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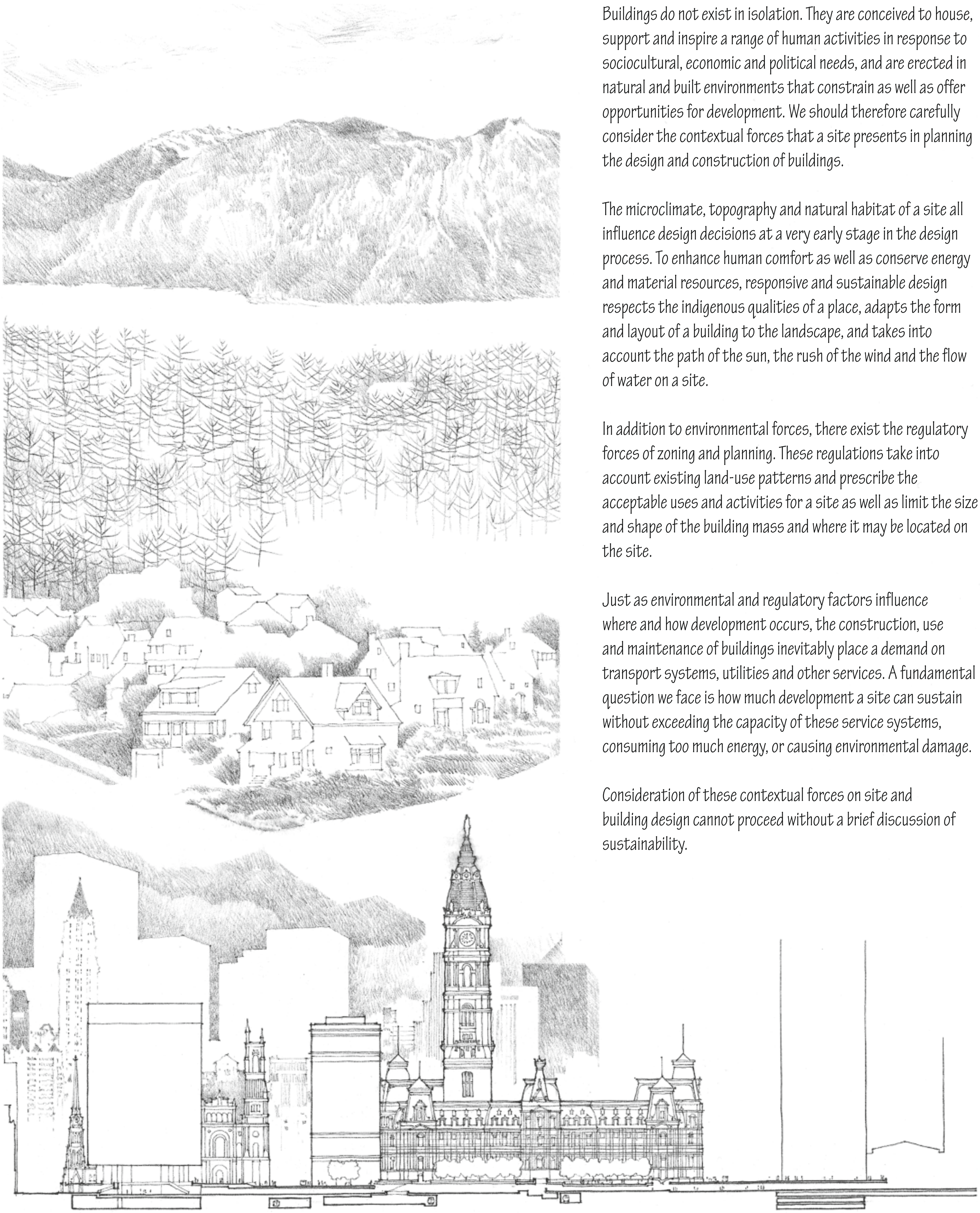
THE BUILDING SITE



Buildings do not exist in isolation. They are conceived to house, support and inspire a range of human activities in response to sociocultural, economic and political needs, and are erected in natural and built environments that constrain as well as offer opportunities for development. We should therefore carefully consider the contextual forces that a site presents in planning the design and construction of buildings.

The microclimate, topography and natural habitat of a site all influence design decisions at a very early stage in the design process. To enhance human comfort as well as conserve energy and material resources, responsive and sustainable design respects the indigenous qualities of a place, adapts the form and layout of a building to the landscape, and takes into account the path of the sun, the rush of the wind and the flow of water on a site.

In addition to environmental forces, there exist the regulatory forces of zoning and planning. These regulations take into account existing land-use patterns and prescribe the acceptable uses and activities for a site as well as limit the size and shape of the building mass and where it may be located on the site.

Just as environmental and regulatory factors influence where and how development occurs, the construction, use and maintenance of buildings inevitably place a demand on transport systems, utilities and other services. A fundamental question we face is how much development a site can sustain without exceeding the capacity of these service systems, consuming too much energy, or causing environmental damage.

Consideration of these contextual forces on site and building design cannot proceed without a brief discussion of sustainability.

In 1987, the United Nations World Commission on Environment and Development, chaired by Gro Harlem Brundtland, former Prime Minister of Norway, issued a report, *Our Common Future*. Among its findings, the report defined sustainable development as 'a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Increasing awareness of the environmental challenges presented by climate change and resource depletion has driven sustainability into becoming a significant issue shaping how the building design industry operates. Sustainability is necessarily broad in scope, affecting how we manage resources as well as build communities and the issue calls for a holistic approach that considers the social, economic and environmental impacts of development and requires the full participation of planners, architects, engineers, surveyors, developers, building owners, contractors and manufacturers, as well as governmental and non-governmental agencies.

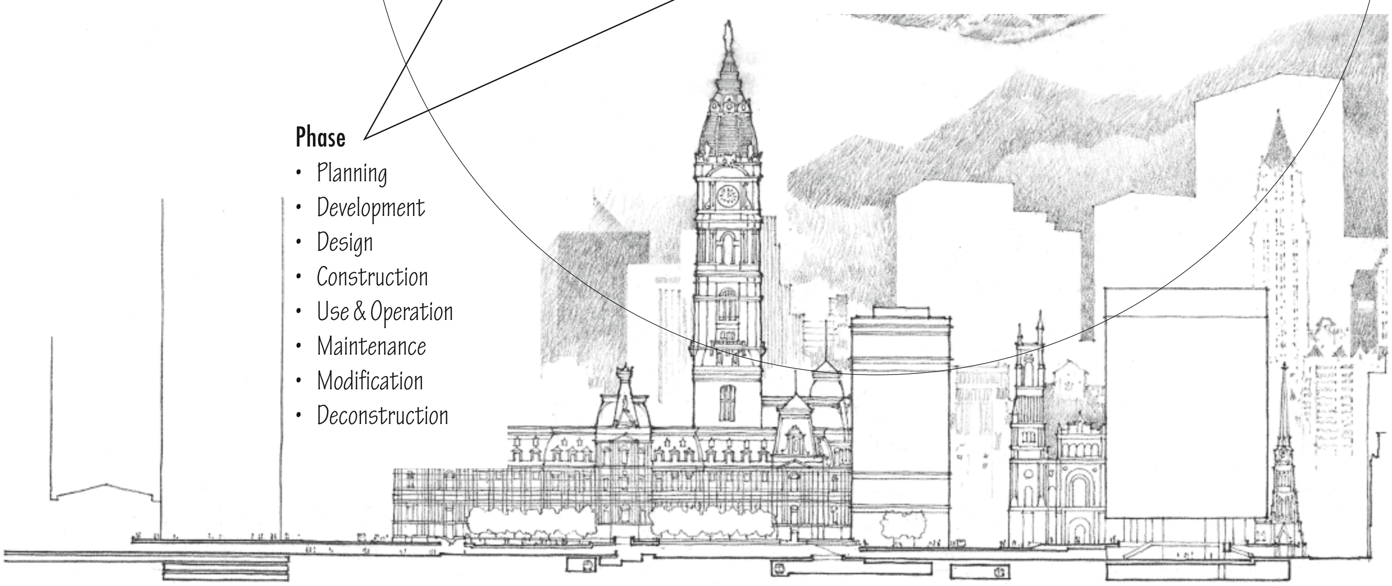
In seeking to minimise the negative environmental impact of development, sustainability emphasises efficiency and moderation in the use of materials, energy and spatial resources. Building in a sustainable manner requires paying attention to the predictable and comprehensive outcomes of decisions, actions and events throughout the life cycle of a building, from conception to the siting, design, construction, use, maintenance, deconstruction and reuse of new buildings as well as the refurbishment process for existing buildings and the reshaping of communities and cities.

Principles
- Reduce resource consumption
- Reuse resources
- Recycle resources for reuse
- Protect nature
- Eliminate toxins
- Apply life-cycle costing
- Focus on quality

Framework for Sustainable Development
In 1994 Task Group 16 of the International Council for Research and Innovation in Building and Construction proposed a three-dimensional framework for sustainable development.

Resources
- Land
- Materials
- Water
- Energy
- Ecosystems

Phase
- Planning
- Development
- Design
- Construction
- Use & Operation
- Maintenance
- Modification
- Deconstruction



1.04 GREEN BUILDING

The terms 'green building' and 'sustainable design' are often used interchangeably to describe any building designed in an environmentally sensitive manner. However, sustainability calls for a whole-systems approach to development that encompasses the notion of green building but also addresses broader social, ethical and economic issues, as well as the community context of buildings. As an essential component of sustainability, green building seeks to provide healthy environments in a resource-efficient manner using ecologically based principles.

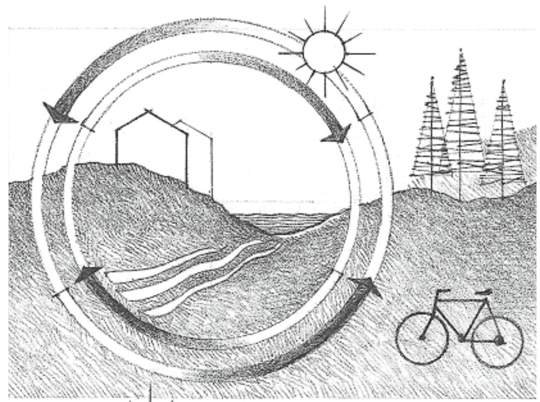
To help drive the green building agenda, the 'sustainability' of buildings is increasingly measured against standards set out within recognised environmental assessment methods. These assessment methods gauge the building's overall performance against a set of measurable criteria. Some such assessment methods or standards focus on specific aspects of sustainability such as environmental impact or energy performance, while others attempt to provide a holistic assessment of the core sustainability issues. The Building Research Establishment Environmental Assessment Method (BREEAM) is one of the longest established and most widely recognised assessment methods in the world. A wide range of similar assessment methods exist within Europe, the European Union's Committee for Standardization is working towards a set of standardised assessment methods for the region building on the European Energy Performance of Buildings Directive (EPBD). The EPBD ensures that the energy use of all domestic and non-domestic buildings within the European Union is assessed when a new building is constructed or an existing building is sold or let, thus allowing for direct comparison of the energy performance between one building and the next.

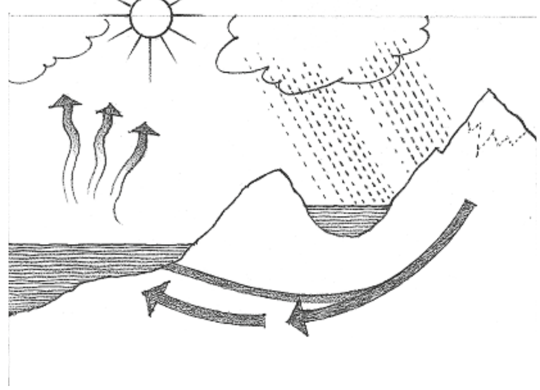
In the UK the Standard Assessment Procedure (SAP) and Simplified Building Energy Model (SBEM) are used to assess the energy performance of domestic and simple non-domestic building respectively producing Energy Performance Certificates (EPC). In accordance with the requirements of the EPBD, public buildings over 1000 m^2 must have a Display Energy Certificate (DEC), which as such is a reflection on the actual energy usage of the building. This is useful as occupant behaviour and building management which are difficult to predict can have a significant impact upon the energy use of a building.

BREEAM®: Building Research Establishment Environmental Assessment Method, first established by the Building Research Establishment (BRE) in 1990, used globally for a range of largely non-domestic buildings.

LEED®: Leadership in Energy and Environmental Design, developed by the US Green Building Council (USGBC), used globally on a wide range of new-build and refurbishment projects.

Both LEED and BREEAM attempt to assess sustainability in broad terms. They consider a wide range of potential environmental impacts associated with the life cycle of the building including materials and embodied energy, building management and waste reduction. Both methods set out a number of criteria for which credits are available. As the project progresses evidence must be gathered to demonstrate how the building complies with the criteria associated with the credits awarded. See 1.05 & 1.06.





First applied in Germany in the early 1990s, the Passive House Standard aims to achieve low energy, comfortable buildings by focusing on the delivery of a high quality, well designed building fabric and appropriate and correctly configured building systems.

This focus on the performance of the building fabric based on a sound understanding of building physics aims to deliver healthy and comfortable internal environments requiring minimum amounts of heating and/or cooling to maintain this comfort. Depending on where the building is to be located some considerations in relation to resources, climatic conditions and building regulation compliance may need to be accounted for.

The application of Passive House principles has helped to improve European construction standards. This is especially true where they have been applied in regions with milder climates where such high levels of thermal performance have not previously been considered. Care must be taken, however, to ensure that in such well insulated buildings overheating does not become an issue. The Passive House Standard does take account of this overheating risk, but some projects may apply Passive House principles without applying the full standard. See 1.08 & 1.09.

BREEAM

The BRE and relevant regional partners have developed a range of assessment methodologies covering a broad spectrum of building and project types in many locations, allowing most non-domestic building to be assessed (domestic buildings are assessed using the Code for Sustainable Homes (CfSH)):

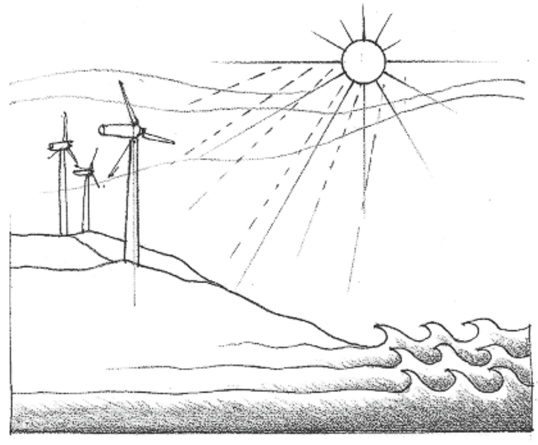
- BREEAM New Construction*
  - Shell and Core
  - Fit-Out
  - Major Refurbishment
- BREEAM Data Centres
- BREEAM Bespoke
- BREEAM Communities
- BREEAM In-Use
- BREEAM NL (The Netherlands)
- BREEAM NOR (Norway)
- BREEAM ES (Spain)
- BREEAM SE (Sweden)
- BREEAM International

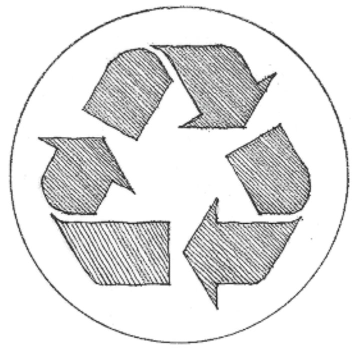
*BREEAM New Construction addresses nine major areas:

1. Management
2. Health & Wellbeing
3. Energy
4. Transport
5. Water
6. Materials
7. Waste
8. Land Use & Ecology
9. Pollution

To try and challenge the industry to deliver innovative solutions, additional credit can also be awarded for 'innovation', allowing for bespoke solutions to unique or challenging problems.

Under the BREEAM rating system each rating has a number of minimum standards that must be met regardless of the overall percentage score in order for a rating to be achieved. For example, in order to gain an 'outstanding' rating, a minimum of 10 credits must be achieved under the section considering the reduction of CO_2 emissions (ENE 01).





Each of the nine areas addressed under BREEAM receives an environmental weighting relative to its importance in delivering a sustainable building. The weighting coupled with the number of credits available for each of the criteria dictates the relative importance or impact of the criteria.

*BREEAM Environmental Weightings:

Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.5%
Waste	7.5%
Land Use & Ecology	10%
Pollution	10%

*Possible BREEAM Ratings:

Unclassified	<30%
Pass	30–44%
Good	45–54%
Very Good	55–69%
Excellent	70–84%
Outstanding	85%+

*Source: www.breeam.org

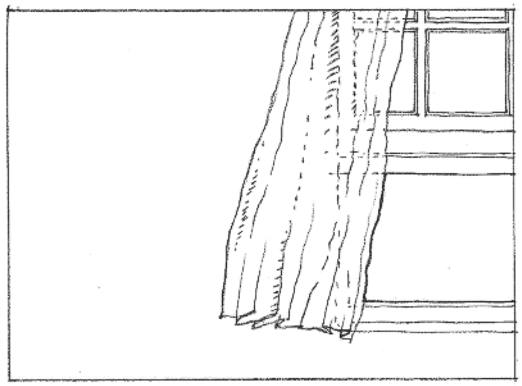
BREEAM® is the registered trademark of the Building Research Establishment Limited

LEED

To aid designers, builders and owners to achieve LEED certification for specific building types and phase of a building life cycle, the US Green Building Council (USGBC) has developed a number of versions of the LEED rating system:

- LEED New Construction and Major Renovations
- LEED Existing Buildings: Operations & Maintenance
- LEED Commercial Interiors
- LEED Core & Shell
- LEED Schools
- LEED Retail
- LEED Healthcare
- LEED Homes
- LEED Neighbourhood Development

The LEED rating system for new construction addresses seven major areas of development.



1. **Sustainable Sites**
   Deals with reducing the pollution associated with construction activity, selecting sites appropriate for development, protecting environmentally sensitive areas and restoring damaged habitats, encouraging alternative modes of transport to reduce the impact of vehicle use, respecting the natural hydrology of a site, and reducing the effects of heat islands.

2. **Water Efficiency**
   Promotes reducing the demand for potable water and the generation of wastewater by using water-conserving fixtures, capturing rainwater or recycled greywater for conveying sewage, and treating wastewater with on-site systems.

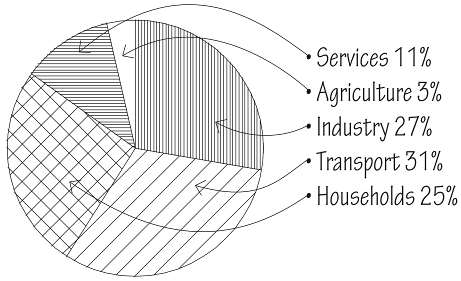
3. **Energy & Atmosphere**
   Encourages increasing the efficiency with which buildings and their sites acquire and use energy, increasing renewable, non-polluting energy sources to reduce the environmental and economic impacts associated with fossil fuel energy use, and minimising the emissions that contribute to ozone depletion and global warming.

4. **Materials & Resources**
   Seeks to maximise the use of locally available, rapidly renewable and recycled materials, reduce waste and the demand for virgin materials, retain cultural resources, and minimise the environmental impacts of new buildings.

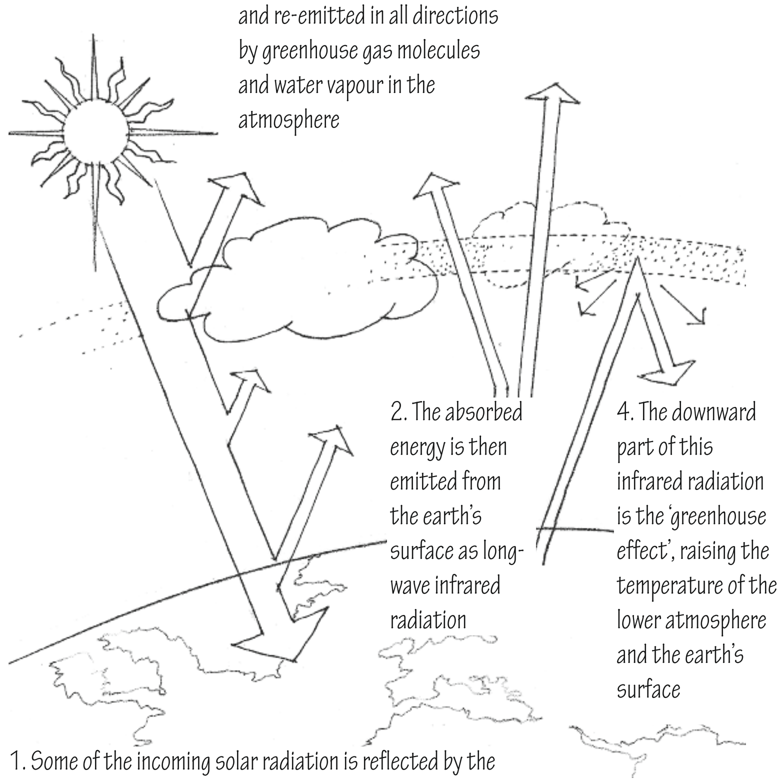
5. **Indoor Environmental Quality**
   Promotes the enhanced comfort, productivity and wellbeing of building occupants by improving indoor air quality, maximising daylighting of interior spaces, enabling user control of lighting and thermal comfort systems to suit task needs and preferences, and minimising the exposure of building occupants to potentially hazardous particulates and chemical pollutants, such as the volatile organic compounds (VOC) contained in adhesives and coatings and the urea-formaldehyde resins in composite wood products.

6. **Innovation & Design Process**
   Rewards exceeding the requirements set by the LEED Green Building Rating System and/or demonstrating innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System.

7. **Regional Priority**
   Provides incentives for practices that address geographically specific environmental priorities.



