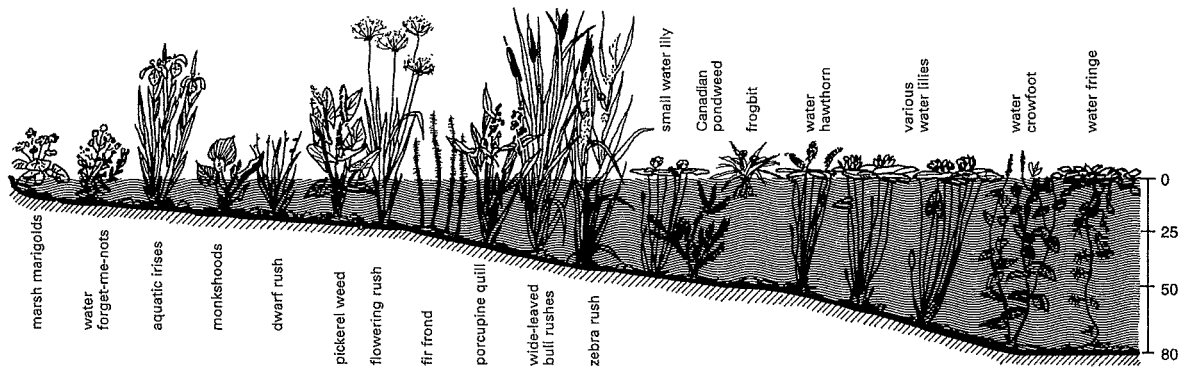
❸ Bog zone → ❺

pondwater starwort	*Callitriche stagnalis*		evergreen, roots into the subsoil
rigid hornwort	*Ceratophyllum demersum*		rootless, overwinters as a bud on the pond floor
Canadian waterweed	*Elodea canadensis*		evergreen, plant in pond floor tends to be invasive
water violet	*Hottonia palustris*		evergreen, roots in bottom mud
water milfoil	*Myriophyllum*		evergreen, roots into pond floor
pond-weed	*Potamogeton species*		plant in a container to control growth
fan-leaved water crowfoot	*Ranunculus circinatus*		evergreen, plant in pond floor
common bladderwort	*Utricularia vulgaris*		rootless, catches small insects with bubbles; overwinters as leaf bud

❻ Oxygenation plants for the pool

sneezewort	*Achillea ptarmica*	VII–VIII	white
blue bugle	*Ajuga reptans*	V–VI	violet
turtle-head	*Chelone obligua*	VIII–IX	pink-red
Indian rhubarb	*Darmera peltata*	IV–V	pink
hemp agrimony	*Eupatorium cannabium*	VII–IX	pink
meadowsweet	*Filipendula ulmaria*	VI–VII	white
leopard plant	*Ligularia przewalskii*	VIII–IX	yellow
creeping jenny	*Lysimachia nummularia*	VI–VII	yellow
purple loosestrife	*Lythrum salicaria*	VII–IX	violet-red
royal fern	*Osmunda regalis*	VI–VII	brown spore frond
Jacob's ladder	*Polemonium caeruleum*	VI–VII	blue to white
bistort	*Polygonum bistorta*	V–VIII	pink
primulas	*Primula*	III–VII	acc.species
meadow buttercup	*Ranunculus acris 'Multiplex'*	V–VI	yellow
globeflower	*Trollius hybrids*	V–VI	yellow tones

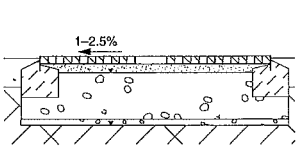
❼ Wet zone → ❺



❹ Water plants

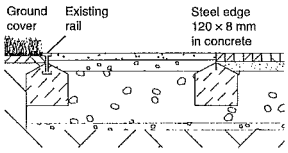
EXTERNAL WORKS – EXAMPLE

Federal Environment Agency



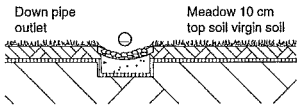
5–7 cm mosaic paving, travertine
3–5 cm compensation layer gravel-sand
40 cm ballast base course 8/32
5 cm filter stable layer of
frost-safe material
filled & compacted subsoil

❶ Standard detail of mosaic stone paving, FEA, Dessau



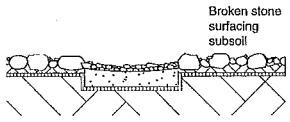
5 cm paving layer 0/5
3 cm dynamic layer 2/16
37 cm ballast base course 8/32
5 cm filter stable layer of
frost-safe material
filled & compacted subsoil

❷ Waterbound path surfacing with connections, detail, FEA, Dessau



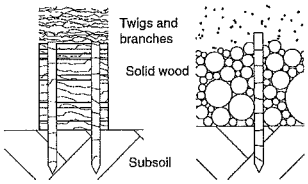
7 cm broken stone in wild pattern
15–20 cm clay layer
3 cm sub-base grassy ground

