Spread of Innovative Solutions for Sustainable Construction

Handbook

4 Products, Structures Building Services Systems

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4 Products, Structures, Building Services Systems

For the reader to be able to use the book usefully, it is necessary to have a common understanding about the same phenomena and titles and, conversely, to define the same things in the same way. To this end, of course, we list a non-exhaustive list of some of the more important concepts and expressions. It is essential to know that different things are named variably by the everyday language use, differently by professional language, and again differently by legal language and terms.

In ancient times, mankind first sought shelter and later, once construction work of mankind started, they made a home for themselves, that is, they transformed their surroundings. By demarcating a part of the environment as a result of conscious construction, the built environment was established. Mankind built a house with this activity, but the professional and legal language coins it differently, namely a structure, which is a collective term. Structures that are typically used for human habitation are called buildings.

Our home, in other words, our apartment, is a stand-alone destination unit that serves the purpose of a long-term residence and includes living quarters, cooking rooms, sanitary rooms, moving rooms, and storage rooms. Buildings comprise of building structures, the components of building structures are building materials with their exact name, construction products, which are permanently built into the structures and play a significant role in the "operation" of the structure.

Different building types also have their own precise definitions. From the point of view of our topic, residential buildings, namely buildings that typically include dwelling and the associated service rooms are relevant. There are also several types of residential buildings. The best-known of these are single-family detached houses, commonly known as family houses and multi-storey multi-apartment buildings, commonly known as condominiums. It is also worth mentioning the semi-detached house, which has two independent buildings with independent

building structures on the common side of two adjacent building plots, which externally show the image of one building. The group house is a separate category; the group house also has several versions, the terraced house, the chain house and the atrium house. What they have in common is that they are built in one phase, connected to a series with independent building structures, and typically have the same or similar architectural design.

4.1 Requirements related to building structures, buildings

We set basic requirements towards the building materials and building structures that compose our buildings to ensure long-lasting, healthy and safe usage.

These essential requirements are the following:

Mechanical resistance and stability

The supporting structure of buildings are expected to withstand the expected loads - additional building structures (e.g. roof), own weight, effects due to use (e.g. furniture, people), etc. - without damage, at least for their intended life phase.

Fire Safety

During the design phase, buildings should be configured to minimise the possible damages from fire. The primary purpose of fire protection is life- and protection safety. Appliances (evidently in addition to fire prevention) of active fire protection equipment (extinguishing systems) and passive systems - this means choosing building materials, designing structures so that they do not facilitate or hinder the spread of fire, and retaining their supporting and separating function at least for the duration of the rescue process.

Hygiene, health and the environment

Buildings must be harmless to health. Therefore, all building materials must be established in a way that no harmful substances (e.g. volatile compounds, small elemental fibres) can escape during use. In addition, the environmental impact of production and transport during the production of building materials have to be reduced as much as possible (the specific environmental impact of different building materials is described in more details in the Annex.)

It also includes the protection of buildings against water and moisture. During the use of the building, a significant amount of vapour is generated (e.g. from people breathing). This condensation must be avoided indoors because - apart from possible damage to the building structure - it creates a favourable environment for the appearance of mould. This can be avoided if our structures are "open towards the outside" in terms of vapour, which means that by moving from the inside, the material layers are more and more vapour permeable (their so-called vapour diffusion resistance is lower). In addition, the design should take into account – significantly on the colder points of the structure - to avoid the formation of thermal bridges. Moisture from the soil has a similar effect to humidity (it can damage the structure and favour mould), so we need to protect against it with waterproofing.

Protection against adverse environmental effects (e.g. radon radiation) is also part of this basic requirement.

Safety and accessibility in use

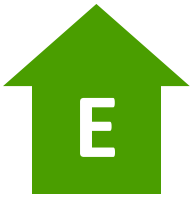
We expect safe operation during use. This includes that there are no hazardous elements (e.g. splinters) in places where they can cause injury during proper use (e.g. walls, windows, etc.), that the floor coverings are non-slip surfaces and that the expected use does not cause damage to the building material (e.g. the stair railing does not break if we lean on it).

This also includes the fact that the delimiting structures of the buildings (wall, roof, window, and door) must also ensure the protection of property.