EU–27 Energy Consumption by Sector
European Environment Agency (2012)



Climate Change & Global Warming

Greenhouse gases, such as carbon dioxide, methane and nitrous oxide, are emissions that rise into the atmosphere. CO_2 accounts for the largest share of EU greenhouse gas emissions. Fossil fuel combustion is the main source of CO_2 emissions.

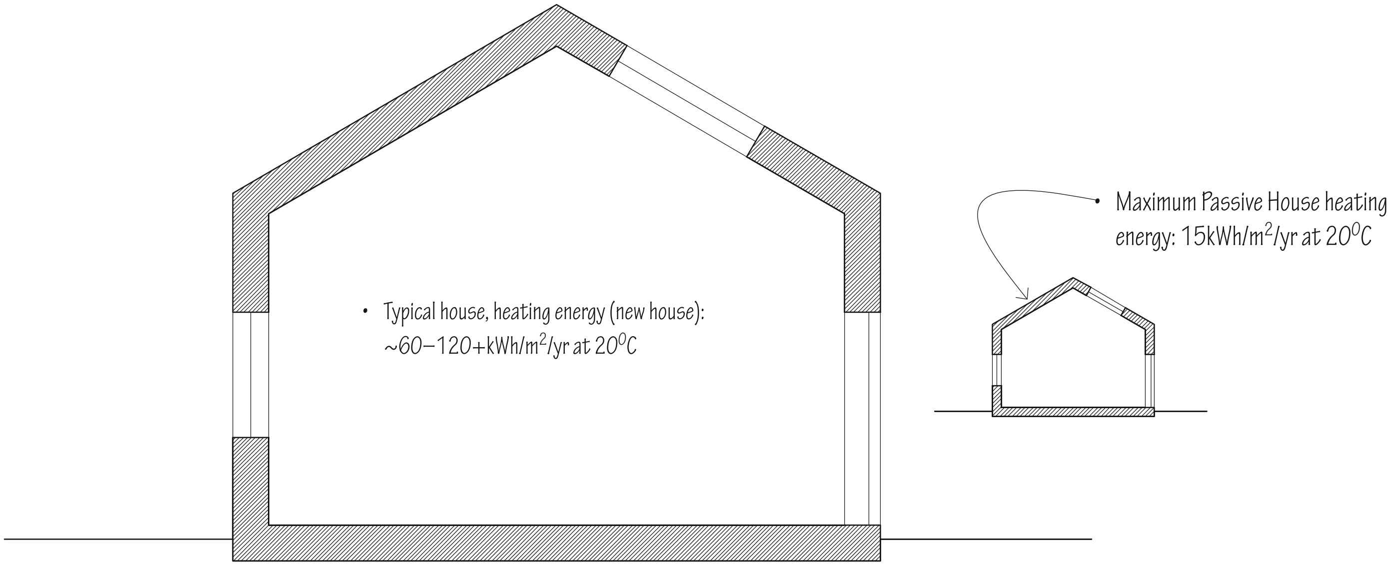
The EU has a number of strategies and targets in place with the overall aim of significantly reducing carbon emissions. As the construction and operation of our buildings is responsible for a large proportion of overall carbon emissions, the industry has the potential to contribute significantly to overall reductions. The EU 20-20-20 target calls for greenhouse gas (GHG) emissions to be reduced by 20% (over a 1990 baseline), for 20% of energy consumption to come from renewable sources and for a 20% reduction in primary energy use from efficiency measures, all by 2020.

What is relevant to any discussion of sustainable design is that most of the building sector's energy consumption is not attributable to the production of materials or the process of construction, but rather to operational processes – the heating, cooling and lighting of buildings. This means that to reduce the energy consumption and GHG emissions generated by the use and maintenance of buildings over their lifespan, it is necessary to properly design, site and shape buildings and incorporate natural heating, cooling, ventilation and daylighting strategies.

There are two approaches to reducing a building's consumption of GHG-emitting fossil fuels. The passive approach is to work with the climate in designing, siting and orienting a building and to employ passive cooling and heating techniques to reduce its overall energy requirements. The active approach is to increase the ability of a building to capture or generate its own energy from renewable or other efficient sources (solar, wind, geothermal, hydro and biomass/biogas) that are available locally and in abundance. While striking an appropriate, cost-effective balance between energy conservation and generating renewable energy is the goal, minimising energy use is a necessary first step, irrespective of the fact that the energy may come from renewable resources.

The energy hierarchy, building upon the above idea, suggests that the need for energy should first be reduced through passive measures, the remaining energy demand should be met with the most appropriate and efficient building services available (including heat recovery), and that the remaining demand should be met using low or zero carbon technologies.

1.08 THE PASSIVE HOUSE STANDARD



Passive House

Developed by Professor Wolfgang Feist and Professor Bo Adamson, the Passive House Standard aims to significantly reduce the space heating (and cooling) load of domestic and non-domestic buildings while delivering high levels of comfort and internal air quality.

This is achieved through a combination of high levels of insulation, minimal or no thermal bridges and high levels of airtightness while carefully managing heat gains to avoid overheating. To attain this, a keen understanding of building physics is required. The Passive House Planning Package (PHPP) provides designers with a tool to assist them in achieving the standard.

Considerations

Careful consideration needs to be given to glazing configuration at the design stage in order to ensure the benefits of useful heat gain and daylight from glazing are balanced against potential heat loss which will lead to an increased heating load.

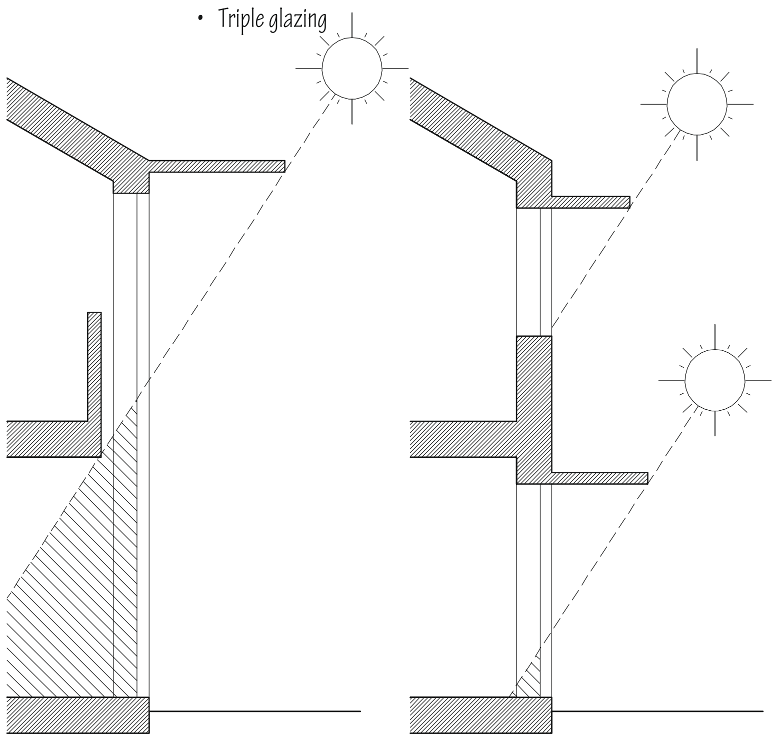
The principles underpinning the Passive House approach are based on building physics and can help to improve the overall quality of the buildings delivered.

The EnerPHit Standard has been developed to address the specific challenges presented by the refurbishment of existing buildings.

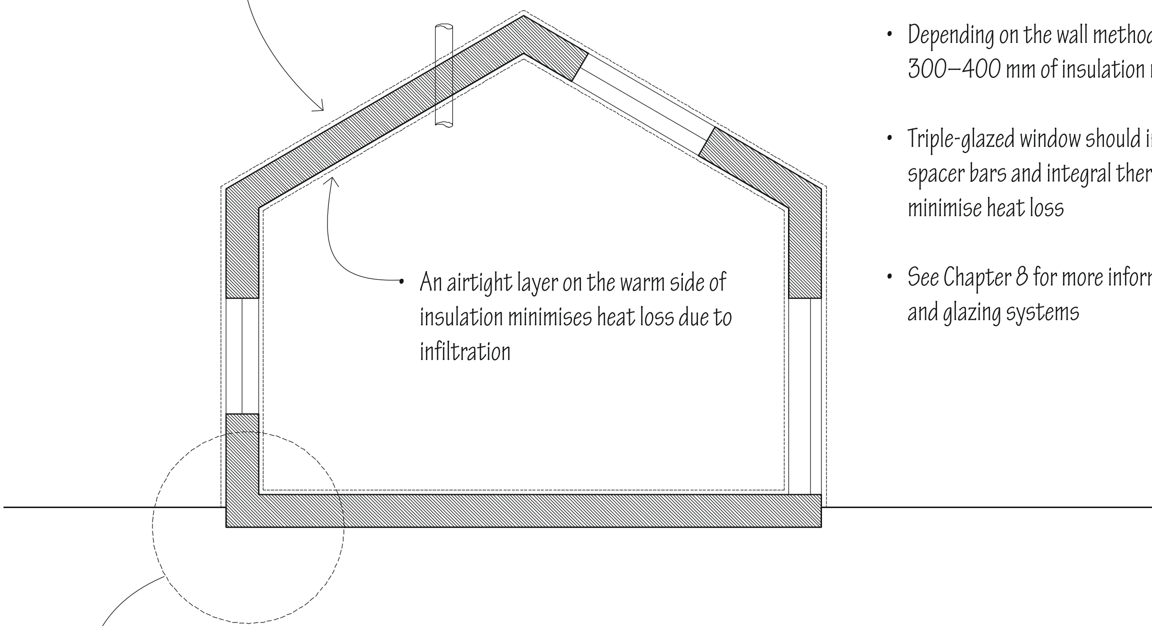
See: www.passiv.de

Achieving the Passive House Standard requires high-quality design and workmanship. Typical features of a Passive House building include:

- Average U-Values of 0.10W/m^{2}K
- Minimum airtightness of 0.6 air changes per hour (ach) @ 50pa pressure difference
- High efficiency mechanical ventilation with heat recovery (MVHR) system
- Triple glazing

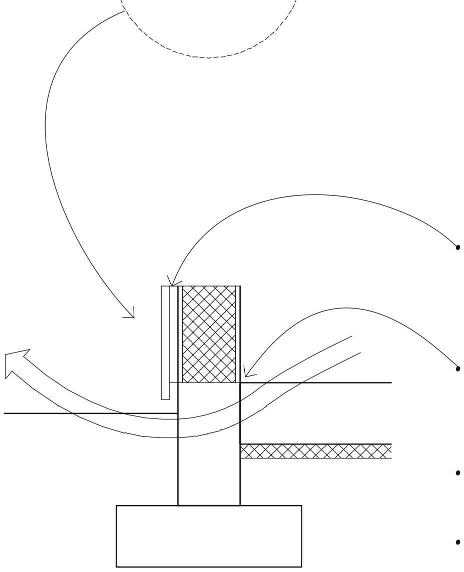


- A wind-tight layer is required to ensure that insulation does not lose heat through air circulation



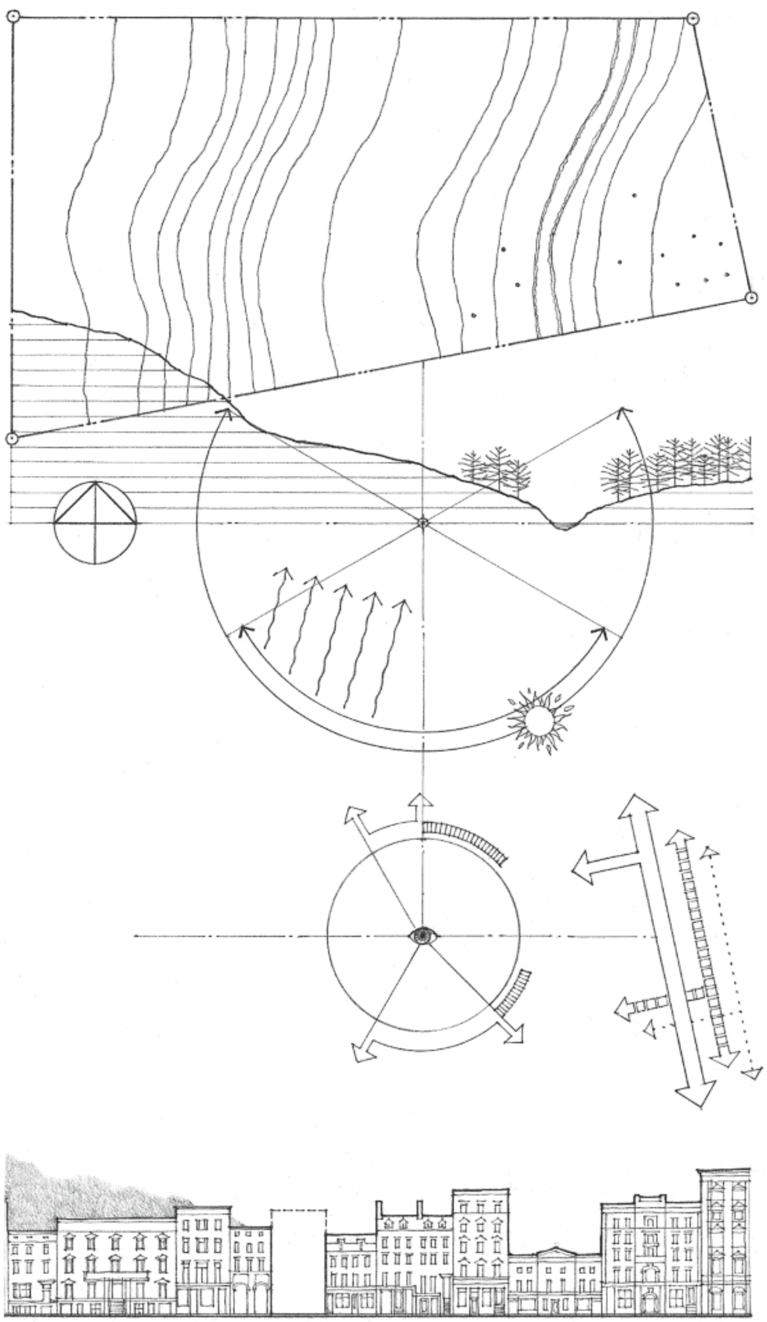
- An airtight layer on the warm side of insulation minimises heat loss due to infiltration

- Detailing around penetrations through the building fabric (building services, doors, windows etc) needs to be carefully designed
- Depending on the wall method used 300–400 mm of insulation may be necessary
- Triple-glazed window should include warm edge spacer bars and integral thermal breaks to minimise heat loss
- See Chapter 8 for more information on windows and glazing systems

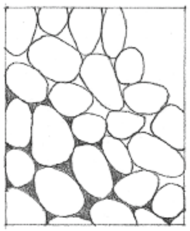


- Any fixings or penetrations required through the wind-tight, airtight and insulation layers need to be carefully considered to avoid compromising the performance of the building fabric
- Gaps in the continuity of thermal insulation lead to cold bridges which increases heat loss and can also result in mould growth
- See 7.36 for more information on cold bridging
- See 7.43 for information on how to achieve good levels of airtightness
- The Passive House Institute (PHI) provides and oversees a quality assurance mechanism for the certification of Passive House buildings

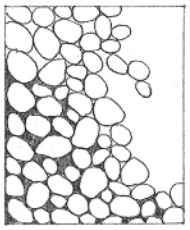
Site analysis is the process of studying the contextual forces that influence how we might situate a building, lay out and orient its spaces, shape and articulate its enclosure and establish its relationship to the landscape. Any site survey begins with the gathering of physical site data.



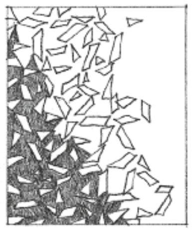
- Draw the area and shape of the site as defined by its legal boundaries
- Indicate required setbacks and rights-of-way
- Estimate the area and volume required for the building programme, site amenities and future expansion, if desired
- Analyse the ground slopes and subsoil conditions to locate the areas suitable for construction and outdoor activities
- Identify steep and moderate slopes that may be unsuitable for development
- Locate soil areas suitable for use as a drainage field, if applicable
- Map existing drainage patterns (LEED SS Credit 6.1, 6.2: Stormwater Design)
- Determine the elevation of the water table
- Identify areas subject to excessive run-off of surface water, flooding or erosion (BREEAM POL 03: Surface Water Run-Off)
- Locate existing trees and native plant materials that should be preserved and map out the corresponding root protection areas (BREEAM LE 02: Ecological Value of Site and Protection of Ecological Features)
- Chart existing water features, such as wetlands, streams, watersheds, flood plains or shorelines that should be protected (LEED SS Credit 5.1: Site Development – Protect or Restore Habitat)
- Map climatic conditions: the path of the sun, the direction of prevailing winds and the expected amount of rainfall
- Consider the impact of landforms and adjacent structures on solar access, prevailing winds and the potential for glare
- Evaluate solar radiation as a potential energy source
- Determine possible points of access from public roadways and public transit stops (BREEAM TRA 01: Public Transport Accessibility; LEED SS Credit 4.1: Alternative Transportation – Public Transportation Access)
- Study possible circulation paths for pedestrians and vehicles from these access points to building entrances
- Ascertain the availability of utilities: water mains, foul and surface water sewers, gas lines, electrical power lines, telephone and data lines and fire hydrants
- Determine access to other municipal services, such as police and fire protection
- Identify the scope of desirable views as well as objectionable views
- Cite potential sources of congestion and noise (BREEAM POL 05: Noise Attenuation)
- Evaluate the compatibility of adjacent and proposed land uses
- Map cultural and historical resources that should be preserved
- Consider how the existing scale and character of the neighbourhood or area might affect the building design
- Map the proximity to public, commercial, medical and recreational facilities (BREEAM TRA 02: Proximity to Amenities; LEED SS Credit 2: Development Density & Community Connectivity)



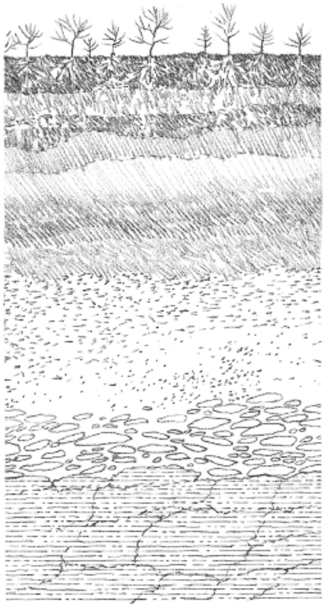
• Gravel

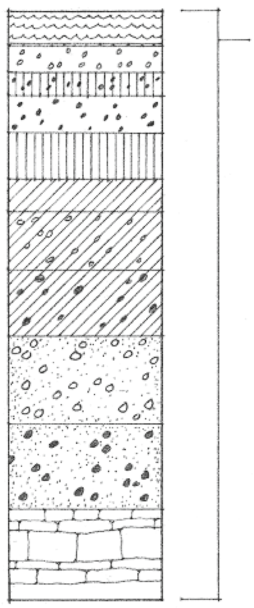


• Sand



• Clay





There are two broad classes of soils – coarse-grained non-cohesive soils and fine-grained cohesive soils. Coarse-grained soils include gravel and sand, which consist of relatively large particles visible to the naked eye; fine-grained soils, such as silt and clay, consist of much smaller particles. EN 1997 Eurocode 7 further divides gravels, sands, silts and clays into soil types based on physical composition and characteristics (see table below). Cohesive soils are more susceptible to heave and compression which has implications for foundation design.

The soil underlying a building site may actually consist of superimposed layers, each of which contains a mix of soil types, developed by weathering or deposition. To depict this succession of layers or strata called horizons, geotechnical engineers draw a soil profile, a diagram of a vertical section of soil from the ground surface to the underlying material, using information collected from a test pit or boring.

The integrity of a building structure depends ultimately on the stability and strength under loading of the soil or rock underlying the foundation. The stratification, composition and density of the soil bed, variations in particle size, and the presence or absence of groundwater are all critical factors in determining the suitability of a soil as a foundation material. When designing anything other than a single-family dwelling, it is advisable to have a geotechnical engineer undertake a subsurface investigation.

Site exploration through the digging of a trial pit or bore hole can help to determine the suitability of a site or project for a particular foundation system. A trial pit can be used to establish the ground conditions and strata for relatively shallow foundations through visual assessment or physical examination. Bore holes are suited to examine soil make-up and greater depth. In both cases it should be noted that the act of digging/drilling will in itself impact upon the properties of the soil by disturbing the area, compacting soil and potentially reducing local moisture content.

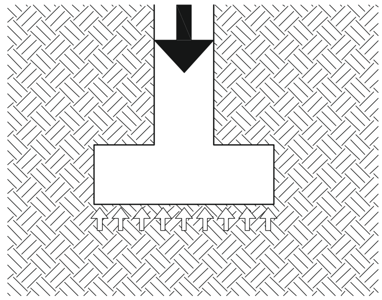
Soil Classification*	Description	Permeability & Drainage
Non-Cohesive		
Gravels	Dense Gravel	Excellent
	Medium-Dense Gravel	Excellent
	Loose Silty Gravel	Poor
Sands	Compact Sand	Excellent
	Medium Dense Sand	Excellent
	Loose Silty Sand	Fair
Cohesive		
Clays	Stiff Clay	Poor
	Firm Clay	Impervious
	Soft Clay	Impervious
Peat & Organic Soils	Organic Clay and Silt	Impervious
Highly Organic Soils	Peat	Poor

Consult a geotechnical engineer and the building regulations for allowable bearing capacities

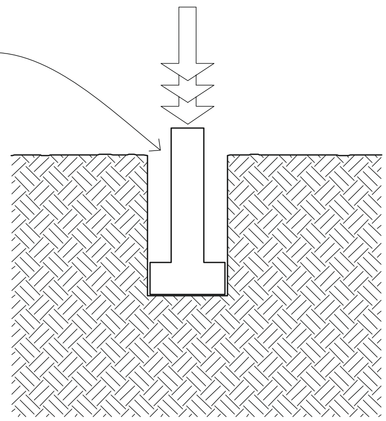
*Based on EN 1997 Eurocode 7

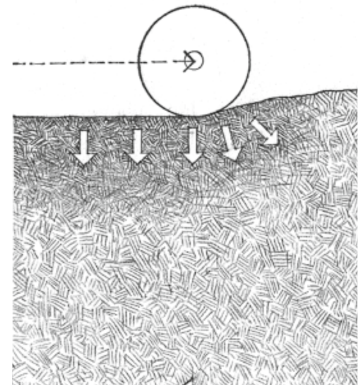
1.12 SOIL MECHANICS

The allowable bearing capacity of a soil is the maximum unit pressure a foundation is permitted to impose vertically or laterally on the soil mass. While high-bearing-capacity soils present few problems, low-bearing-capacity soils may dictate the use of a certain type of foundation and load distribution pattern, and ultimately, the form and layout of a building.