❸ Gutter for building drainage, detail, FEA, Dessau

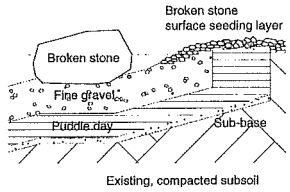


7 cm broken stone in wild pattern
15–20 cm clay layer
3 cm sub-base

❹ Gutter for pond inlet, detail, FEA, Dessau



❺ Dead wood wall, detail, FEA, Dessau

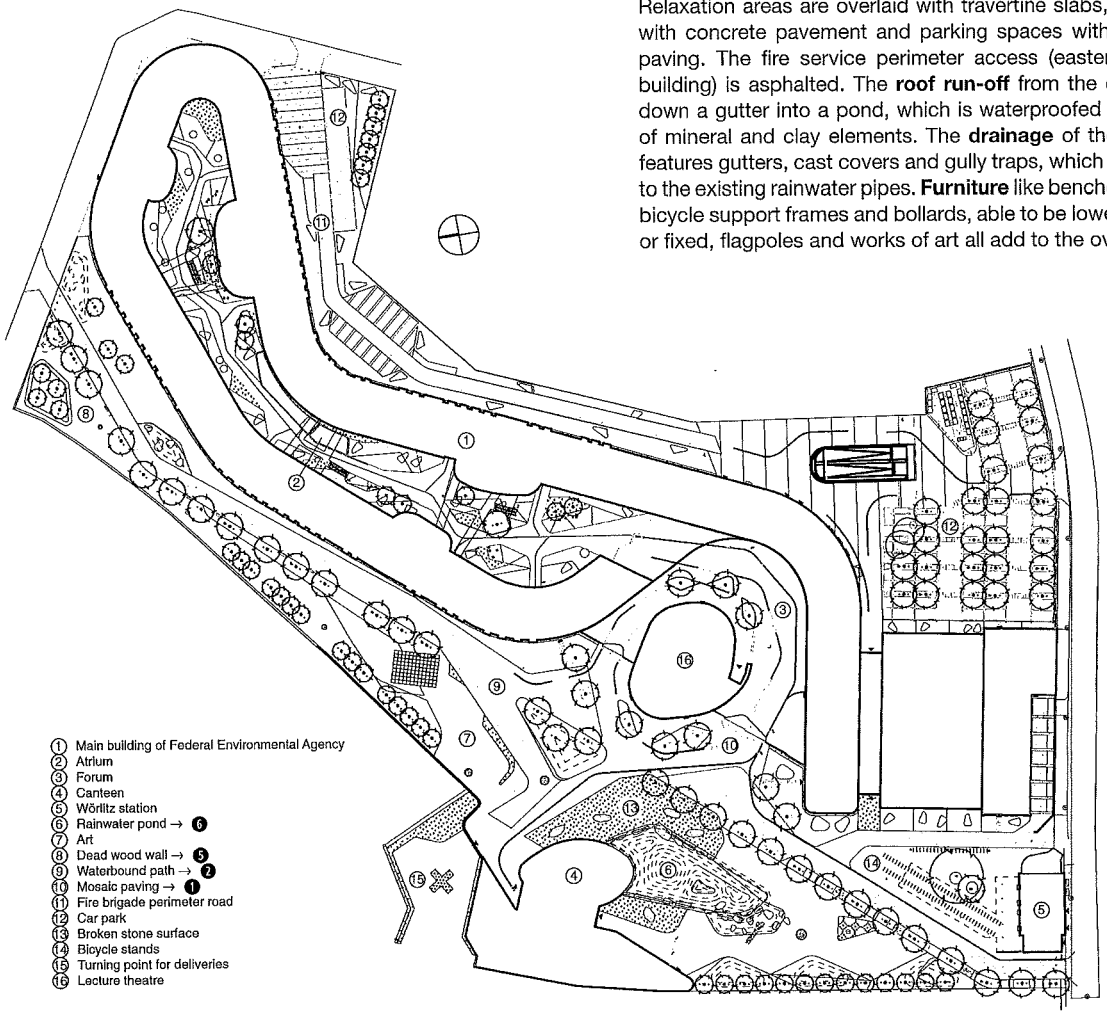


❻ Rainwater pond, detail, FEA, Dessau

The design of the external works for the Federal Environment Agency (FEA) in Dessau is based on a continuous idea: it mediates between the building and the city and forms its own landscape theme – nature in movement. This is divided into two landscape areas: 1. inside the building, 2. outside the building. Elements of naturalistic design, which are based thematically on the function of the building, are part of the production.

The **planting** follows a functional and an aesthetic principle. The functional component is aligned with the pragmatic requirements for external works, like for example the enclosure of the plot (a hornbeam hedge borders the plot to the west, the fire service perimeter road to the east is marked by planting with red bushes and ground-cover plants). The aesthetic component is oriented towards the sculptural quality of each plant with regard to the theme of the building (meadow areas are sown with grasses and wild flowers, succession areas covered with broken stone demonstrate natural development, approx. 100 new trees have been planted, green fields are strewn with ground-cover plants, perennials and decorative shrubs).

The material excavated during the construction work was used to model the plot. **Paths/paved areas**, covered with mosaic stone paving and waterbound surfacing, also serve as fire service perimeter access. Paths are bounded with steel edges and rails found on the site. The guidance system for the visually impaired consists of black natural stone slabs let into the pale paving. Relaxation areas are overlaid with travertine slabs, access roads with concrete pavement and parking spaces with grass-jointed paving. The fire service perimeter access (eastern side of the building) is asphalted. The **roof run-off** from the canteen pours down a gutter into a pond, which is waterproofed with a mixture of mineral and clay elements. The **drainage** of the paved areas features gutters, cast covers and gully traps, which are connected to the existing rainwater pipes. **Furniture** like benches, waste bins, bicycle support frames and bollards, able to be lowered, taken out or fixed, flagpoles and works of art all add to the overall effect.



① Main building of Federal Environmental Agency
② Atrium
③ Forum
④ Canteen
⑤ Wörlitz station
⑥ Rainwater pond → ❻
⑦ Art
⑧ Dead wood wall → ❺
⑨ Waterbound path → ❷
⑩ Mosaic paving → ❶
⑪ Fire brigade perimeter road
⑫ Car park
⑬ Broken stone surface
⑭ Bicycle stands
⑮ Turning point for deliveries
⑯ Lecture theatre

❼ External works at the FEA, Dessau