Protection against noise and vibration

We distinguish between two types of sound propagation: airborne sound and body sound. Airborne sound spreads through the air (such as a conversation in an adjacent room), protection against it can also be achieved by using a high-mass containment structure and a soft acoustic as well (e.g. rock wool, glass wool). Body sounds spread within bodies — building structures — (e.g., a person walking in a room above us, hence also called a step sound). The higher the density of a building material, the better it conducts body sounds, so we can protect against them with soft materials - with the right structural design.

Energy saving and heat retention



Thermal protection has a key role to play in making buildings as energy efficient as possible. In this respect, the relevant concepts are heat storage and thermal insulation. An example of heat storage is when the temperature of a heated room is taken in by the wall in winter and then when the temperature drops inside it "radiates" it back. The higher the density of a material, the higher its heat storage capacity is. Thermal insulation, on the other hand, prevents the material or space behind it from absorbing the temperature on the other side (thus protecting the heated space from cooling). In this case, the ratio is reversed, typically lighter materials are good thermal insulators.

Sustainable use of natural resources

This essential requirement applies partly to manufacturing of building materials and partly their environmental impact during use. The production of building materials is a burden to the environment, but we must strive to do as little burden as possible. This depends partly on the manufacturing technology, but it also includes using only the necessary amount of materials. For example, in case of thermal insulation, there is a certain level of thickness after which energy saving can no longer be felt by applying more insulation. It is also typical for thermal insulations that if a material with better thermal insulation can be produced with almost the same production environmental load (e.g. smooth EPS and graphite ESP thermal insulation), it is more sustainable.

4.2 Building structures

Our buildings consist of several main building structures and we have different expectations from them. This chapter provides an overview of building structures, their function and their most typical structural build up.

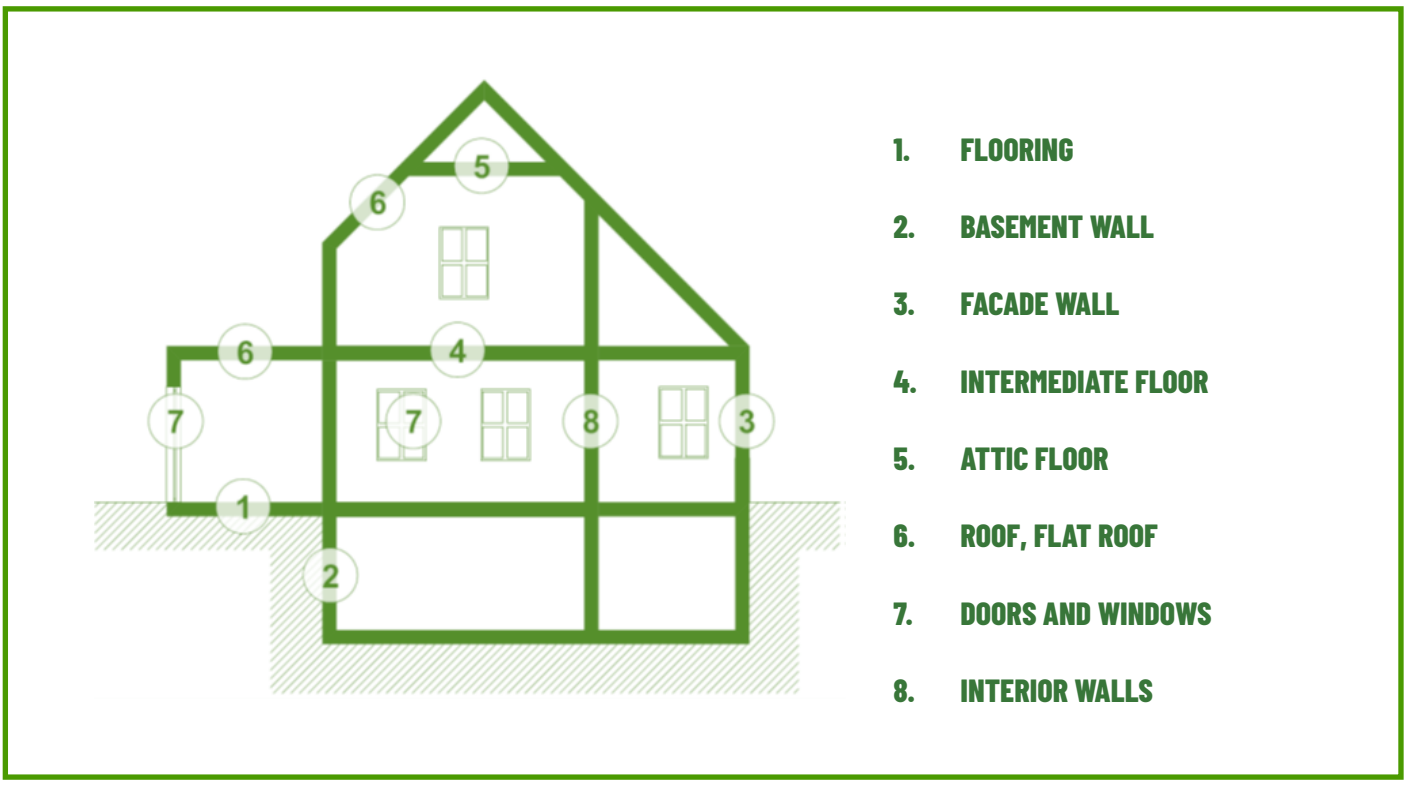
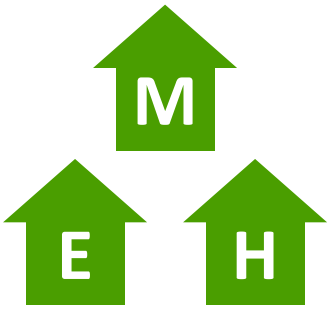