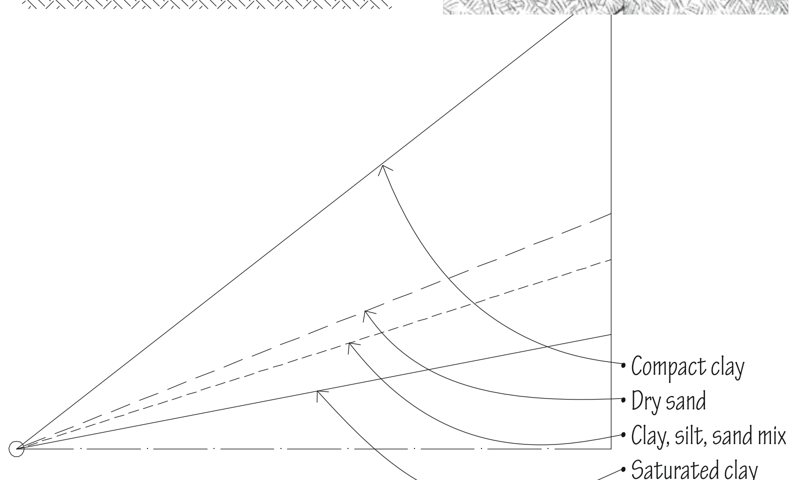
Density is a critical factor in determining the bearing capacity of granular soils. The Standard Penetration Test measures the density of granular soils and the consistency of some clays at the bottom of a bore hole, recording the number of blows required by a hammer to advance a standard soil sampler. In some cases, compaction, by means of rolling, tamping or soaking to achieve optimum moisture content, can increase the density of a soil bed. BS 1377 sets out a number of standardised tests for various soil types.





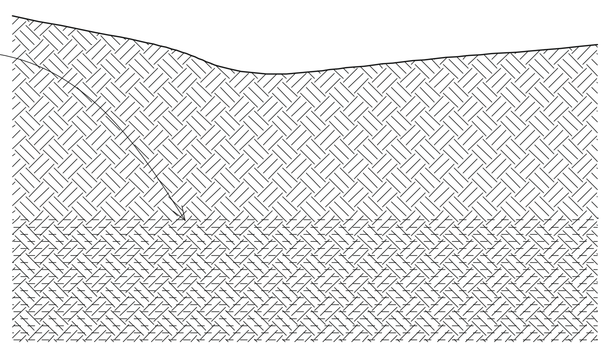
Coarse-grained soils have a relatively low percentage of void spaces and are more stable as a foundation material than silt or clay. Clay soils, in particular, tend to be unstable because they shrink and swell considerably with changes in moisture content. Unstable soils may render a site unbuildable unless an elaborately engineered and expensive foundation system is put in place.

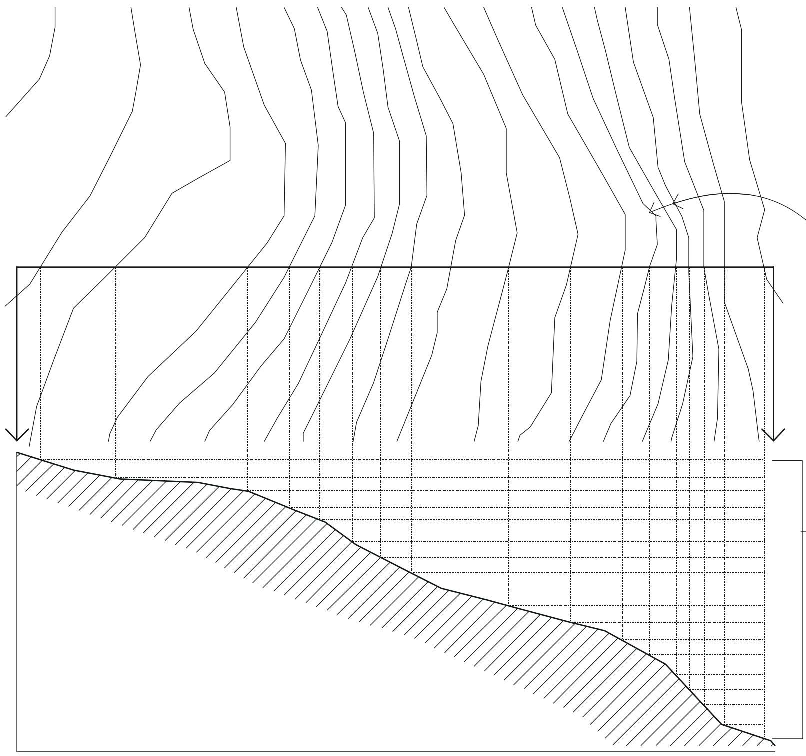
The shearing strength of a soil is a measure of its ability to resist displacement when an external force is applied, due largely to the combined effects of cohesion and internal friction. On sloping sites, as well as during the excavation of a flat site, unconfined soil has the potential to displace laterally. Cohesive soils, such as clay, retain their strength when unconfined; granular soils, such as gravel, sand or some silts, require a confining force for their shear resistance and have a relatively shallow angle of repose.



Angle of Repose for Bare Soil Embankments

The water table is the level beneath which the soil is saturated with groundwater. Some building sites are subject to seasonal fluctuations in the level of groundwater. Any groundwater present must be drained away from a foundation system to avoid reducing the bearing capacity of the soil and to minimise the possibility of water leaking into a basement. Coarse-grained soils are more permeable and drain better than fine-grained soils, and are less susceptible to frost action.

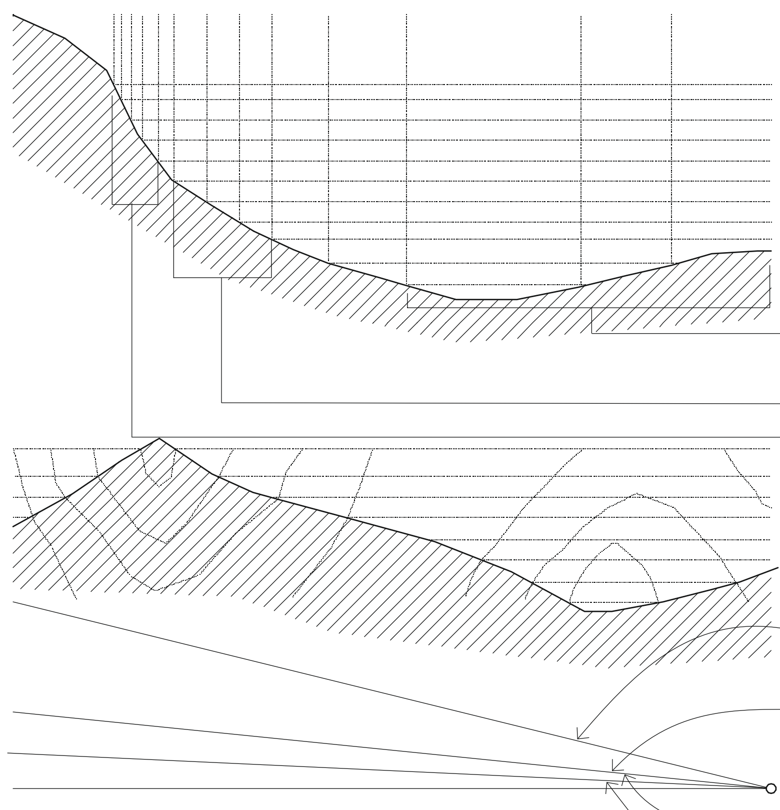




Topography refers to the configuration of surface features of a plot of land, which influences where and how to build and develop a site. To study the response of a building design to the topography of a site, we can use a series of site sections or a site plan with contour lines.

Contour lines are imaginary lines joining points of equal elevation above a datum or benchmark. The trajectory of each contour line indicates the shape of the land formation at that elevation. Note that contour lines are always continuous and never cross one another; they coincide in a plan view only when they cut across a vertical surface.

Contour interval refers to the difference in elevation represented by any two adjacent contour lines on a topographic map or site plan. The interval used is determined by the scale of a drawing, the size of the site and the nature of the topography. The larger the area and the steeper the slopes, the greater the interval between contours. For large or steeply sloping sites, 5 or 10 m contour intervals may be used. For small sites having relatively gradual slopes, 0.5 or 1.0 m contours may be necessary.



We can discern the topographical nature of a site by reading the horizontal spacing and shape of contour lines.

- Contours spaced far apart indicate a relatively flat or gently sloping surface
- Equally spaced contours denote a constant slope
- Closely spaced contours disclose a relatively steep rise in elevation
- Contour lines represent a ridge when pointing toward lower elevations; they represent a valley when pointing toward higher elevations

- Ground slopes over 25% are subject to erosion and are difficult to build on
- Ground slopes over 10% are challenging to use for outdoor activities and are more expensive to build on
- Ground slopes from 5% to 10% are suitable for informal outdoor activities and can be built on without too much difficulty
- Ground slopes up to 5% are usable for most outdoor activities and relatively easy to build on

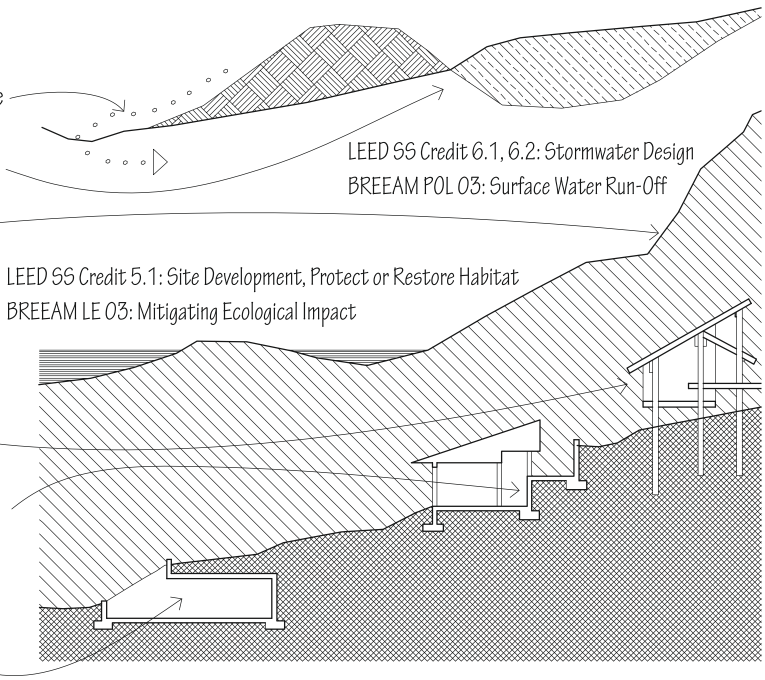
- Slope (%) = [elevation gain (v)/horizontal distance (h)] x 100

The ground slope between any two contour lines is a function of the total change in elevation and the horizontal distance between the two contours.

1.14 TOPOGRAPHY

For aesthetic and economic, as well as ecological reasons, the general intent in developing a site should be to minimise the disturbance of existing landforms and features while taking advantage of natural ground slopes and the microclimate of the site.

- Site development and construction should minimise disrupting the natural drainage patterns of the site and adjacent properties
- When modifying landforms, include provisions for the drainage of surface water and groundwater
- Attempt to equalise the amount of cut and fill required for construction of a foundation and site development
- Avoid building on steep slopes subject to erosion or slides
- Wildlife habitats may require protection and limit the buildable area of a site
- Pay particular attention to building restrictions on sites located in or near a flood plain



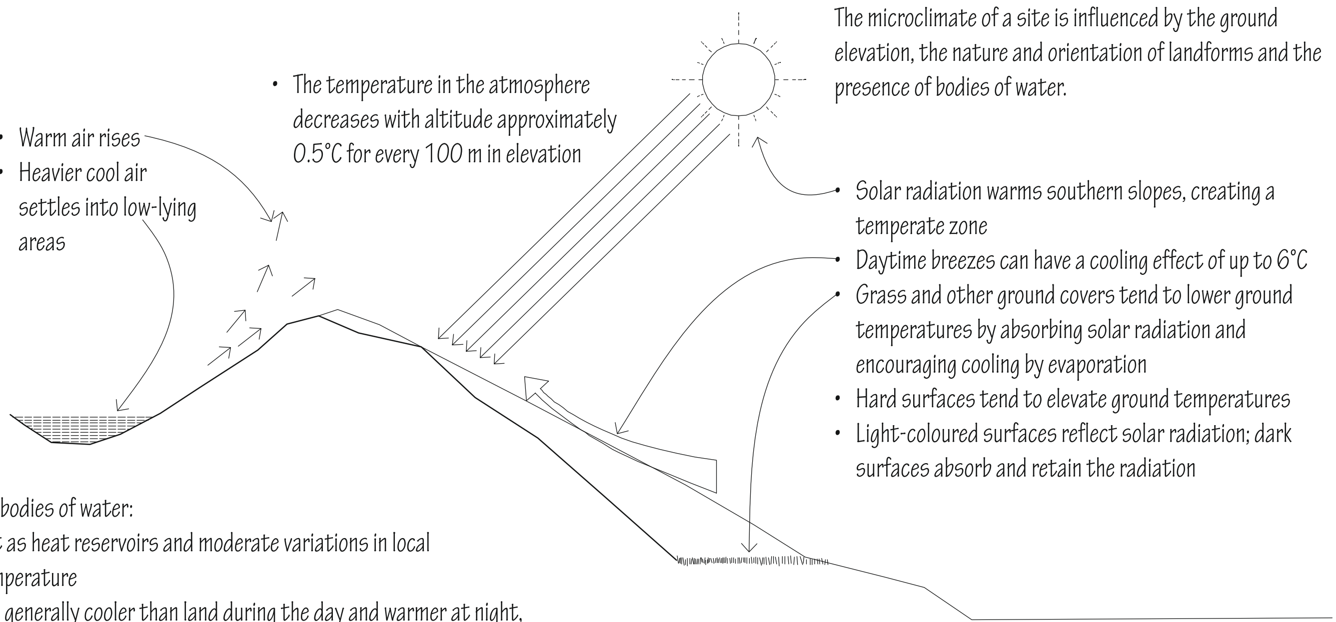
- Elevating a structure on poles or piers minimises disturbance of the natural terrain and existing vegetation
- Terracing or stepping a structure along a slope requires excavation and the use of retaining walls or bench terracing
- Cutting a structure into a slope or locating it partially underground moderates temperature extremes and minimises exposure to wind, and heat loss in cold climates

The microclimate of a site is influenced by the ground elevation, the nature and orientation of landforms and the presence of bodies of water.

- Warm air rises
- Heavier cool air settles into low-lying areas

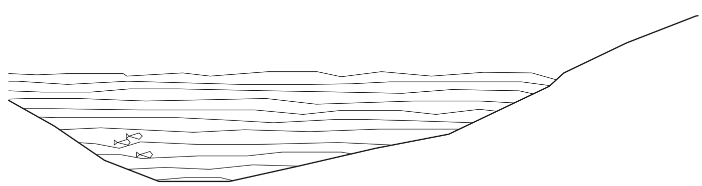
- The temperature in the atmosphere decreases with altitude approximately 0.5°C for every 100 m in elevation

- Solar radiation warms southern slopes, creating a temperate zone
- Daytime breezes can have a cooling effect of up to 6°C
- Grass and other ground covers tend to lower ground temperatures by absorbing solar radiation and encouraging cooling by evaporation
- Hard surfaces tend to elevate ground temperatures
- Light-coloured surfaces reflect solar radiation; dark surfaces absorb and retain the radiation



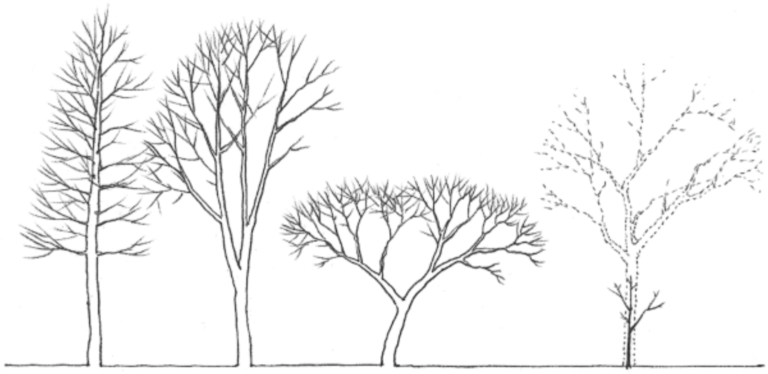
Large bodies of water:

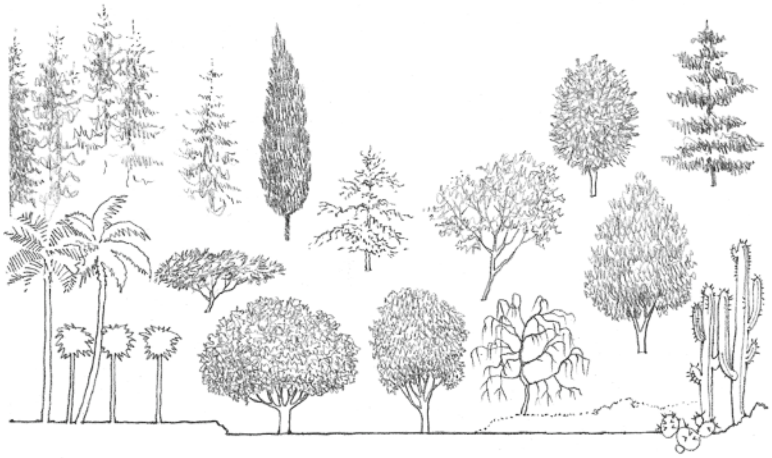
- Act as heat reservoirs and moderate variations in local temperature
- Are generally cooler than land during the day and warmer at night, generating offshore breezes
- Are generally warmer than land in winter and cooler in summer
- In hot-dry climates, even small bodies of water are desirable, both psychologically and physically, for their evaporative cooling effect



Plant materials provide aesthetic as well as functional benefits in conserving energy, framing or screening views, moderating noise, retarding erosion and visually connecting a building to its site. Factors to consider in the selection and use of plant materials in landscaping include the:

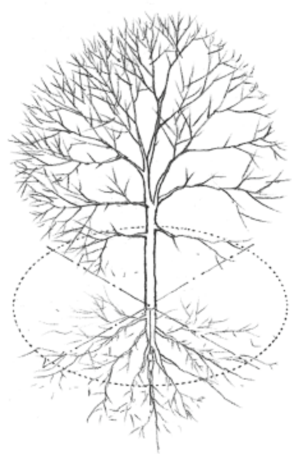
- Tree structure and shape
- Seasonal density, texture and colour of foliage
- Speed or rate of growth
- Mature height and spread of foliage
- Requirements for soil, water, sunlight and temperature range
- Depth and extent of the root structure





- Trees and other plant life adapt their forms to the climate

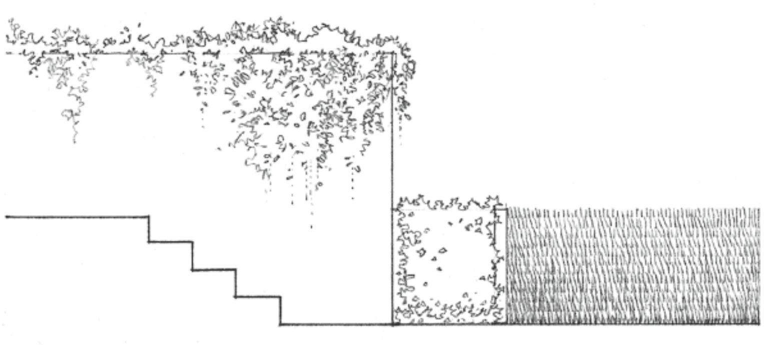
- Existing healthy trees and native plant materials should be preserved whenever possible. During construction and when regrading a site, root protection areas should be calculated to ensure existing tress are not damaged. The root systems of trees planted too close to a building may disturb the foundation system. Root structures can also interfere with underground utility lines
- To support plant life, a soil must be able to absorb moisture, supply the appropriate nutrients, be capable of aeration and be free of concentrated salts



LEED SS Credit 6.1, 6.2: Stormwater Design
LEED SS Credit 7.1: Heat Island Effect – Non-Roof
LEED WE Credit 1.2: Water Efficient Landscaping

BREEAM POL 03: Surface Water Run-Off
BREEAM LE 04: Enhancing Site Ecology

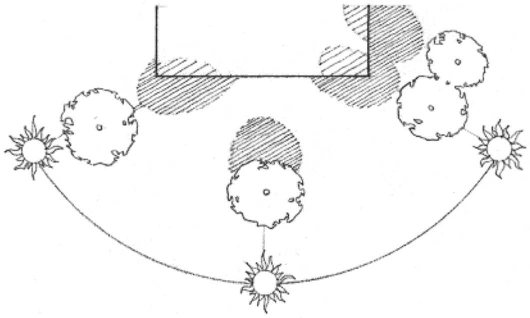
Grass and other ground covers:
- Can reduce air temperature by absorbing solar radiation and encouraging cooling by evaporation
- Aid in stabilising soil embankments and preventing erosion
- Increase the permeability of soil to air and water

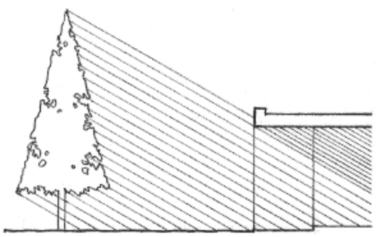


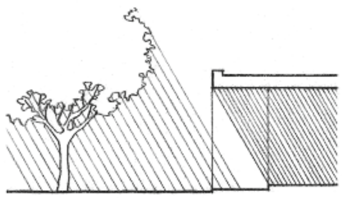
- Vines can reduce the heat transmission through a sunlit wall by providing shade and cooling the immediate environment by evaporation
- Care must be taken when planting near buildings as root systems can interfere with building foundations

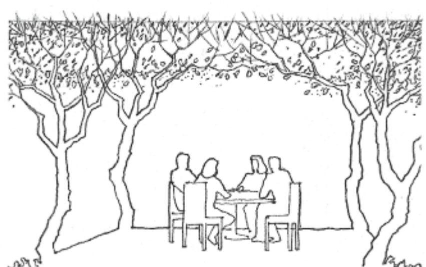
1.16 TREES

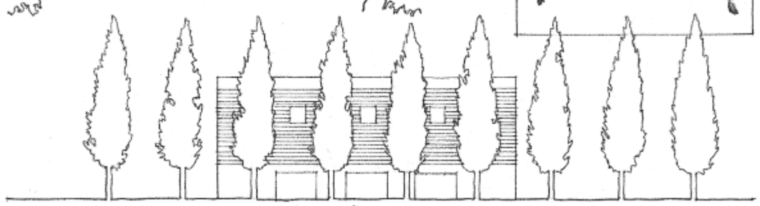
Trees affect the immediate environment of a building in the following ways:











Providing Shade

The amount of solar radiation obstructed or filtered by a tree depends on its:

- Orientation to the sun
- Proximity to a building or outdoor space
- Shape, spread and height
- Density of foliage and branch structure

- Trees shade a building or outdoor space most effectively from the south-east during the morning and the south-west during the late afternoon when the sun has a low altitude and casts long shadows
- South-facing overhangs provide more efficient shading during the midday period when the sun is high and casts short shadows
- Deciduous trees provide shade and glare protection during the summer and allow solar radiation to penetrate through their branch structures during the winter
- Evergreens provide shade throughout the year and help reduce snow glare during the winter

Serving as Windbreak

- Evergreens can form effective windbreaks and reduce heat loss from a building during the winter
- The foliage of plant materials reduces wind-blown dust

Defining Space

- Trees can shape outdoor spaces for activity and movement

Directing or Screening Views

- Trees can frame desirable views
- Trees can screen undesirable views and provide privacy for outdoor spaces

Attenuating Sound

- A combination of deciduous and evergreen trees is most effective in intercepting and attenuating airborne sound, especially when combined with earth mounds

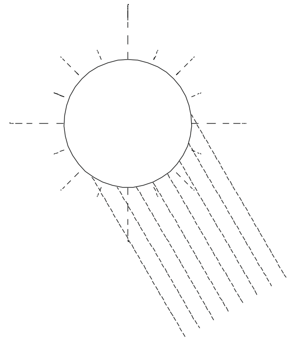
Improving Air Quality

- Trees trap particulate matter on their leaves, which is then washed to the ground during rainfall
- Leaves can also assimilate gaseous and other pollutants
- Photosynthetic process can metabolise fumes and other odours

Stabilising Soil

- The root structures of trees aid in stabilising soil, increasing the permeability of the soil to water and air and preventing erosion

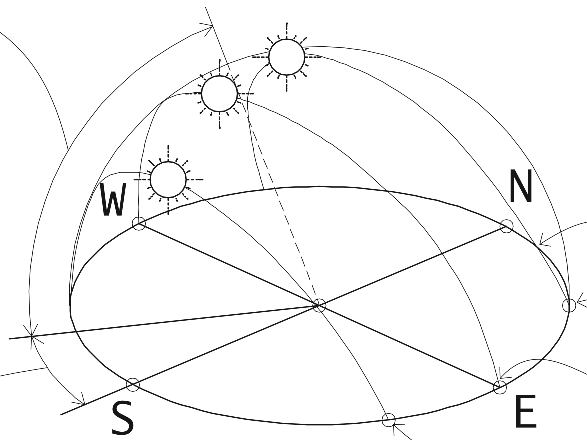
Care must be taken when placing trees near to buildings as root systems can interfere with building foundations.



The location, form and orientation of a building and its spaces should take advantage of the thermal, hygienic and psychological benefits of sunlight. Solar radiation, however, may not always be beneficial, depending on the latitude and climate of the site. In planning the design of a building, the objective should be to maintain a balance between underheated periods when solar radiation is beneficial and overheated periods when radiation should be avoided.

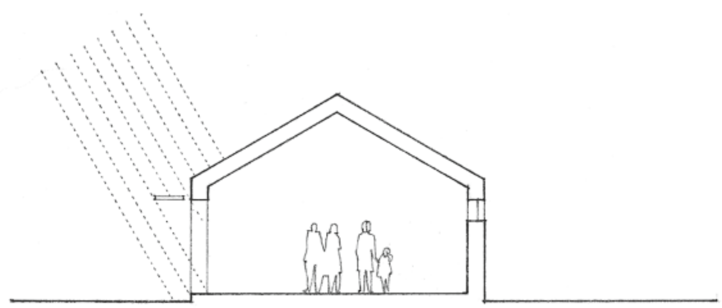
The path of the sun through the sky varies with the seasons and the latitude of a building site. The range of solar angles for a specific site should be obtained from the relevant national meteorological office before calculating the potential solar heat gain and shading requirements for a building design.

- Altitude is the angular elevation of the sun above the horizon



- Horizon
- Summer solstice (21 June)
- Spring equinox (21 March)
- Autumnal equinox (22 September)
- Winter solstice (22 December)
- Azimuth is the angle of horizontal deviation, measured clockwise, of a bearing from a standard south direction

Solar Path Diagram



Representative Solar Angles

North Latitude	Representative City	Altitude at Noon		Azimuth at Sunrise & Sunset	
		22 Dec	21 Mar/22 Sept	22 Dec	21 June
59°	Oslo	6°	30°	40°	143°
53°	Dublin	13°	37°	47°	133°
51°	London	15°	39°	50°	129°
43°	Nice	22°	47°	56°	122°
40°	Madrid	26°	50°	59°	123°

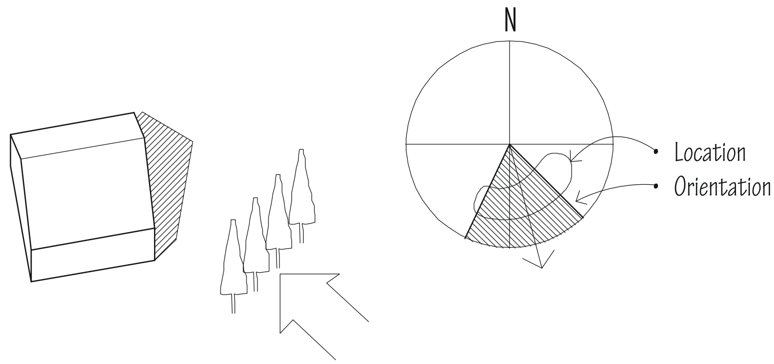
1.18 SOLAR RADIATION

The following are recommended forms and orientations for isolated buildings in different climatic regions. The information presented should be considered along with other contextual and programmatic requirements.

Cool Regions

Minimising the surface area of a building reduces exposure to low temperatures.

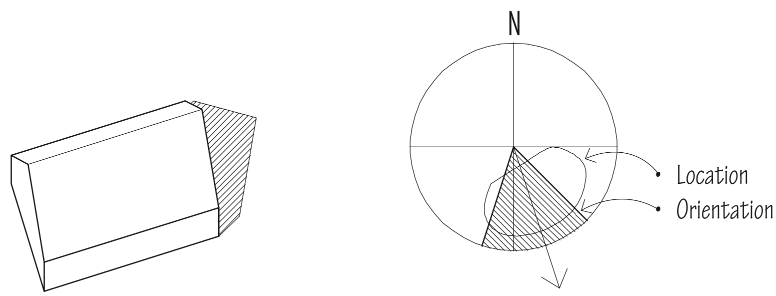
- Maximise absorption of solar radiation
- Reduce radiant, conductive and evaporative heat loss
- Provide wind protection



Temperate Regions

Elongating the form of a building along the east–west axis maximises south-facing walls.

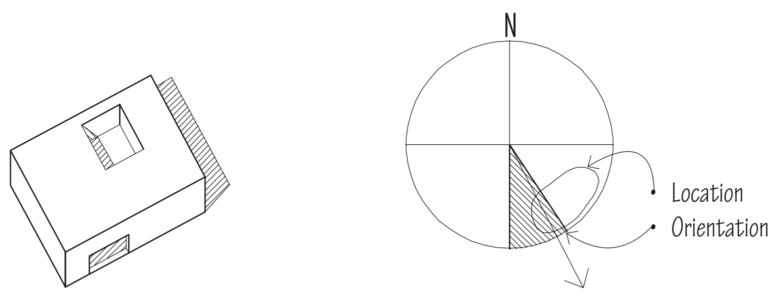
- Minimise east and west exposures, which are generally warmer in summer and cooler in winter than southern exposures
- Balance solar heat gain with shade protection on a seasonal basis
- Encourage air movement in hot weather; protect against wind in cold weather



Hot-Arid Regions

Building forms should enclose courtyard spaces.

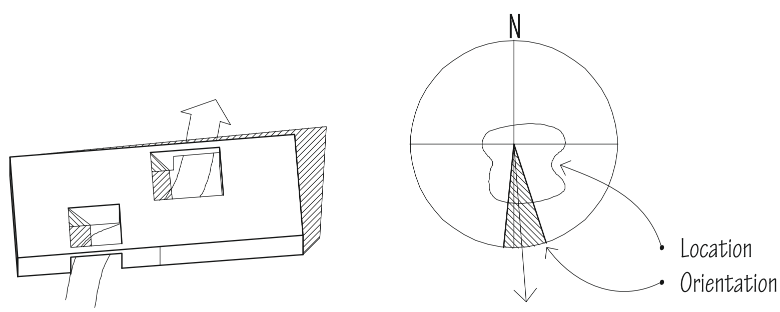
- Reduce solar and conductive heat gain
- Promote cooling by evaporation using water features and planting
- Provide solar shading for windows and outdoor spaces



Hot-Humid Regions

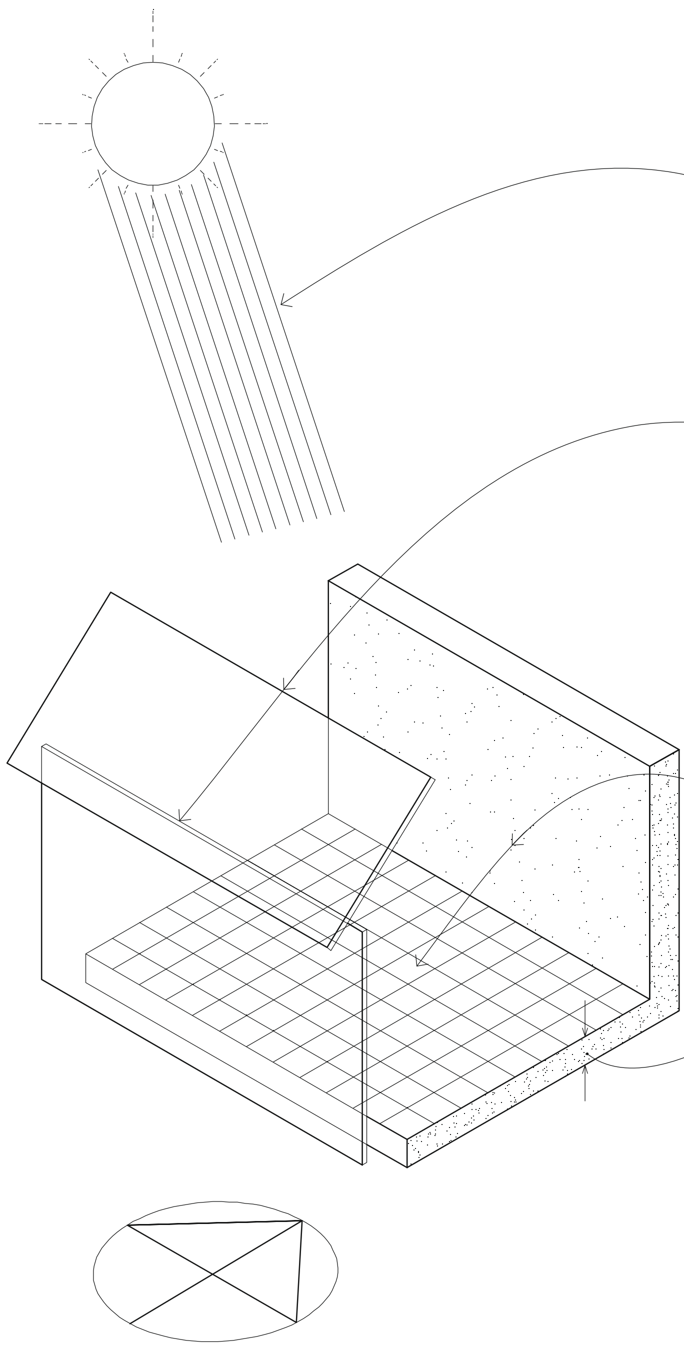
Building form elongated along the east–west axis minimises east and west exposures.

- Reduce solar heat gain
- Utilise wind to promote cooling by evaporation
- Provide solar shading for windows and outdoor spaces



LEED EA Credit 1: Optimize Energy Performance

BREEAM ENE 01: Reduction of CO_2 Emissions



Passive solar heating refers to using solar energy to heat the interior spaces of a building without relying on mechanical devices that require additional energy. Passive solar systems rely instead on the natural heat transfer processes of conduction, convection and radiation for the collection, storage, distribution and control of solar energy.

- The solar constant is the average rate at which radiant energy from the sun is received by the earth, equal to 1353 W/m^2/hr, used in calculating the effects of solar radiation on buildings

There are two essential elements in every passive solar system:

1. South-facing glass or transparent plastic for solar collection
- Area of glazing should be 30–50% of floor area in cold climates and 15–25% of floor area in temperate climates, depending on average outdoor winter temperature and projected heat loss
- Glazing material should be resistant to the degradation caused by the ultraviolet rays of the sun
- Double- or triple-glazing and insulation are required to minimise night-time heat loss

2. Thermal mass for heat collection, storage and distribution, oriented to receive maximum solar exposure
- Thermal storage materials include concrete, brick, stone, tile, rammed earth, sand and water or other liquid. Phase-change materials, such as eutectic salts and paraffins, are also feasible
- Concrete: 305–455 mm
- Brick: 255–355 mm
- Earth: 200–305 mm
- Water: 150 mm or more
- Dark-coloured surfaces absorb more solar radiation than light-coloured surfaces

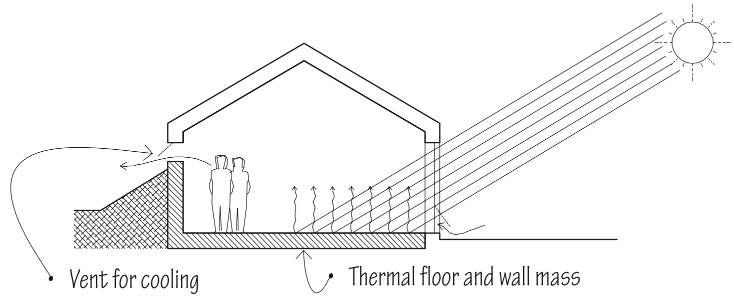
- Vents, dampers, movable insulation panels and shading devices can assist in balancing heat distribution

Based on the relationship between the sun, the interior space and the heat collection system, there are three ways in which passive solar heating can be accomplished: direct gain, indirect gain and isolated gain.

LEED EA Credit 2: On-Site Renewable Energy
LEED EA Credit 6: Green Power
BREEAM ENE 01: Reduction of CO_2 Emissions

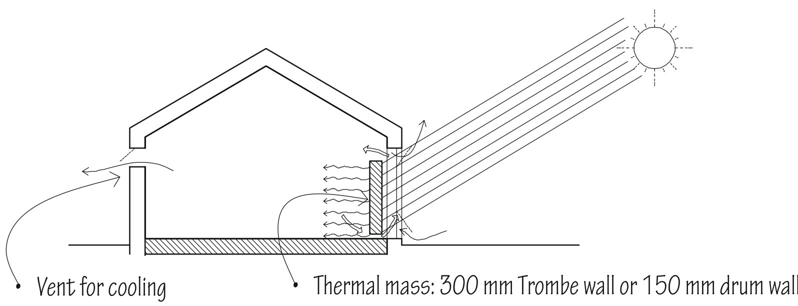
Direct Gain

Direct gain systems collect heat directly within an interior space. The surface area of the storage mass, which is incorporated into the space, should be 50–66% of the total surface area of the space. During the cooling season, operable windows and walls are used for natural or induced ventilation.



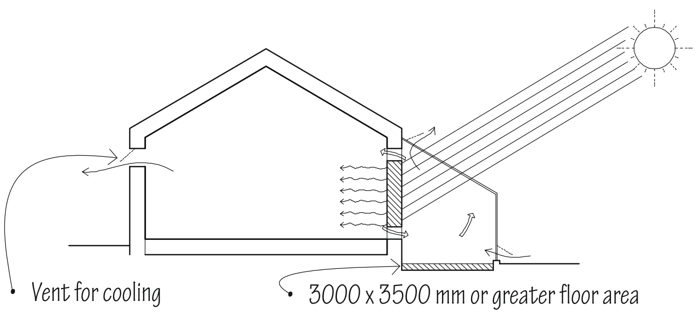
Indirect Gain

Indirect gain systems control heat gain at the exterior skin of a building. The solar radiation first strikes the thermal mass, either a concrete or masonry Trombe wall, or a drum wall of water-filled barrels or tubes, which is located between the sun and the living space. The absorbed solar energy moves through the wall by conduction and then to the space by radiation and convection.



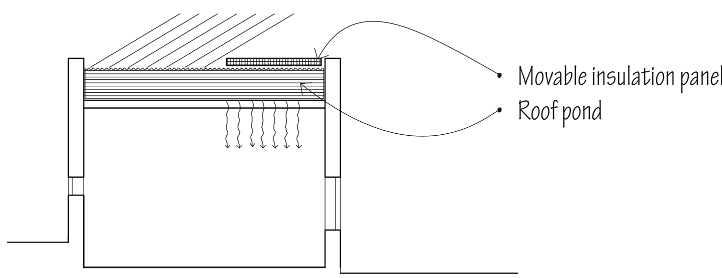
Sunspace

A sun room or solarium is another medium for indirect heat gain. The sunspace, having a floor of high thermal mass, is separated from the main living space by a thermal storage wall from which heat is drawn as needed. For cooling, the sunspace can be vented to the exterior.



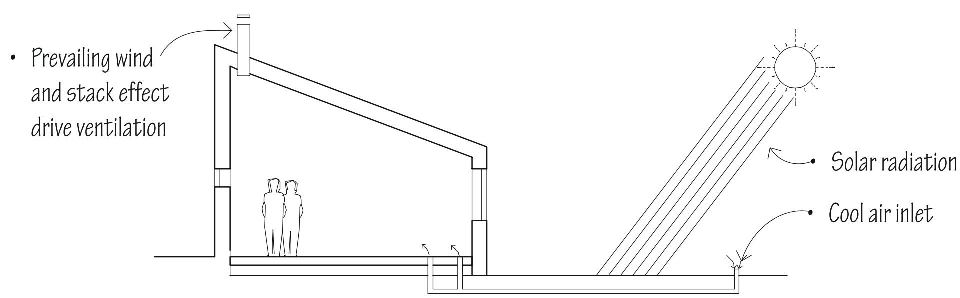
Roof Pond

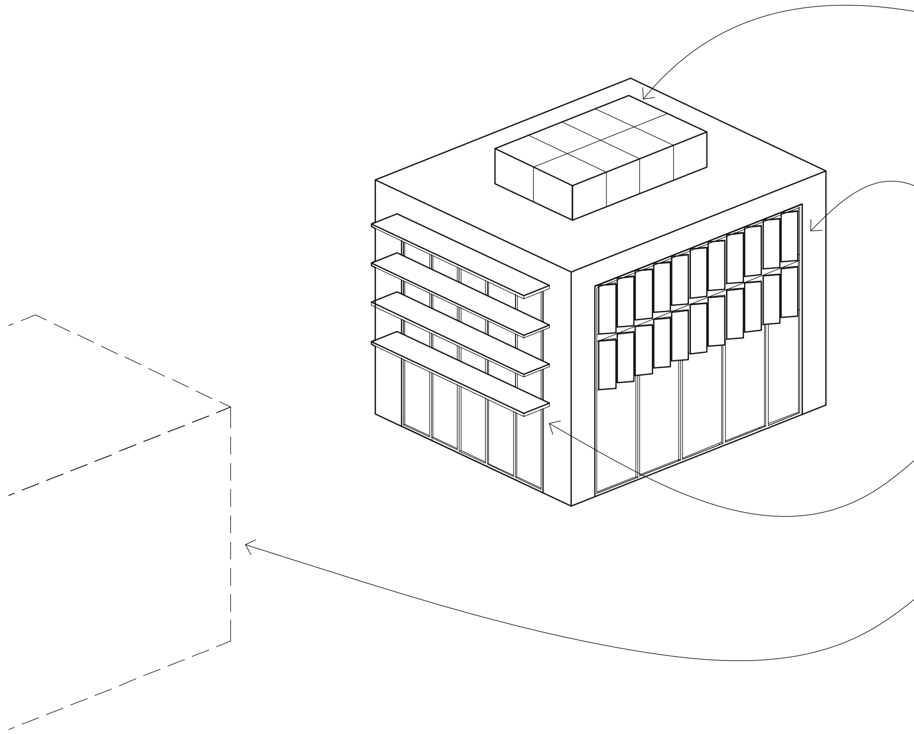
Another form of indirect gain is a roof pond that serves as a liquid mass for absorbing and storing solar energy. An insulating panel is moved over the roof pond at night, allowing the stored heat to radiate downward into the space. In summer, the process is reversed to allow internal heat absorbed during the day to radiate to the sky at night.