Figure 9: Main building structure types

Flooring

As the name mentions, this structure seals the lowest level of the building, which is in direct contact with the ground. In case of a basement building, it is the basement, in case of a building without a basement, the floor structure of the ground floor.

Requirements and consequent function:



- forms a solid, flat, walkable surface
- insulation against moisture from the ground (soil vapour, soil moisture, groundwater)
- thermal insulation from the ground
- insulation against radon from the ground[39]

Typical structures

1. Monolithic structures

In the vast majority of cases, a monolithic structure (usually concrete – as also referred to subgrade concrete) forms the basis, and additional layers built into and below it, depending on the location, soil moisture conditions and local climate conditions. These are water, radon and thermal insulation layers, as well as floor coverings and related technical layers.

Advantages
- economically feasible
- durable

Disadvantages
- high demand of on-site labour
- weather-dependent design
- subsequent repairs / renovations are more difficult

2. Lightweight structures

In the case of lightweight construction technologies, the floor of the lowest building level may not be monolithic, and is rather made up from some kind of frame structure (wood or steel). In this case, the structure usually does not rest on the ground directly, but is elevated from it to a greater or lesser extent. In such a case, it is also necessary to install layers that allow the required functions to be performed (flat, solid, continuous surface; water, heat and radon insulation, establishment of tread design). Here, more emphasis is placed on thermal insulation.

Advantages
- low demand for labour on site
- less weather-dependent design
- easy to repair / renovate

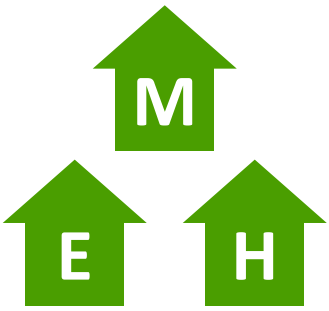
Disadvantages
- more sensitive structural design
- requires a high level of expertise

39 Radon is a colourless, odourless, natural radioactive gas found in the earth's crust. It enters into homes through the soil. Its radioactive decay products adhere to dust particles in the air, which, when inhaled, can damage the lungs.

Basement wall

In basement buildings, it is the wall section that rests on the foundations and extends to the wreath above the basement. This is the vertical boundary structure between the cellar and the ground. It also has a supporting structure role, so the vertical loads of the building are transferred to it, but it can also have a different design.