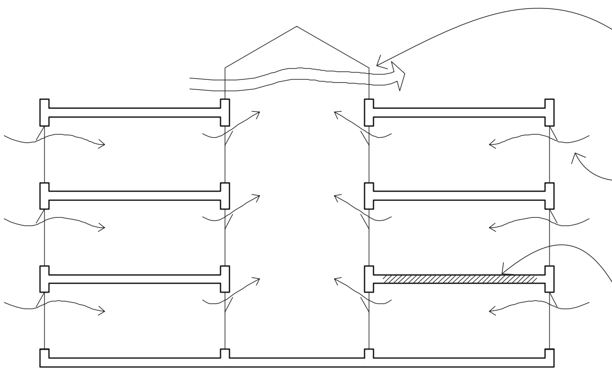
Isolated Gain

Ground tempered ventilation utilises the relatively constant warmth of the earth at depth in excess of 2 m to pre-heat ventilation air. Ventilation will need to be driven by the stack effect, a solar chimney, the prevailing winds or a combination of these measures.

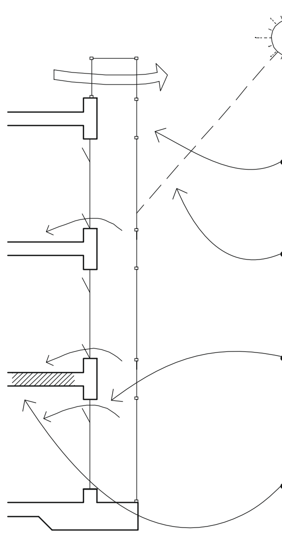




- Introducing an atrium into the centre of a deep plan building can facilitate good daylighting levels, additionally the atrium can be used as part of a natural ventilation system utilising the stack effect
- East- and west-facing glazing can be difficult to shade and may contribute to glare. West-facing glazing particularly, if unshaded can contribute to overheating
- South-facing glazing can be more easily shaded, while allowing for good levels of daylighting and utilising solar heat gains during the heating season
- When considering the daylighting and shading of a new building, the effect of nearby adjacent buildings (or planned buildings) should be taken into account



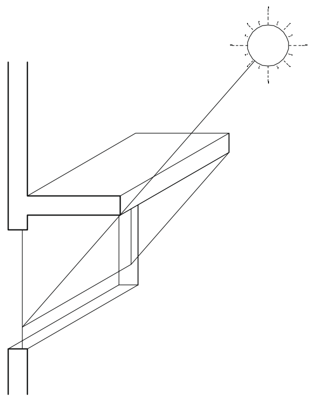
- An atrium can be used to drive a natural ventilation system using the stack effect. Care must be taken when designing an atrium space to ensure it does not contribute to overheating
- Pressure difference due to the stack effect will draw ventilation air through designed paths in the facade
- Unwanted heat gains can be stored in thermal mass and purged from the building as part of a night-time purge ventilation system, introducing coolth to the building structure
- The introduction of an atrium can increase the depth to which useful daylight can be experienced and natural ventilation used in a building by up to three times



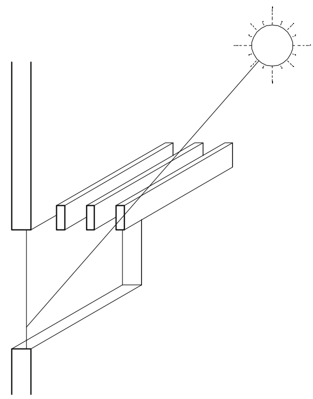
- A twin-wall system can also use the stack effect to drive natural ventilation
- Solar gains can pre-heat ventilation air before it enters the building
- Pre-heated ventilation air can be drawn into the building mechanically or as part by utilising passive means
- Thermal mass must remain coupled to the ventilation air flow in order to be useful

Shading devices shield windows and other glazed areas from direct sunlight in order to reduce glare and excessive solar heat gain in warm weather. Their effectiveness depends on their form and orientation relative to the solar altitude and azimuth for the time of day and season of the year. Exterior devices are more efficient than those located within interior spaces because they intercept solar rays before they can reach an exterior wall or window.

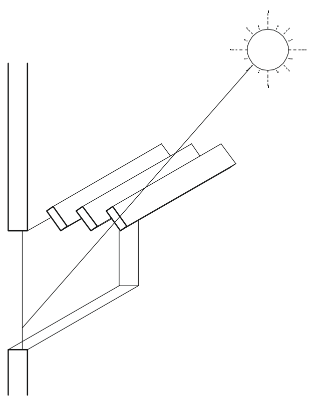
Illustrated are basic types of solar shading devices. Their form, orientation, materials and construction may vary to suit specific situations. Their visual qualities of pattern, texture and rhythm, and the shadows they cast, should be considered when designing the facades of a building.



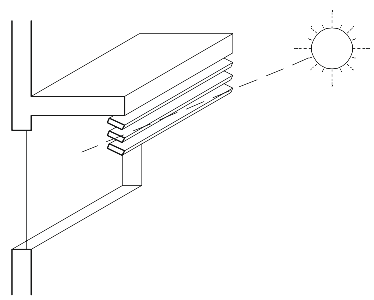
- Horizontal overhangs are most effective when they have southern orientations



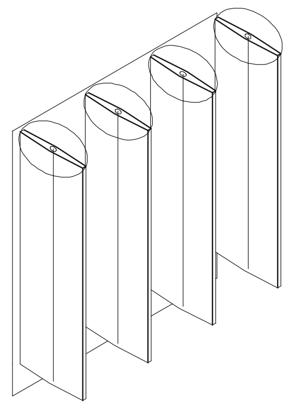
- Horizontal louvres parallel to a wall permit air circulation near the wall and reduce conductive heat gain



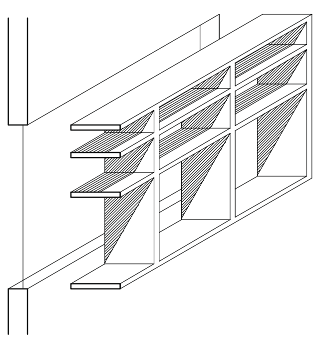
- Slanted louvres provide more protection than those parallel to a wall
- Angle varies according to the range of solar angles



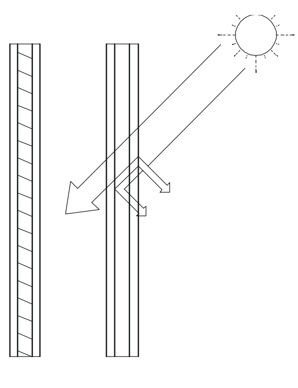
- Louvres hung from a solid overhang protect against low sun angles
- Louvres may interfere with view



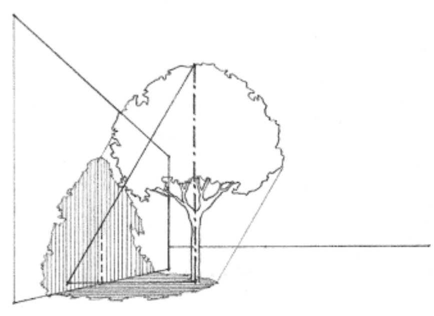
- Vertical louvres are most effective for eastern or western exposures
- Louvres may be operated manually or controlled automatically with time or photoelectric controls to adapt to solar angle
- Separation from wall reduces conductive heat gain



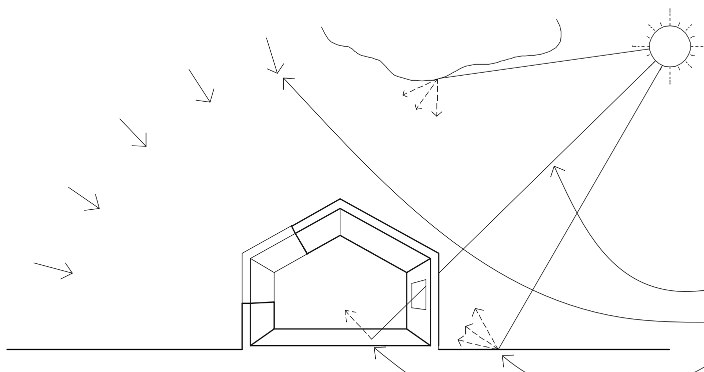
- Brise-soleil combine the shading characteristics of horizontal and vertical louvres and have a high shading ratio
- Brise-soleil are very efficient in hot climates



- Solar blinds and screens can provide up to a 50% reduction in solar radiation, depending on their reflectivity
- Heat-absorbing glass can absorb up to 40% of the radiation reaching its surface



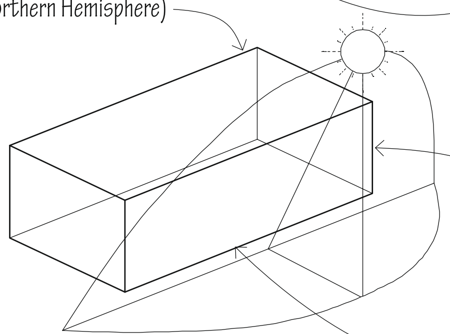
- Trees and adjacent structures may provide shade depending on their proximity, height and orientation



Solar radiation provides not only heat but also light for the interior spaces of a building. This daylight has psychological benefits as well as practical in reducing the amount of energy required for artificial lighting. While intense, direct sunlight varies with the time of day, from season to season, and from place to place, it can be diffused by cloud cover, haze and precipitation, and reflected from the ground and other surrounding surfaces.

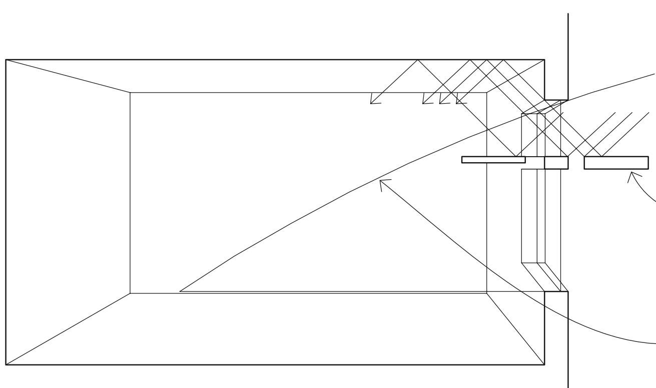
- Direct sunlight
- Skylight reflected and diffused by air molecules
- External reflectance from ground and adjacent structures
- Internal reflectance from room surfaces

- North-facing windows let in soft, diffuse skylight (in the Northern Hemisphere)



The quantity and quality of daylighting in a space are determined by the size and orientation of its window openings, transmittance of the glazing, reflectance of room surfaces and outdoor surfaces, and obstructions of overhangs and nearby trees.

- East- and west-facing windows require shading devices to avoid the bright early-morning and late-afternoon sun
- South-facing windows are ideal sources for daylight if horizontal shading devices can control excessive solar radiation and glare

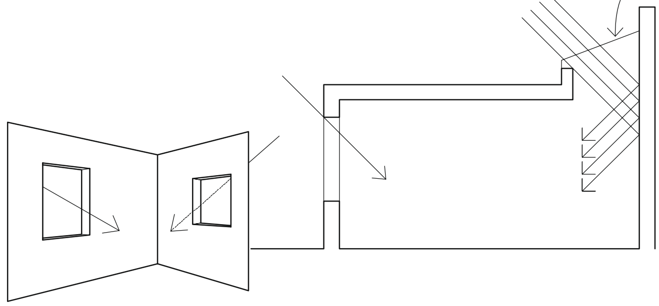


LEED EQ Credit 8.1: Daylight & Views – Daylight
BREEAM HEA 01: Visual Comfort

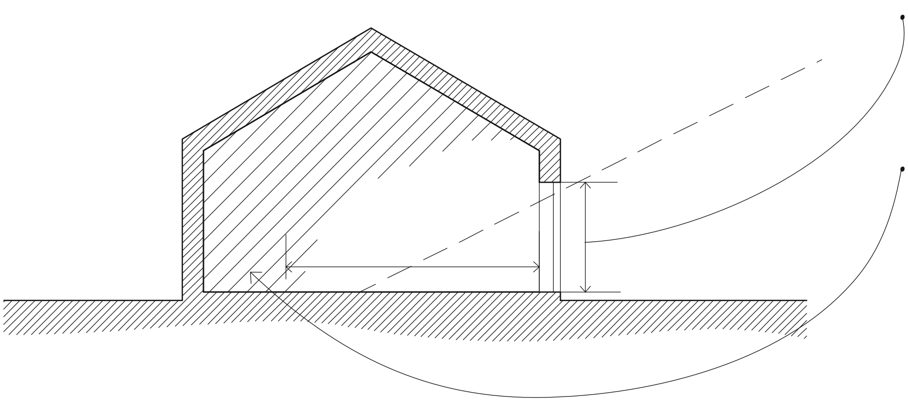
The level of illumination provided by daylight diminishes as it penetrates an interior space. Generally, the larger and higher a window is, the more daylight will enter a room; see 1.21.

- Light shelves shade glazing from direct sunlight while reflecting daylight onto the ceiling of a room. A series of parallel, opaque white louvres can also provide solar shading and reflect diffused daylight into the interior
- A useful rule of thumb is that daylighting can be effective for task illumination up to a depth of twice the height of a window
- The ceiling and back wall of a space are more effective than the side walls or the floor in the reflection and distribution of daylight; light-coloured surfaces reflect and distribute light more efficiently, but large areas of shiny surfaces can cause glare
- Skylights with translucent glazing can effectively daylight a space from above without excessive heat gain

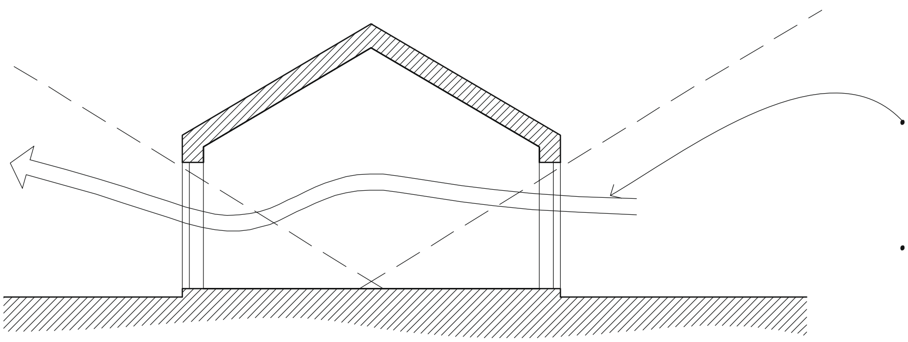
Excessive brightness ratios can lead to glare and impairment of visual performance. Glare can be controlled by the use of shading devices, the proper orientation of task surfaces and allowing daylight to enter a space from at least two directions.



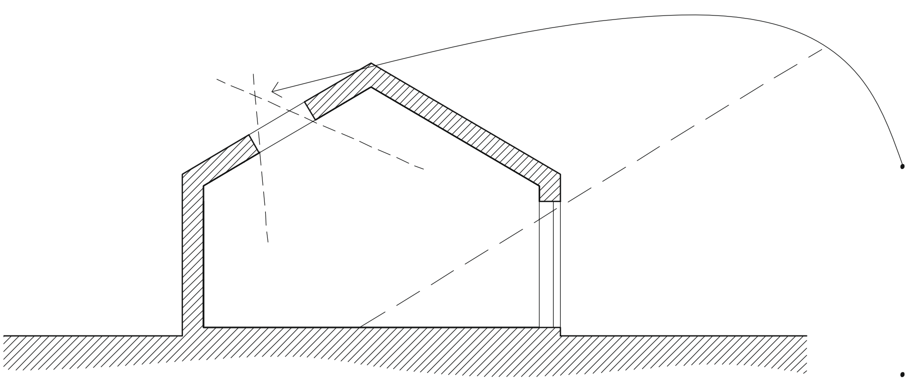
- For an even daylight distribution, allow daylight to penetrate a space from at least two directions



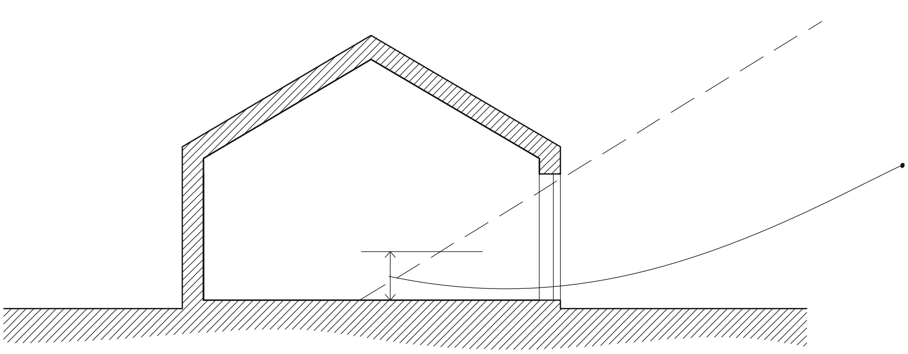
- Typically useful daylight will be experienced to a depth of up to twice the corresponding window head height
- Single-sided daylighting can lead to poor daylight uniformity. Where possible and where orientation and layout allow, daylight from at least two sides is preferable



- Daylighting from two directions can improve daylighting uniformity and also be used as part of a natural ventilation system
- The daylight factor is a measure of daylight as a percentage of the level of illumination available outside that will be experienced at a point in a corresponding inside space. To allow for natural variation the daylight factor is measured using a standard overcast sky. For daylight to be useful a minimum daylight factor of 2% is required with specific tasks such as reading requiring 4–6%

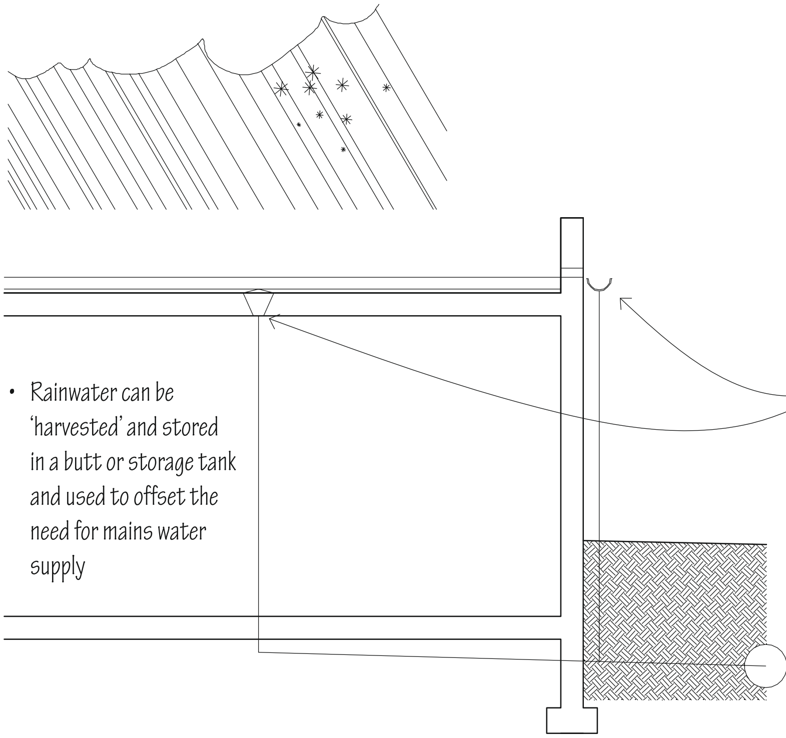


- North-facing roof lights can deliver good levels of daylighting and uniformity while avoiding the issues of glare and overheating
- Poor uniformity of daylight, or where the back of the room has a low daylight factor and the front a high daylight factor, can lead to issues of visual discomfort such as glare



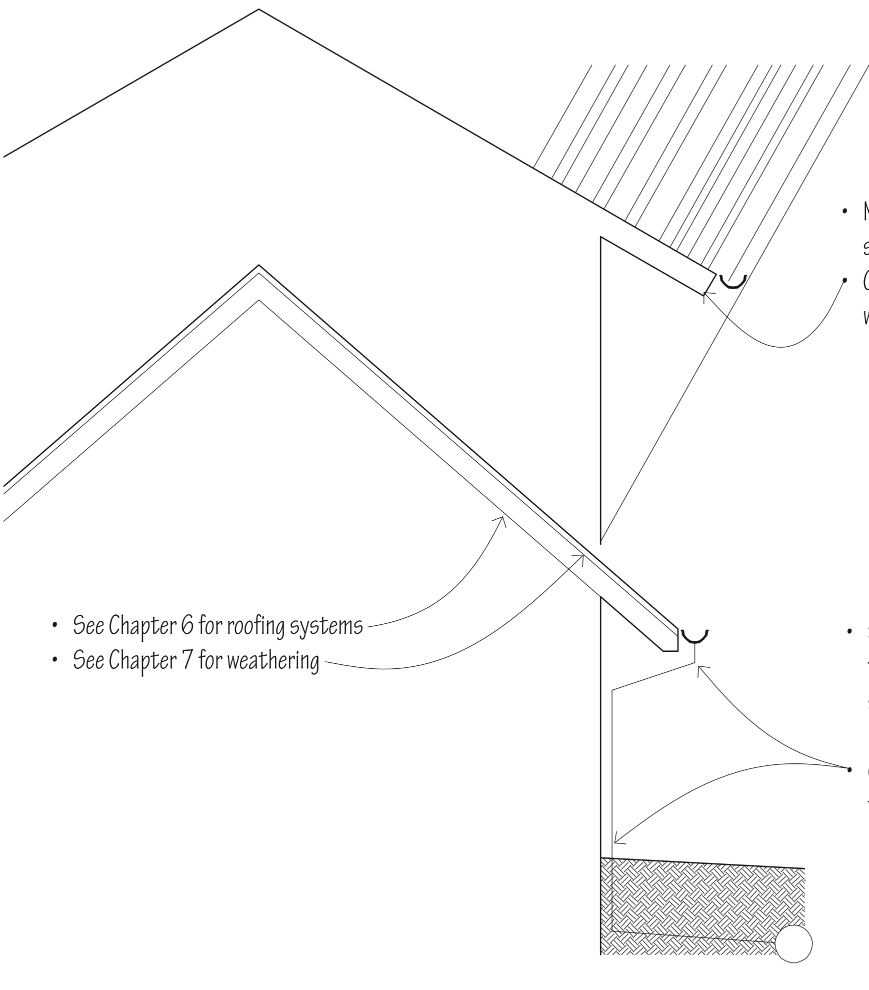
- Daylighting levels in an internal space should be measured at the working plane height (desk height) normally 700 mm above the finished floor level

The amount of annual and seasonal precipitation expected for a building site should influence the design and construction of the roof structure of a building, the choice of building materials and the detailing of its exterior wall assemblies. Furthermore, the run-off of rain and melting snow from constructed roof areas and paved surfaces increases the amount of surface water that must be drained from the site.



- Rainwater can be 'harvested' and stored in a butt or storage tank and used to offset the need for mains water supply

- Flat roofs require either interior roof drains or gutters along their perimeter for drainage
- In cold climates, flat roofs are subject to heavy snow loads. The layer of snow may serve as additional insulation



- Moderately pitched roofs easily shed rain but may retain snow
- Overhangs protect the exterior walls of a building from the weathering effects of sun and rain

- See Chapter 6 for roofing systems
- See Chapter 7 for weathering

- Steeply pitched roofs shed rainwater quickly. If the angle of the slope is greater than 60°, the roof may also be able to slough off snow

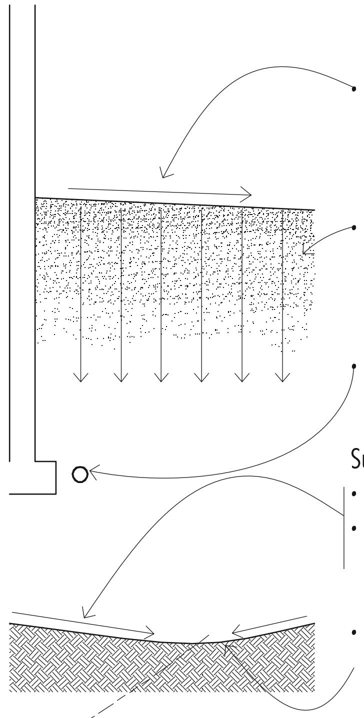
- Gutters and downspouts lead to a surface water sewer or to a natural soakaway on the site

1.26 SITE DRAINAGE

Development of a site can disrupt the existing drainage pattern and create additional water flow from constructed roof areas and paved surfaces. Limiting disruption of a site's natural hydrology and promoting infiltration by such means as pervious paving and green roofs is preferable. Site drainage is necessary to prevent erosion and the collection of excess surface water or groundwater resulting from new construction.

There are two basic types of site drainage: subsurface and surface drainage systems. Subsurface drainage consists of an underground network of piping for conveying groundwater to a point of disposal, as a storm sewer system or a natural outfall at a lower elevation on the site. Excess groundwater can reduce the load-carrying capacity of a foundation soil and increase the hydrostatic pressure on a building foundation. Waterproofing is required for basement structures situated close to or below the water table of a site.

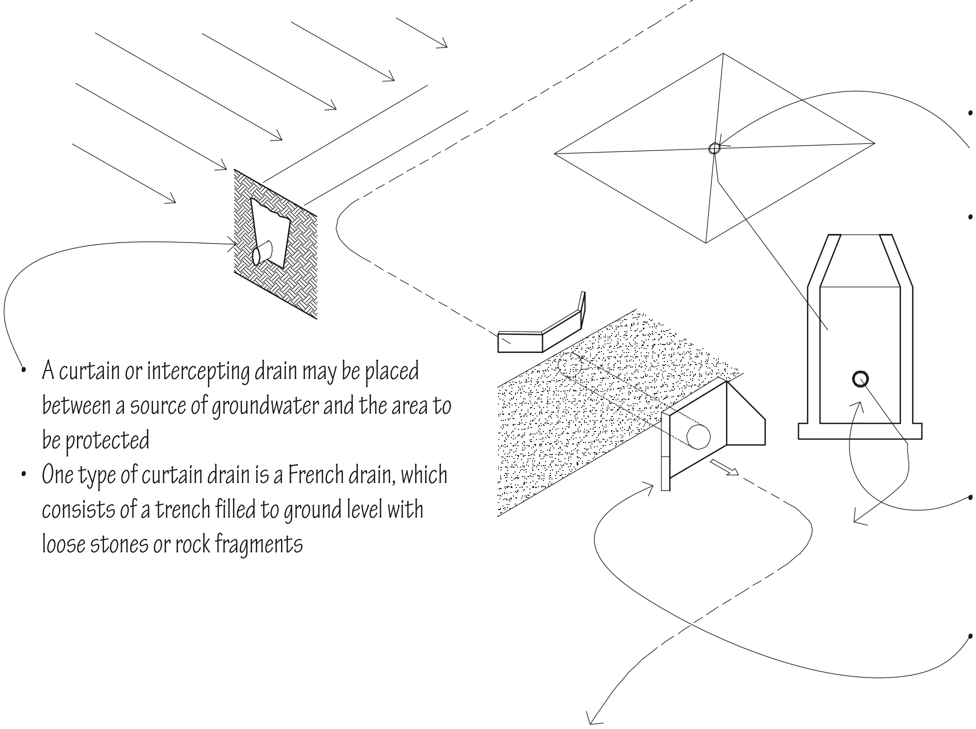
Surface drainage refers to the grading and surfacing of a site in order to divert rain and other surface water into natural drainage patterns or a local authority sewer system. An attenuation pond may be necessary when the amount of surface run-off exceeds the capacity of the storm sewer system.



- Finish grades should be sloped to drain surface water away from a building: 5% minimum; 2% minimum for impervious surfaces
- Groundwater consists largely of surface water that has seeped down through porous soil
- Foundation drain system; see 3.14

Surface Drainage Slopes
- Grass lawns and fields: 1.5–10% recommended
- Paved parking areas: 2–3% recommended

- Swales are shallow depressions formed by the intersection of two ground slopes, designed to direct or divert the run-off of surface water. Vegetated swales can increase infiltration

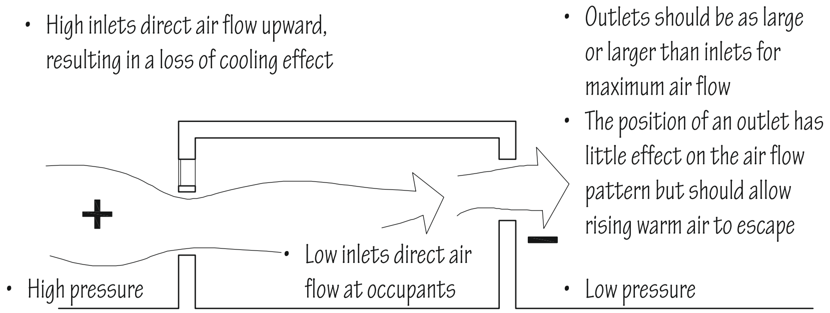


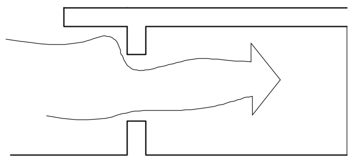
- Surface water drains collect water from a paved or impermeable area where necessary
- Soakaways are drainage pits lined with gravel or rubble to receive surface water and allow it to percolate away to absorbent earth underground

- A curtain or intercepting drain may be placed between a source of groundwater and the area to be protected
- One type of curtain drain is a French drain, which consists of a trench filled to ground level with loose stones or rock fragments

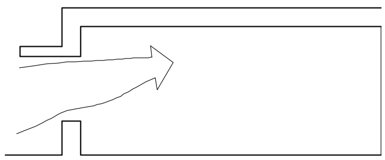
- Gullies have a basin or sump that retains heavy sediment before it can pass into underground drainage, they may also have a trap
- Culverts are drains or channels passing under a road or walkway

LEED SS Credit 6.1, 6.2: Stormwater Design
LEED WE Credit 2: Innovative Wastewater Technologies
BREEAM POL 03: Surface Water Run-Off

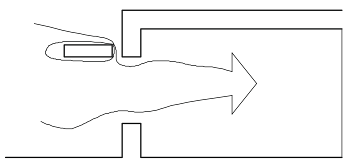




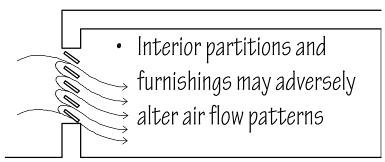
• Roof overhangs increase incoming flow of air



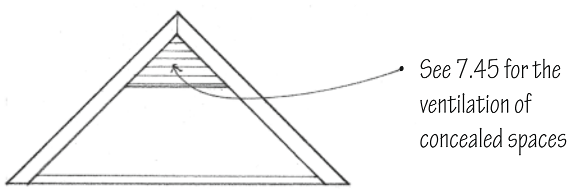
• Overhangs over openings direct flow upward which may be undesirable for cooling

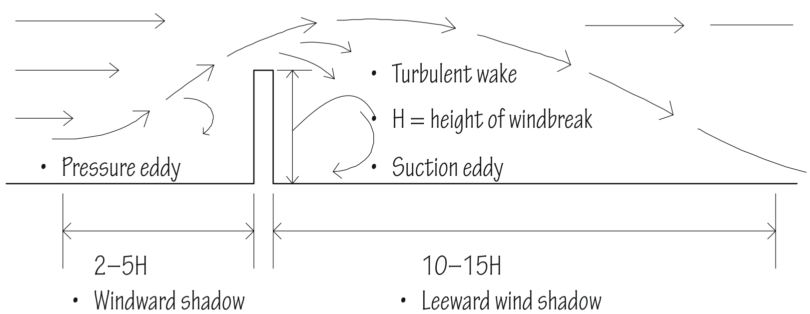


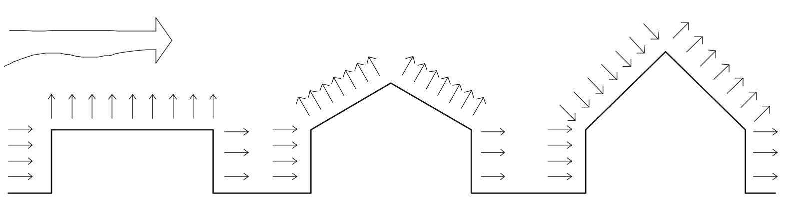
• Slots in overhangs equalise external pressure



• Louvres can beneficially redirect and diffuse air flow







• Flat roof • Roof slopes up to 7:12 • Roof slopes greater than 7:12

The direction and velocity of prevailing winds are important site considerations in all climatic regions. The seasonal and daily variations in wind should be carefully considered in evaluating its potential for ventilating interior spaces and outdoor courtyards in warm weather, causing heat loss in cold weather and imposing lateral loads on a building structure.

Wind-induced ventilation of interior spaces aids in the air exchange necessary for health and odour removal. In hot weather, and especially in humid climates, ventilation is beneficial for convective or evaporative cooling. Natural ventilation also reduces the energy required by mechanical fans and equipment.
(LEED IEQ Credit 2: Increased Ventilation)

The movement of air through a building is generated by differences in air pressure as well as temperature. The resulting patterns of air flow are affected more by building geometry and orientation than by air speed.

The ventilation of concealed roof spaces is required to remove moisture and control condensation. In hot weather, attic ventilation can also reduce overhead radiant heat gain.

In cold climates, a building should be buffered against chilling winds to reduce infiltration into interior spaces and lower heat loss. A windbreak may be in the form of an earth berm, a garden wall or a dense stand of trees. Windbreaks reduce wind velocity and produce an area of relative calm on their leeward side. The extent of this wind shadow depends on the height, depth and density of the windbreak, its orientation to the wind and the wind velocity.

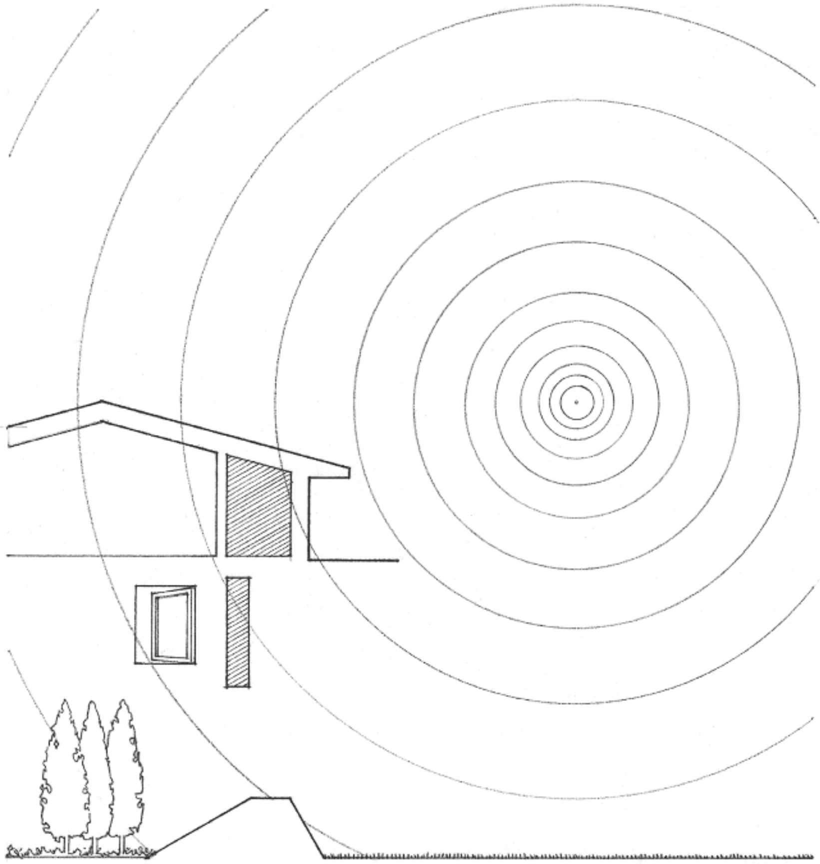
• A partially penetrable windscreen creates less pressure differential, resulting in a large wind shadow on the leeward side of the screen

The structure, components and cladding of a building must be anchored to resist wind-induced overturning, uplift and sliding. Wind exerts positive pressure on the windward surfaces of a building and on windward roof surfaces having a slope greater than 30°. Wind exerts negative pressure or suction on the sides and leeward surfaces and normal to windward roof surfaces having a slope less than 30°. See 2.09 for more information on wind forces.

1.28 SOUND & VIEWS

Sound requires a source and a path. Undesirable exterior sounds or noise may be caused by vehicular traffic, aircraft and other machinery. The sound energy they generate travels through the air outward from the source in all directions in a continuously expanding wave. This sound energy, however, lessens in intensity as it disperses over a wide area. To reduce the impact of exterior noise, therefore, the first consideration should be distance – locating a building as far from the noise source as possible. When the location or dimensions of a site do not make this possible, then the interior spaces of a building may be screened from the noise source in the following ways.

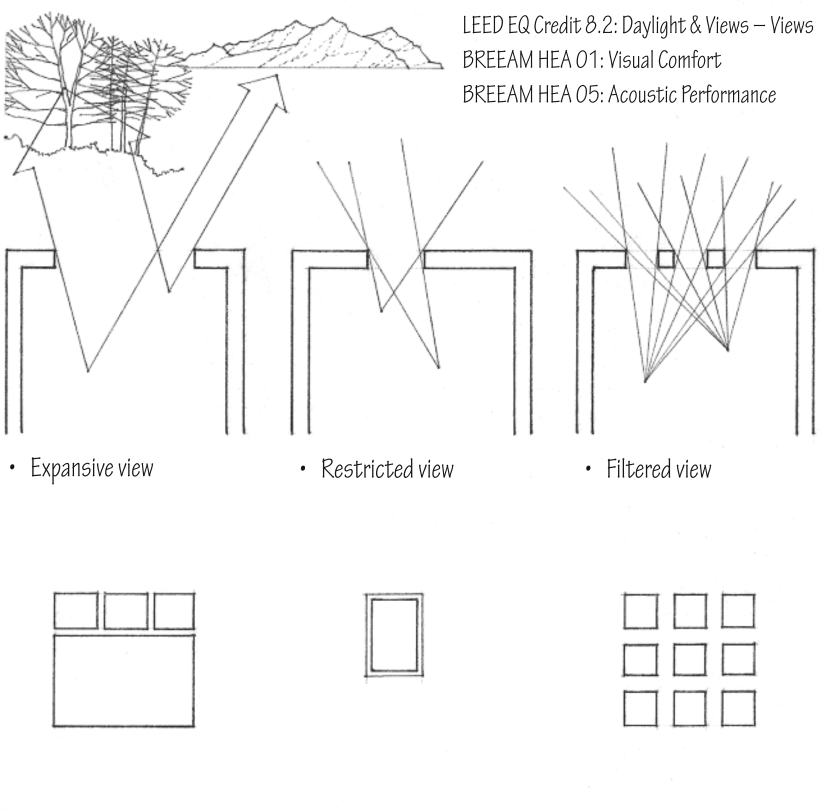
- Use building zones where noise can be tolerated, for example, mechanical, service and utility areas, as a buffer
- Employ building materials and construction assemblies designed to reduce the transmission of airborne and structure-borne sound
- Orient door and window openings away from the sources of undesirable noise
- Place physical mass, such as earth berms, between the noise source and the building
- Utilise dense planting of trees and shrubs, which can be effective in diffusing or scattering sound
- Plant grass or other ground cover, which is more absorptive than the hard, reflective surfaces of pavements

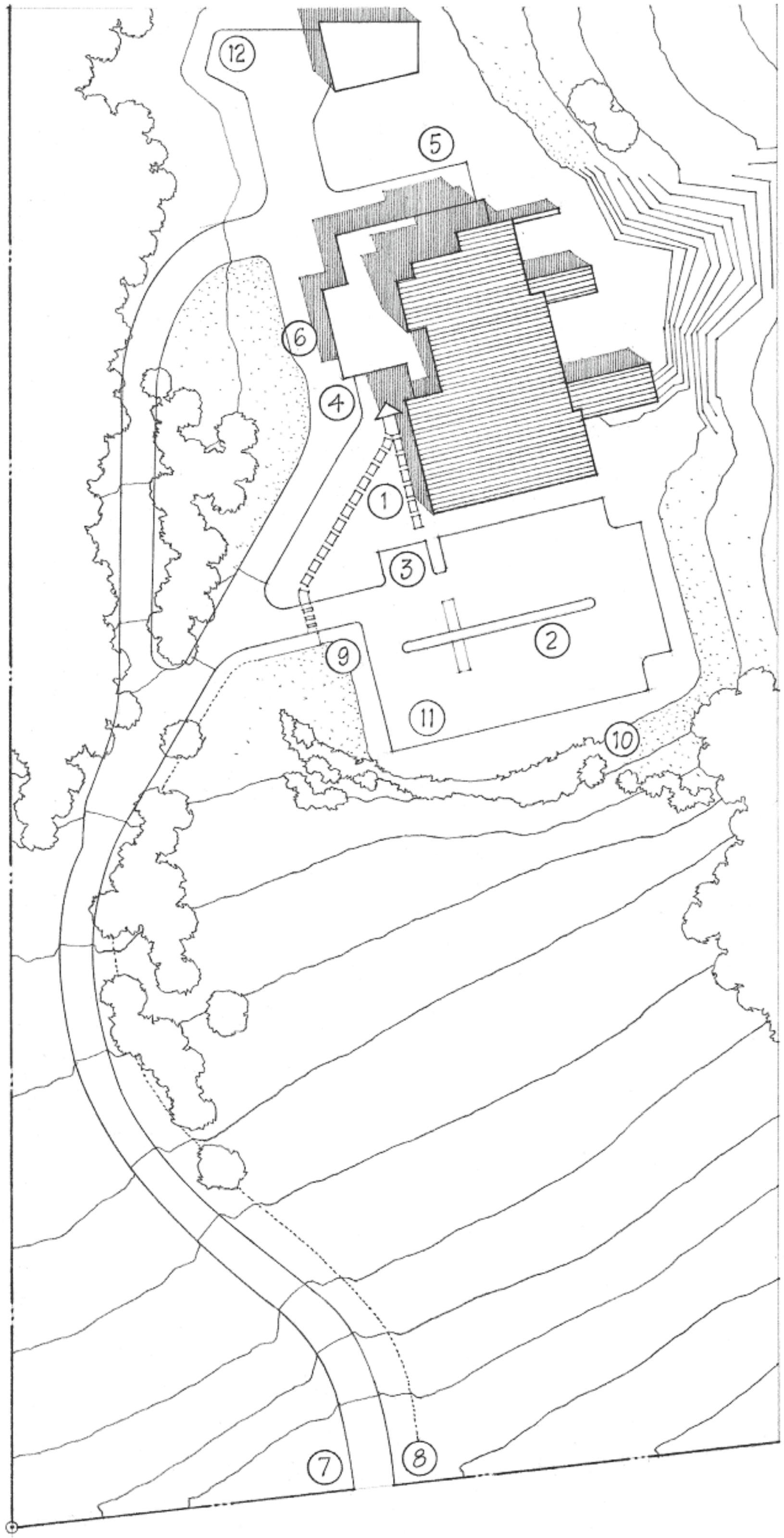


An important aspect of site planning is orienting the interior spaces of a building to the amenities and features of a site. Given the appropriate orientation, window openings in these spaces should be positioned not only to satisfy the requirements for natural light and ventilation, but also to reveal and frame desirable views. Depending on the location of the site, these views may be close or distant in nature. Even when desirable views are non-existent, a pleasant outlook can often be created within a building site through landscaping.