Requirements and consequent function:



- supporting structure (not always) - bears the vertical loads of the building
- resistance to ground pressure
- waterproofing
- thermal insulation

Typical structures

1. Monolithic structure

Concrete made on the construction site or, in case of higher loads, a reinforced concrete structure on which heat and water insulation can be applied. This solution is usually used when it has to withstand a higher load (e.g. large amounts of groundwater, deep cellar, tall building).

Advantages
- high load bearing capacity
- withstands side pressure with proper reinforcement
- waterproofing failure causes fewer problems

Disadvantages
- high demand of on-site labour
- requires shuttering
- expensive

Typical structures

2. Remaining shutter monolithic structure

A wall structure made of lightweight concrete or concrete shuttering elements, its cavities are poured concrete into them, on site. As an additional layer, heat and water insulation can be applied.

Advantages
- fast construction
- does not require a high level of expertise
- waterproofing failure causes fewer problems
- economically feasible

Disadvantages
- high demand of on-site labour
- less resistant to side pressure

3. Masonry constructed/Built of blocks

A wall made of stone, concrete or brick masonry units. The most common and well-proven masonry material for basement walls is small brick. They also produce frame ceramic products specifically, called cellar masonry. As an additional layer, heat and water insulation can be applied.

Advantages
- preparation does not require a high level of expertise
- economically feasible

Disadvantages
- more sensitive to waterproofing failure
- high demand of on-site labour
- less resistant to side pressure

4. Prefabricated basement wall

Prefabricated reinforced concrete structure, which is lifted to its final location by crane at the construction site. Large, high-level elements.

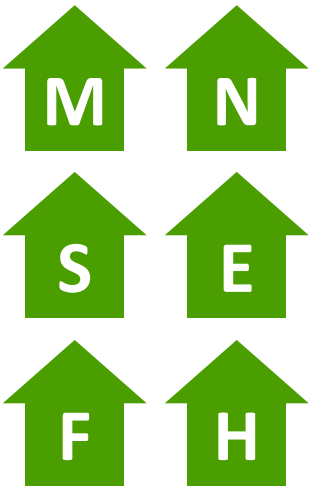
Advantages
- fast construction
- its preparation does not require a high level of expertise
- low demand of on-site labour
- plant prefabricated

Disadvantages
- expensive
- complex on-site work organization

Facade wall

Vertical boundary structure between the exterior and the interior. Often, especially in the case of family houses, it also has a supporting role, so the vertical loads of the building are transferred to it, but it can also be of a different design.

Requirements and consequent function:



- space delimitation
- load bearing
- thermal insulation
- architectural appearance
- reception of doors and windows
- sound insulation

Typical structures

1. Monolithic structure

A wall structure cast between formwork/shuttering, typically of concrete material, this solution rarely used in family houses and smaller condominiums. Additional thermal insulation is required as concrete alone is a poor thermal insulator.

Advantages

- high load bearing capacity

Disadvantages

- high demand of on-site labour
- requires formwork/shuttering
- expensive

Typical structures

2. Remaining shutter monolithic structure

A wall structure made of formwork elements, which is poured with concrete at the construction site. Formwork elements are most often made of lightweight concrete, polystyrene, or wood wool/wood concrete, and they are sized to be moved by hand. The design of formwork elements made of a good thermal insulation material (e.g. polystyrene) allows the wall structure to be made without additional thermal insulation.

Advantages
- high load bearing capacity
- preparation does not require a high level of expertise
- no additional layers required if properly designed

Disadvantages
- high demand of on-site labour
- less commonly used solution

3. Built of masonry

This is the most commonly used solution for residential buildings. Sometimes it is made of stone or concrete, more often of fired ceramics, aerated concrete, wood concrete elements. It is usually necessary to provide additional thermal insulation.

Advantages
- a traditional, well-known solution
- preparation does not require a high level of expertise

Disadvantages
- high demand of on-site labour
- allows a lot of moisture entering into the structure
- time consuming construction

4. Lightweight structure

Some kind of frame structure (typically wood or thin-walled steel) provides the supporting structure; the cavities between them are filled with thermal insulation. Both sides are bounded by building boards (usually gypsum board inside, OSB board outside, but gypsum fibre and cement-bonded chipboard are also common). An important element of the structure is the vapor barrier layer, which is a kind of film preventing excess moisture entering the structure, which could then precipitate and lead to mould. It can be partly or completely prefabricated or assembled on site.