A window may be created within a wall in a number of ways, depending on the nature of the view and the way it is framed in the wall construction. It is important to note that the size and location of windows also affect the spatial quality and daylighting of a room, and the potential for heat loss or gain.

LEED EQ Credit 8.2: Daylight & Views – Views
BREEAM HEA 01: Visual Comfort
BREEAM HEA 05: Acoustic Performance



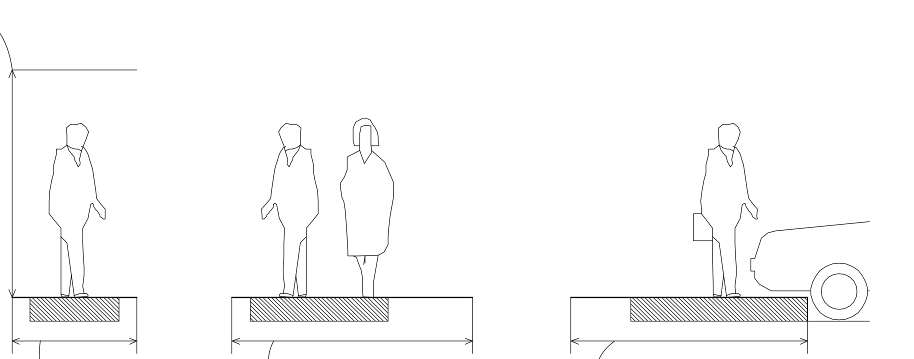


Providing for access and circulation for pedestrians, personal vehicles and service vehicles is an important aspect of site planning, which influences both the location of a building on its site and the orientation of its entrances. Outlined here and on the following pages are fundamental criteria for estimating and laying out the space required for walkways, roadways and surface parking.

1. Provide for safe and convenient pedestrian access and movement to building entrances from parking areas or public transit stops with minimal crossing of roadways
2. Determine the number of parking spaces required by the planning authority for the type of occupancy and total number of units or floor area of the building
3. Determine the number of accessible parking spaces as well as ramps, and paths to accessible building entrances required by building regulations
4. Provide loading zones for buses and other public transport vehicles where applicable
5. Separate service and truck loading areas from pedestrian and vehicular traffic
6. Furnish access for emergency vehicles such as fire engines and ambulances
7. Establish the required width and location of crossways and their intersection with public streets
8. Ensure clear sightlines for vehicles entering public roadways
9. Plan for control of access to parking areas where required.
10. Provide space for landscaping; screening of parking areas may be required by planning requirements
11. Slope paved walkways and parking areas for drainage
12. Provide space for snow removal equipment in cold climates

Illustration adapted from the site plan for the Maison Louis Carré House, designed by Alvar Aalto

- 2400 mm minimum overhead clearance
- Minimise conflicts with roadways and parking areas
- Provide traction in areas subject to icy conditions
- 0.5% minimum slope for drainage; 1.5% preferred

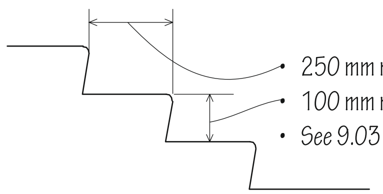


Pedestrian Walks

- Minimum of three risers per run of stairs
- Handrails are required for stairs having four or more risers, or where icy conditions exist

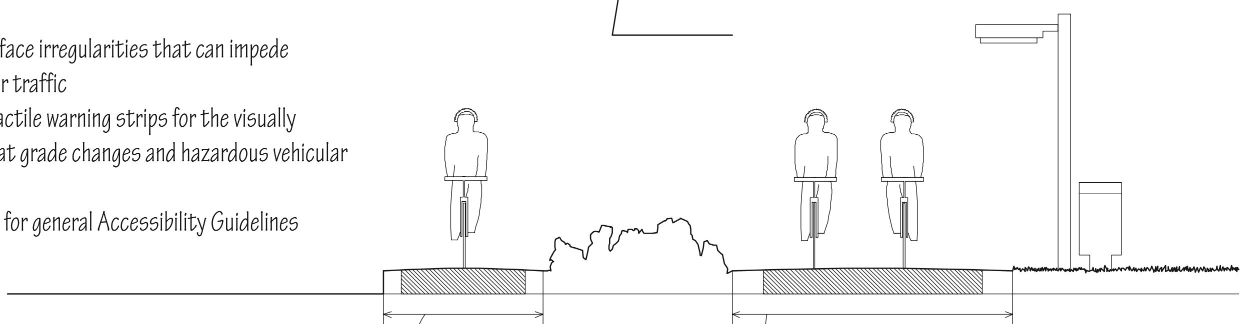
Exterior Stairs

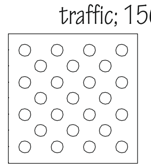
- Provide amenities, such as benches, rubbish bins and lighting



Bike Paths

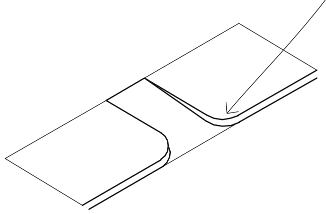
- Avoid surface irregularities that can impede wheelchair traffic
- Provide tactile warning strips for the visually impaired at grade changes and hazardous vehicular areas
- See A.03 for general Accessibility Guidelines

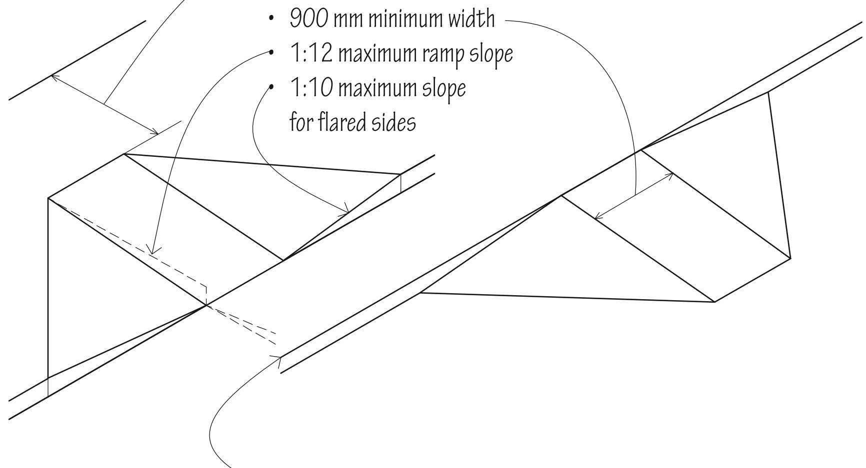




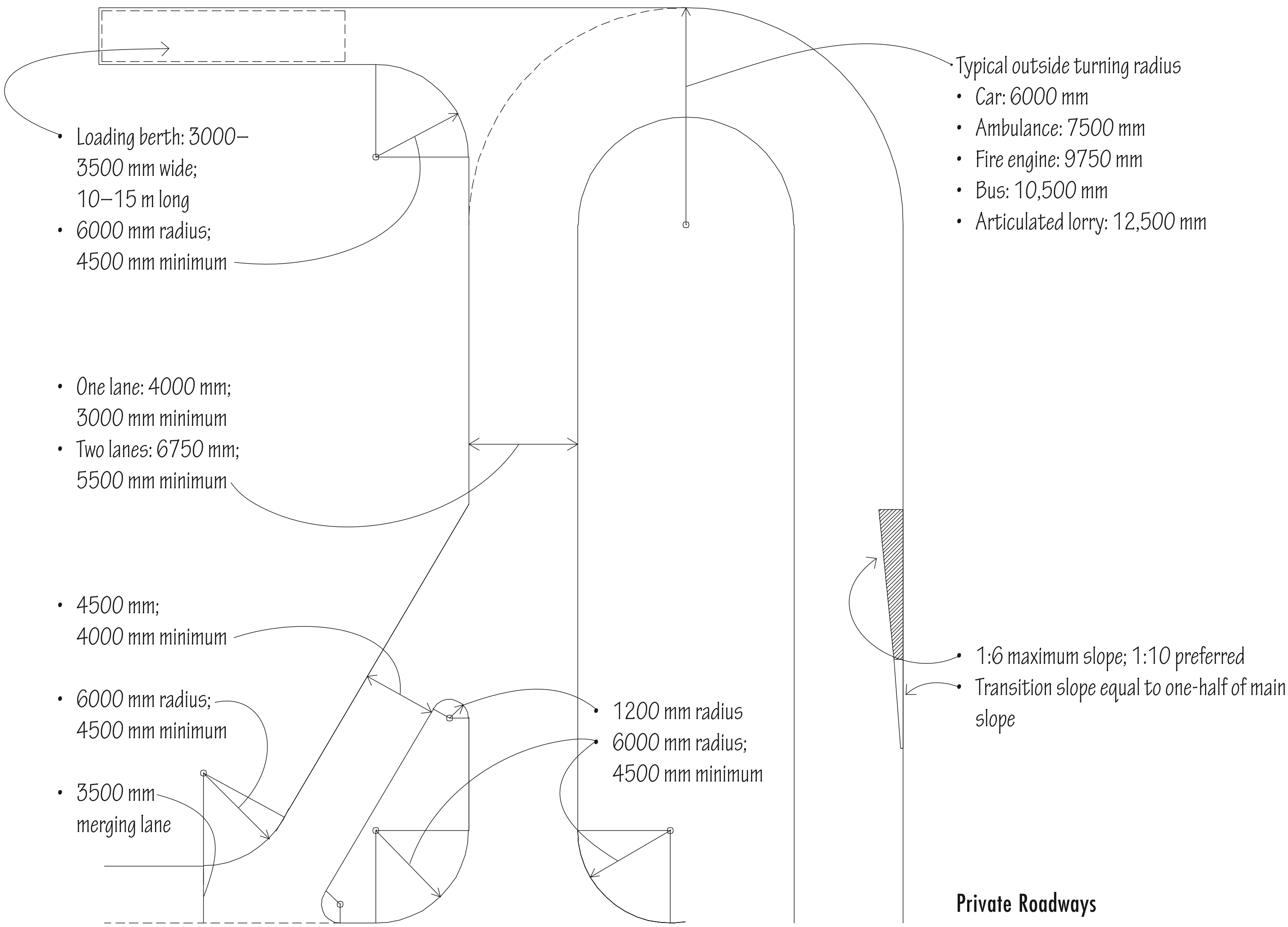
Accessibility Guidelines

- Kerb ramps are required wherever an accessible route crosses a kerb
- Surface of ramp should be stable, firm and slip-resistant
- Returned kerbs are allowable where pedestrians would not normally walk across the ramp

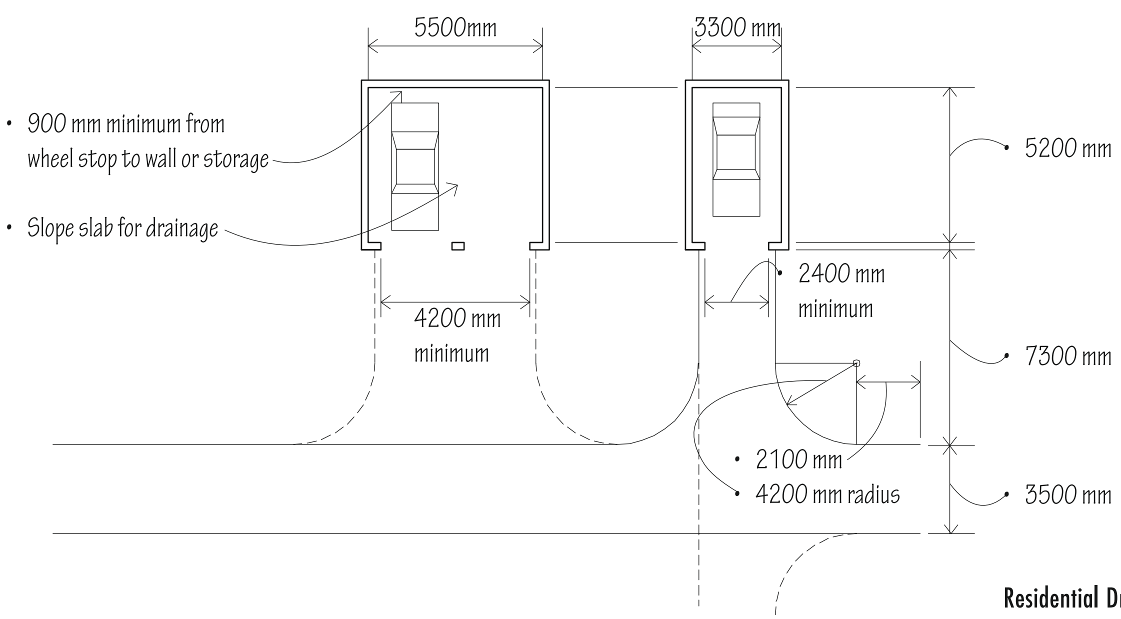




Kerb Ramps

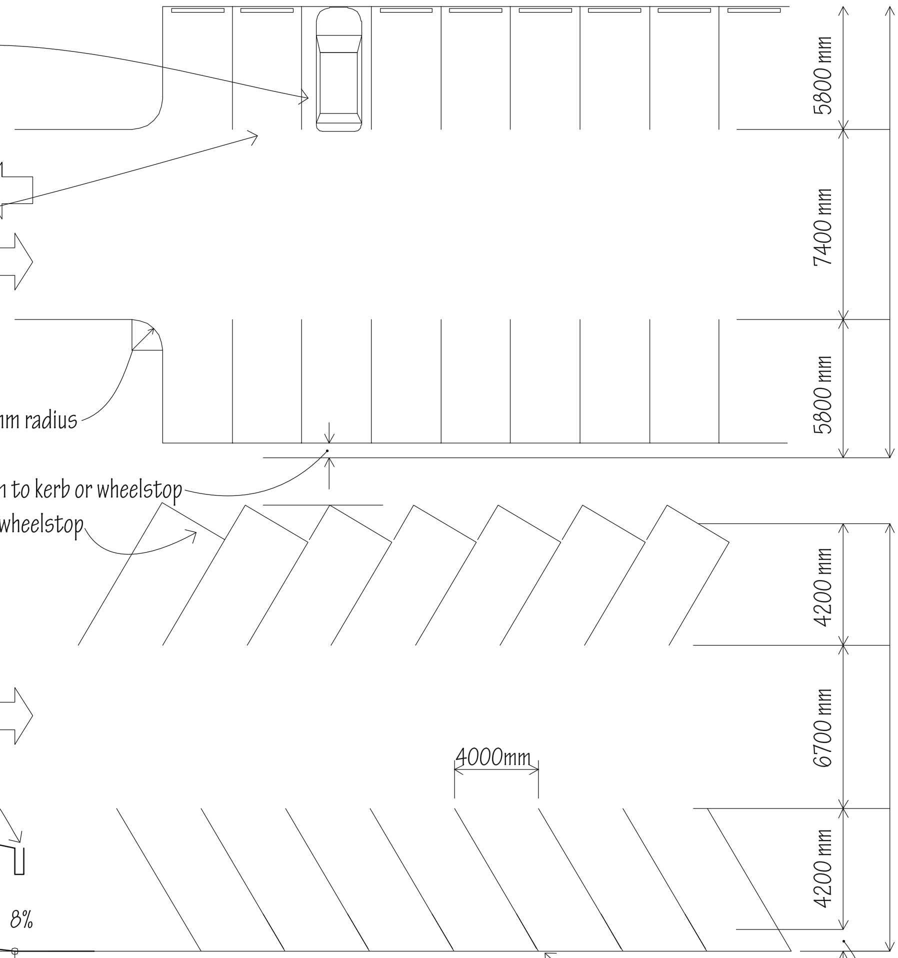


Private Roadways



Residential Drives and Garages

Required criteria may vary from one location to another and depending on the classification of the road.



Vehicle Dimensions

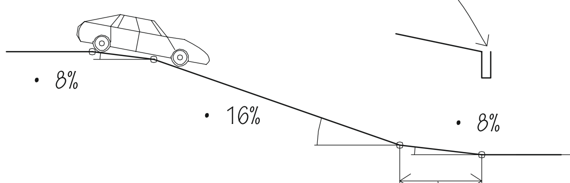
- Small car: 1900 x 4000 mm
- Standard car: 1900 x 4500 mm

Parking Spaces

- Standard cars: 2400–2800 mm x 5800–6000mm
- Slope 1–5% for drainage; 2–3% recommended
- 1200 mm radius
- 760 mm to kerb or wheelstop
- Kerb or wheelstop

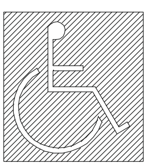
Car Parks

- 2100 mm minimum overhead clearance

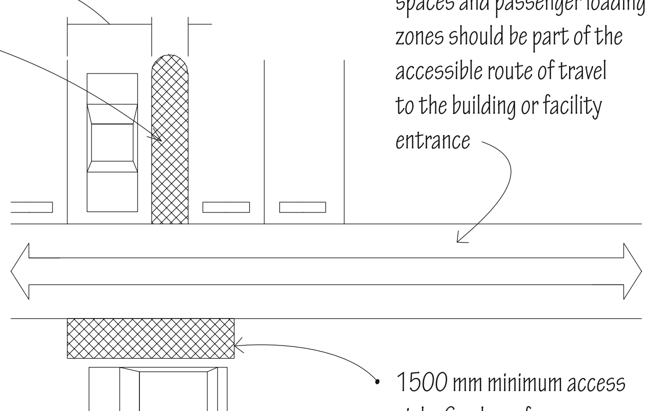


- Transition slope equal to one-half of ramp slope; 3050 mm length
- Wall line
- 800 mm
- Access aisles for parking spaces and passenger loading zones should be part of the accessible route of travel to the building or facility entrance

Garage Ramps



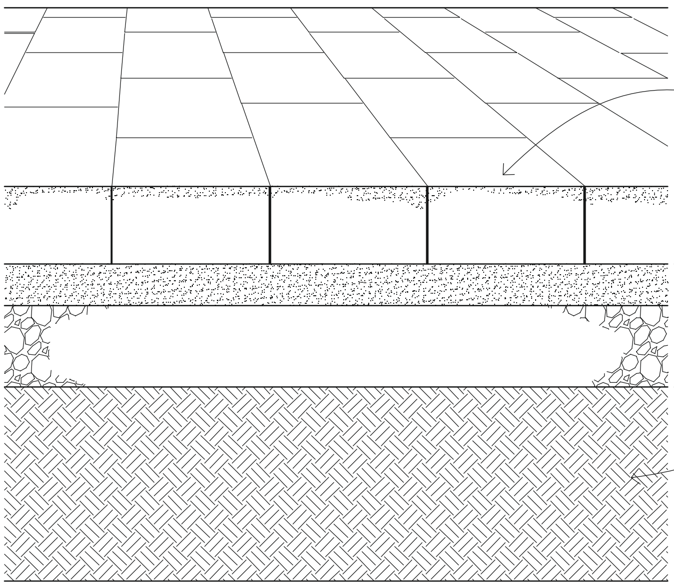
- 2400 mm minimum width
- Access aisle; may be shared by two accessible parking spaces
- Identify accessible parking spaces with a sign showing the international symbol of accessibility
- Accessible parking spaces for vans used by persons with disabilities should have a clear height of 2500 mm and an access aisle at least 2400 mm wide



- 1500 mm minimum access aisle, 6 m long, for passenger loading zones adjacent and parallel to the vehicle pull-up space
- Generally the number of accessible spaces required is regulated by local planning policy
- Locate accessible parking spaces as close as possible to building or facility entrance
- 1:50 maximum slope for spaces and access aisles

Required criteria may vary from one location to another. In the UK *The Metric Handbook* (Littlefield, 2004) provides detailed design data.

Paving provides a wearing surface for pedestrian or vehicular traffic on a site. It is a composite structure the thickness and construction of which are directly related to the type and intensity of traffic and loads to be carried, and the bearing capacity and permeability of the subgrade.

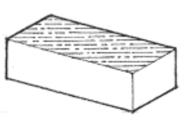


- The pavement receives the traffic wear, protects the base and transfers its load to the base structure. There are two types of pavement: flexible and rigid
- The base is a foundation of well-graded aggregate that transfers the pavement load to the subgrade. It also prevents the upward migration of capillary water. Heavy-duty loads may require an additional layer of subbase of coarser aggregate
- The subgrade, which must ultimately carry the pavement load, should be undisturbed soil or compacted fill. Because it may receive moisture from infiltration, it should be sloped to drain

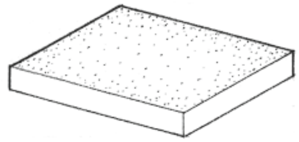
Flexible pavements, consisting of unit pavers of concrete, brick or stone laid on a sand setting bed, are somewhat resilient and distribute loads to the subgrade in a radiating manner. They require wood, steel, stone, masonry or concrete edging to restrain the horizontal movement of the paving material.