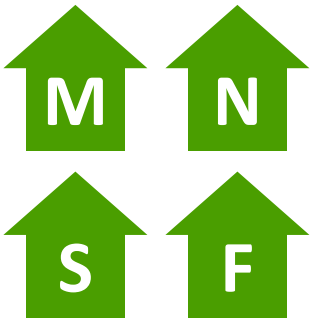
Advantages
- fast construction
- less weather-dependent construction work
- lower on-site labour requirements
- can be prefabricated in operation
- good thermal insulation

Disadvantages
- sensitive to fire
- preparation requires a higher level of expertise
- complex structure

Intermediate floor

A horizontal boundary structure between two functional levels of a building.

Requirements and consequent function



- forms a solid, flat, walkable surface
- forms the ceiling of the level below it
- bears the resulting loads and transfers them to the vertical load-bearing structures (wall, column)
- sound insulation (both airborne and body / step sounds)
- thermal insulation if the temperature require ments of the separated two levels are very differ ent (e.g. slab between living room and garage)

Typical structures

1. Monolithic structure

Reinforced concrete structure with formwork on site. The formwork can also remain in the structure, thus simplifying the construction. It is characterized by high load-bearing capacity, so it is often used in places where the span (distance between support points) is large or the expected load is larger. Adequate sound insulation is provided by the installation of additional layers.

Advantages
- high load bearing capacity
- fireproof

Disadvantages
- heavy
- formwork required (which remains in place)
- high demand of on-site labour
- construction is more time-consuming

Typical structures

2. Beam and block structure (beam and block)

Load-bearing is provided by beams (nowadays they are typically made of concrete or concrete-ceramic composite material, but in the past steel beams were also common), and the sections between them are filled with block elements. Block elements can be made of concrete, lightweight concrete, or ceramic (or other load-bearing material). This often involves an extra layer of concrete, as well as additional layers providing sound insulation and layers of the pavement.

Advantages
- fast construction
- a traditional, well-known solution
- fireproof

Disadvantages
- heavy
- high demand of on-site labour

3. Lightweight structure

Load-bearing is provided by beams (typically made of wood or thin-walled steel), and the cavities between them are filled with thermal insulation. It is bordered at the bottom and top by building boards (usually at the bottom by drywall, at the top by OSB board). Additional layers of insulation are used to achieve adequate sound insulation.
It can be partly or completely prefabricated or assembled on site.

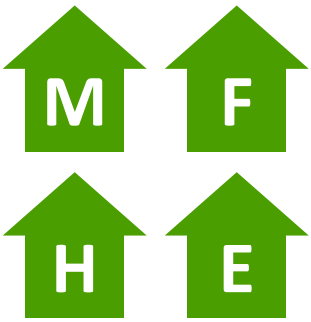
Advantages
- fast construction
- less weather-dependent construction work
- lower on-site labour requirements
- can be prefabricated in the factory

Disadvantages
- sensitive to fire
- preparation requires a higher level of expertise
- complex structure

Attic floor

Horizontal boundary structure between the uppermost functional level and the unheated attic. As it typically has little load, its main function is not load bearing but thermal insulation and space delimitation.

Requirement and consequent function



- spatial delimitation
- forms the ceiling of the level below
- thermal insulation
- in the case of a walkable attic, providing floor structure there as well

Typical structures

1.Monolithic structure

Reinforced concrete structure with formwork on site. The formwork can also remain in the structure, thus simplifying the construction. It is a very rarely used solution, as the main advantage of a monolithic structure - high load-bearing capacity - is typically not required in case of a slab (except for a large span), however, concrete is a poor thermal insulator. Additional thermal insulation layers are used for proper thermal insulation.

Advantages
- high load bearing capacity
- fireproof

Disadvantages
- heavy
- poor thermal insulation
- high demand of on-site labour
- more time-consuming construction

2. Beam and block structure (Beam and liner)

Load-bearing is provided by beams (nowadays they are typically made of concrete or concrete-ceramic composite material, but in the past steel beams were also common), and the sections between them are filled with block elements. In addition to conventional concrete, lightweight concrete or ceramic liners, the closing slab may be made of a heat-insulating material (e.g. polystyrene). It is a solution not as commonly used, for reasons similar to the monolithic structure.