Rigid pavements, such as reinforced-concrete slabs or paving units mortared over a concrete slab, distribute their loads internally and transfer them to the subgrade over a broad area. They require reinforcement and an extension of the base material along their edges.

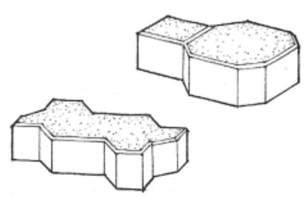
- 1% minimum slope for drainage; highly textured paving may require a steeper slope



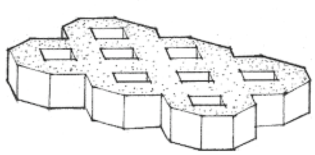
- Brick paver: 100 x 100, 205, 305; 25–60 mm thick



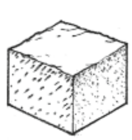
- Concrete unit paver: 305, 455, 610 mm square; 38–75 mm thick



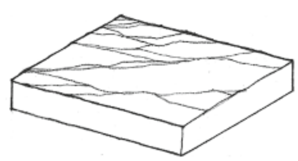
- Interlocking pavers: 64–90 mm thick



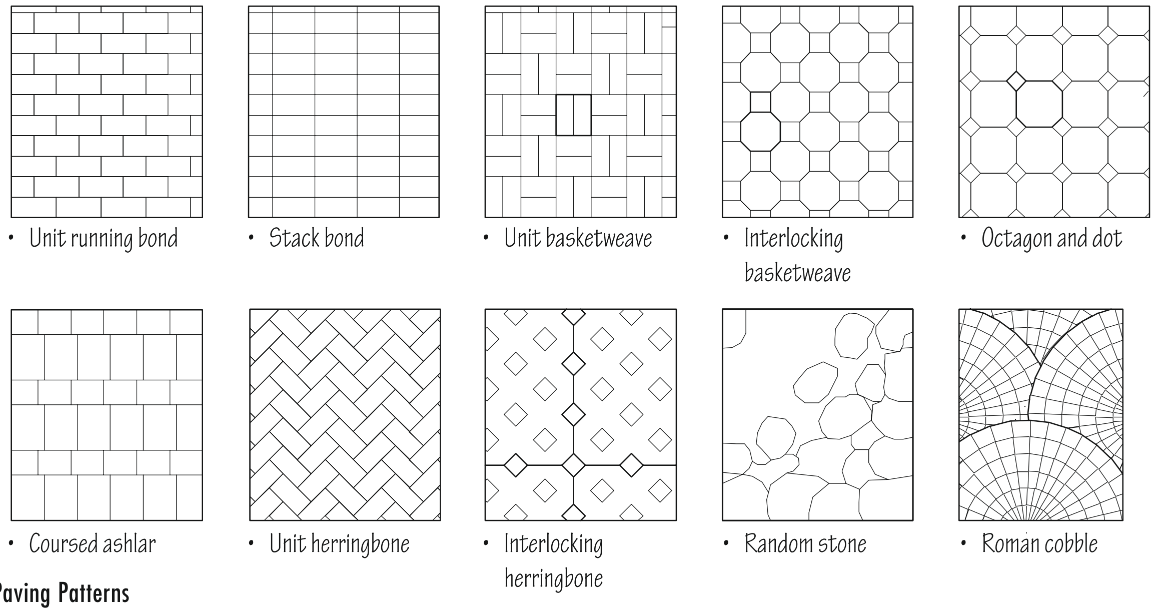
- Grid or turf block: 90 mm thick



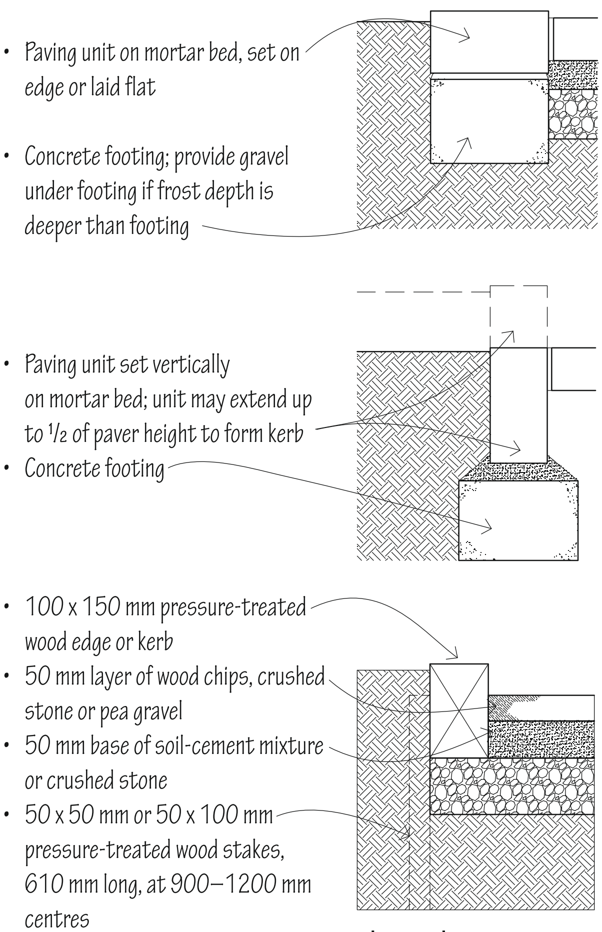
- Granite cobble: 100 or 150 mm square; 150 mm thick



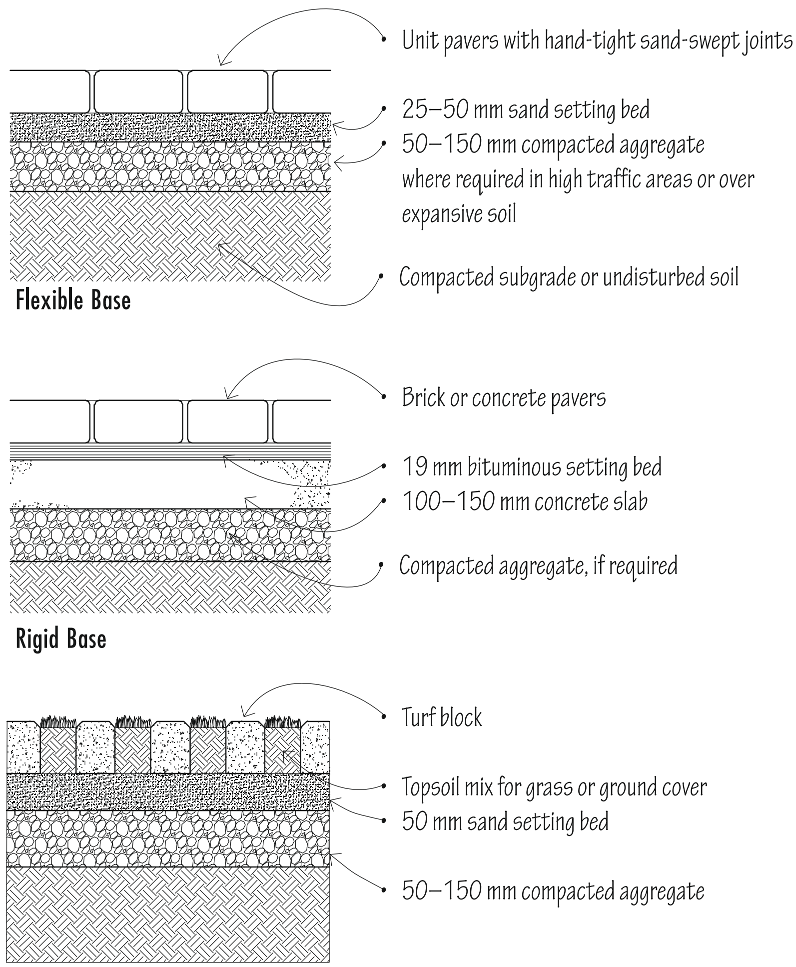
- Cut stone: width and length varies; 25–50 mm thick



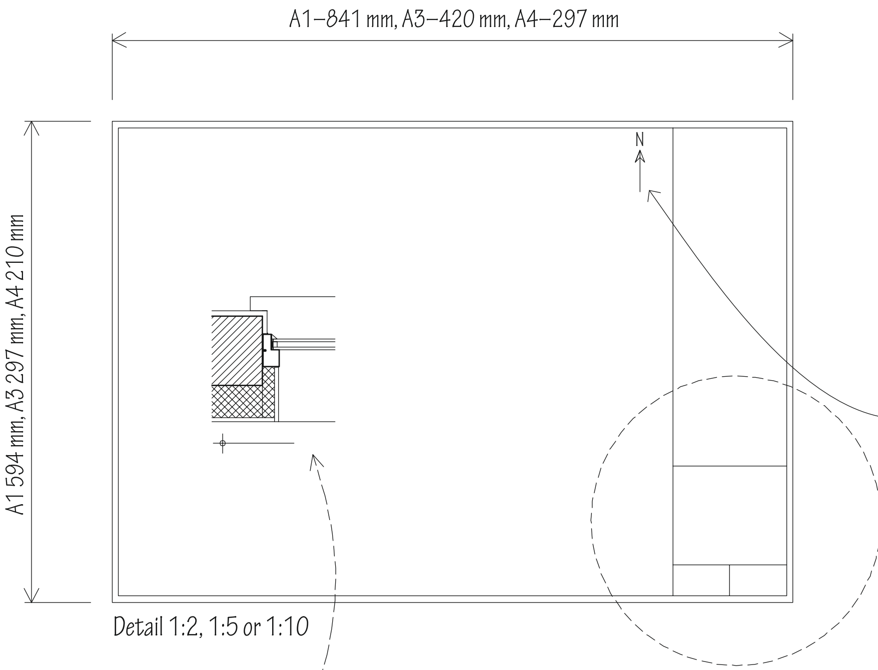
Paving Patterns



Edge Conditions



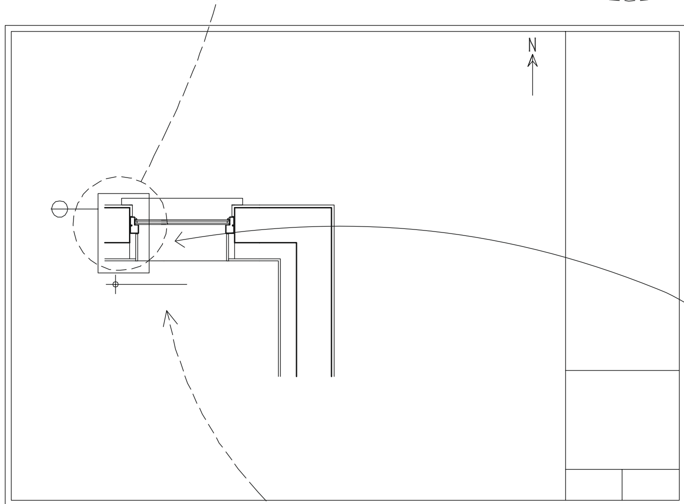
Paving Details



Detail 1:2, 1:5 or 1:10

Construction details visually explain how the various materials and elements that make up a building are joined. As buildings are composed of many materials it is important to take account of how those materials will interact with each other and with the environment around them. A well detailed building will stand the test of time, whereas a poorly detailed building may become obsolete prematurely.

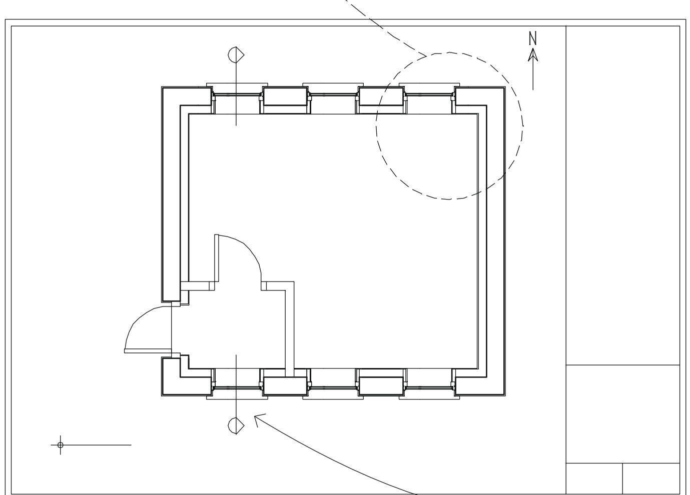
- All plan drawings should include a north-point, maps and other legal documents are oriented north to the top of the page by convention
- The title block contains important information such as drawing title, project name, scale, client and consultant details and drawing number



Detailed plan 1:20

As it may take large volumes of drawings to explain a building in sufficient detail it is important to include cross-referencing between the drawings to ensure the correct area is being considered. Cross-referencing may be between drawings, to window/door or other schedules or to specifications.

- Detailed plans include wall build-up, finishes and mechanical and electrical information
- Construction details should be identified and cross-referenced back to the relevant drawing



Floor plan 1:50 or 1:100

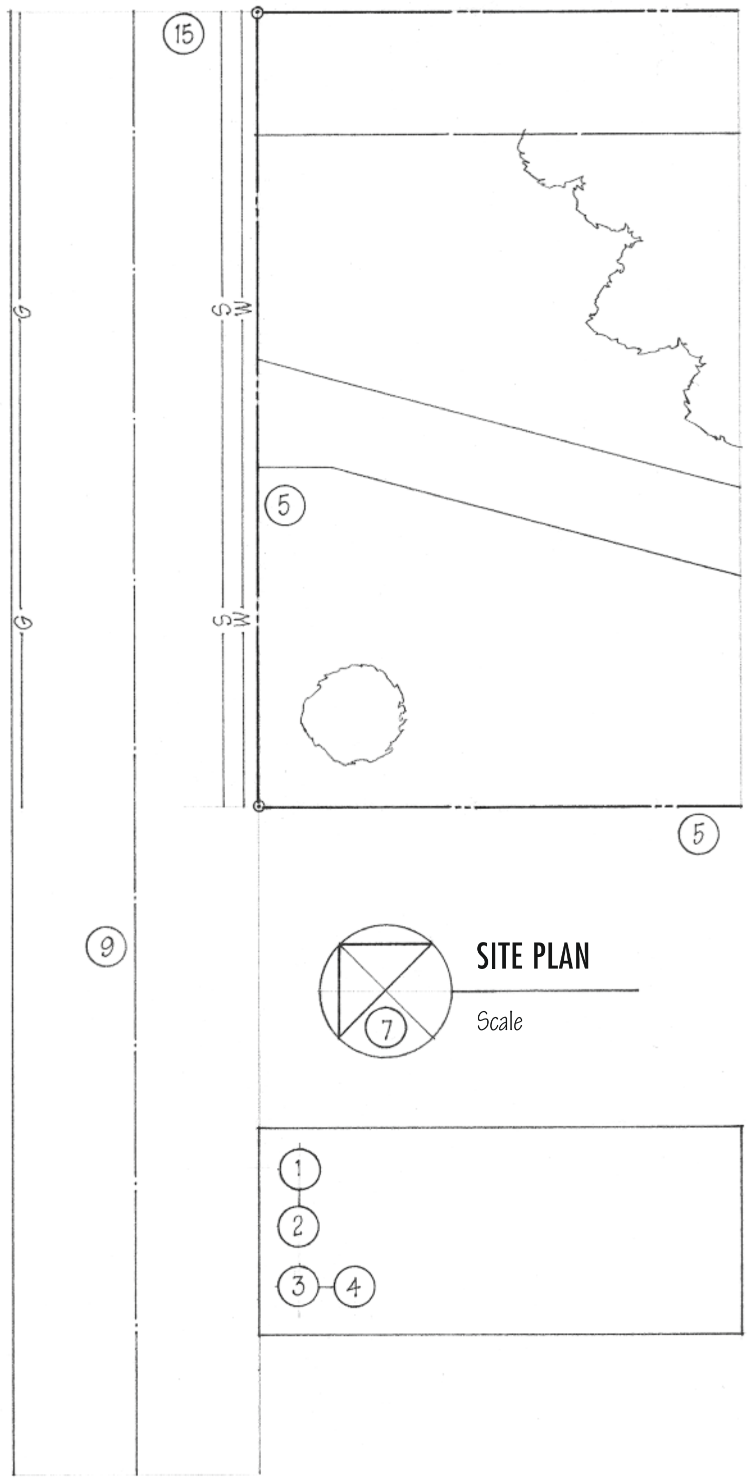
General arrangement drawings set out the location of the major elements within the building, such as openings and internal or external walls. The general arrangement drawing may contain layers of information such as the location of mechanical and electrical services, finishes, floor area and internal and external dimension of major elements. These plans should include door and window numbers (referencing to related schedules) and contain cross references to section and detail drawings.

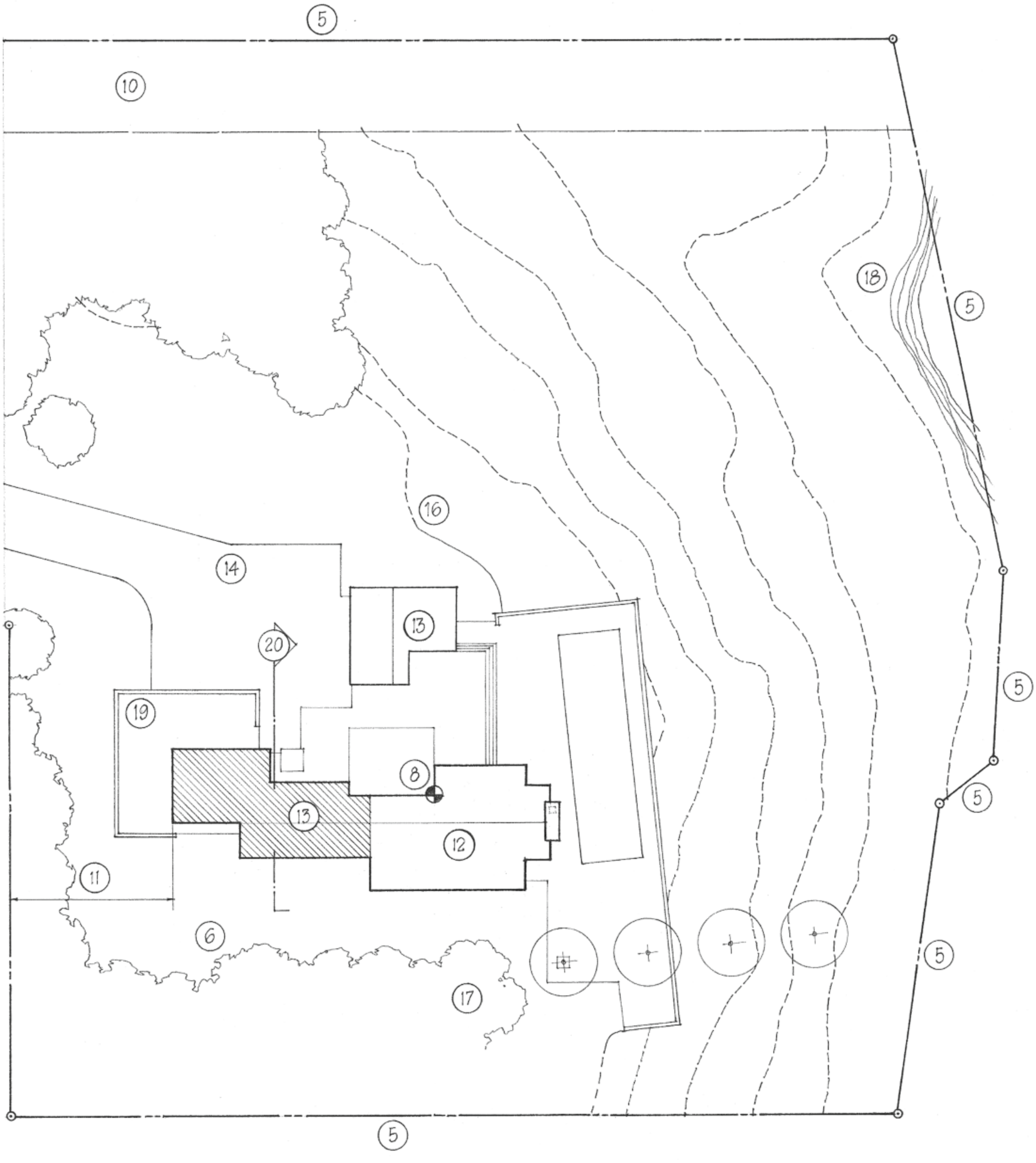
- Section lines indicate the location a section is taken and refer back to the relevant drawing number

THE SITE PLAN

The site plan illustrates the existing natural and built features of a site and describes proposed construction in relation to these existing features. The site plan is an essential piece of construction documentation. A completed site plan should include the following items:

1. Name and address of property owner
2. Address of property, if different from owner's address
3. Legal description of property
4. Source and date of land survey
5. Description of the site boundaries: dimensions of property lines, their bearing relative to north, angles of corners and radii of curves
6. Contract or project limits, if different from site boundaries
7. North point and scale of drawing
8. Location and description of benchmarks that establish the reference points for the location and elevations of new construction
9. Identification and dimensions of adjacent streets, lanes and other public rights-of-way
10. Location and dimensions of any easements or rights-of-way that cross the site
11. Dimensions of setbacks required by planning
12. Location and size of existing structures and a description of any demolition required by the new construction
13. Location, shape and size of structures proposed for construction
14. Location and dimensions of existing and proposed paved walkways, drives and parking areas
15. Location of existing utilities: water mains, sanitary and sewers, gas lines, electrical power lines, telephone, data and cable lines, fire hydrants, as well as proposed points of connections
16. Existing contour lines, new contour lines and the finish grades of drives, walks, lawns or other improved surfaces after completion of construction or grading operations
17. Existing plant materials to remain and those to be removed
18. Existing water features, such as drainage swales, flood plains, watersheds or shorelines
19. Proposed landscaping features, such as fencing, retaining walls and planting; if extensive, landscaping and other site improvements may be shown on a separate site plan
20. References to related drawings and details

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