Advantages
- high load bearing capacity
- fireproof
- fast construction
- a traditional, well-known solution

Disadvantages
- heavy
- high demand of on-site
- usually poor thermal insulation

Typical structures

3. Lightweight structure

Load bearing is provided by beams (typically made of wood or thin-walled steel), and the cavities between them are filled with thermal insulation. At the bottom, it is bordered by building boards (usually drywall). The attic-facing walkway is formed with OSB or decking, if necessary. Providing vapour barrier is especially important in this case, it is provided with foil. If necessary, additional insulating layers are used to achieve adequate thermal insulation.
It can be partly or completely prefabricated or assembled on site.

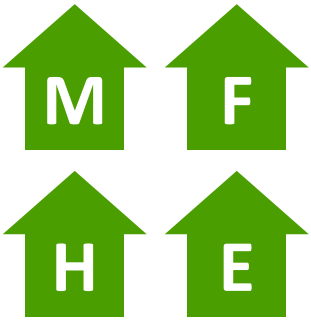
Advantages
- fast construction
- less weather-dependent construction work
- lower on-site labour requirements
- lightweight
- can be prefabricated in the factory

Disadvantages
- sensitive to fire
- preparation requires a higher level of expertise
- complex structure

Roof, flat roof

The top closing structure of the building. It can be designed with a high roof - at an angle closing more than 8 degrees to the horizontal - and a flat roof with a horizontal angle of up to 8 degrees. Various designs are possible, as well as materials that prevent water from entering. In case of a flat roof, a surface-continuous waterproof insulation sheet provides protection against precipitation, while in case of a high roof, two layers do accordingly: the roof cladding (e.g. tile, sheet metal, bituminous shingles) and the underlying foil together provide protection.

Requirements and consequent function



- insulation against precipitation
- space delimitation
- thermal insulation (flat roof and high roof in case of attic installation)
- sound insulation (flat roof and high roof in case of attic installation)

Typical structures

1. Monolithic structures

Reinforced concrete structure with formwork on site. The formwork can also remain in the structure, thus simplifying the construction. This solution is usually used for flat roofs where the distance between the supporting structures is large (large span). Thermal, sound and water insulation are provided by the installation of additional layers.

Advantages
- high load bearing capacity
- fireproof

Disadvantages
- heavy
- poor thermal insulation
- formwork required (which can be left in place)
- high demand of on-site labour
- construction is more time-consuming

2. Beam and Block Structure (Beam and block)

Load bearing is provided by beams (nowadays they are typically made of concrete or concrete-ceramic composite material, but in the past steel beams were also common), and the sections between them are filled with block elements. This solution is used in case of flat roofs. Thermal, sound and water insulation are provided by the installation of additional layers.

Advantages
- high load bearing capacity
- fireproof
- fast construction
- a traditional, well-known solution

Disadvantages
- heavy
- high demand of on-site labour
- generally poor thermal insulation

3. Lightweight structures

High roofs typically have this type of structure but these solutions are also applied in flat roofs. In case of a flat roof, the difference compared to the intermediate slab is that additional layers are applied to provide thermal and water insulation (sloping layer, waterproofing sheets, additional thermal insulation, etc.). In case of a high roof, the sloping load-bearing beams are called rafters, and the horizontal ones are called slats. The rafters or slats (depending on the structural design) are covered with roofing and with the necessary structural layers (underlay, roof slats, tiles, etc.). In case of an attic, the parts between the supporting structures are filled with thermal insulation material and are covered from the inside (usually with plasterboard or other building board). Vapour barrier is provided as foil.
It can be partly or completely prefabricated or assembled on site.

Advantages
- fast construction
- a traditional, well-known solution
- lower on-site labour requirements
- can be prefabricated in operation
- light
- good thermal insulation

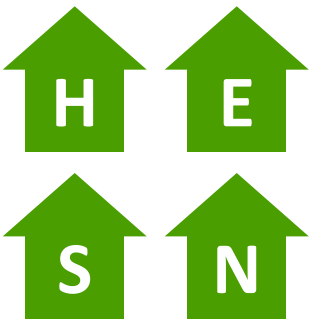
Disadvantages
- sensitive to fire

Doors and windows

A predominantly vertical (typically the roof plane window located in the plane of the roof) boundary structure between the exterior and the interior. It has no load-bearing function. Its tasks are to ensure at least one of the following:

- access;
- view;
- natural ventilation;
- lighting with natural daylight;
- favourable facade appearance.

Requirements and consequent function



- space delimitation
- thermal insulation
- sound insulation
- safe operation
- architectural appearance

Typical structures

1. Wood

The traditional material for doors and windows. Today's complex and high-level requirements are met by complex structure designs developed by professional engineering work.

Advantages
- pleasant surface

Disadvantages
- expensive
- high maintenance
- UV sensitive

Typical structures

2. Aluminium

Light metal frame covered door and window, which is made for various profiles and appearances.

Advantages
- high load capacity
- stability
- long service life
- not sensitive to UV
- low maintenance

Disadvantages
- expensive
- less pleasant feel of the metal surface
- worse heat insulating capacity

3. Plastic

Doors and windows with a plastic (usually PVC) frame structure and cover, which are made for various profiles and looks.

Advantages
- economical (good value for money)
- long service life
- good thermal insulation
- low maintenance

Disadvantages
- UV sensitive

4. Wood / aluminium, plastic / aluminium

It combines the advantages of doors and windows of different materials. Primarily, the outdoor aluminium cladding is important, it prevents damage from UV radiation

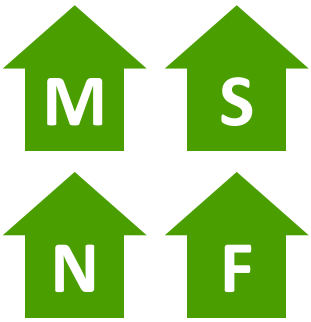
Advantages
- UV resistant
- low maintenance necessity

Disadvantages
- expensive

Interior walls
(partition wall, interior bearing wall, sound proofing wall)

A structure that vertically separates the interiors of the building. Its length and height are multiplied compared to the values of structural thickness. In addition to space separation, it can also have other functions: load-bearing, sound insulation, in rare cases thermal insulation.

Requirements and consequent function



- in case of internal load-bearing walls, load-bearing, stiffening
- fire demeanor appropriate to its role in the building
- impact resistance
- carrying equipment and fittings
- sound insulation according to the level of demand

Typical structures

1. Monolithic structures

A wall structure, typically of concrete material, cast between the formwork. Due to its high load-bearing capacity, it is used as a load-bearing wall. A solution rarely used in family houses and smaller condominiums.

Advantages
- high load-bearing capacity

Disadvantages
- high demand of on-site labour
- requires formwork
- slow construction
- expensive

Typical structures

2. Remaining shutter monolithic structure

A wall structure made of formwork elements, which is poured with concrete at the construction site. Formwork elements are most often made of lightweight concrete, polystyrene, or wood wool / wood concrete, and can be moved by hand.

Advantages
- high load-bearing capacity
- not require a high level of expertise

Disadvantages
- high demand of on-site labour
- less common solution

3. Built of masonry

The most commonly used solution for residential buildings. Occasionally made of stone or concrete, more often brick (fired clay masonry element), aerated concrete, wood concrete, gypsum elements.

Advantages
- traditional, a known solution
- not require a high level of expertise

Disadvantages
- high demand of on-site labour
- it allows a lot of moisture entering into the structure
- time consuming construction

4. Lightweight structure

Some kind of frame structure (typically wood or thin-walled steel) provides the supporting structure, the cavities between them are filled with thermal insulation. Both sides are bordered by building boards (usually gypsum board inside, OSB board outside, but gypsum fibre and cementitious chipboard are also common). It can be partly manufactured, completely prefabricated, or assembled on site.

Advantages
- fast construction
- less weather-dependent design
- lower on-site labour requirements
- can be prefabricated

Disadvantages
- sensible to fire
- its preparation requires a high level of expertise
- complicated structural build up

4.3 Building materials

There are many types of building materials and with the improvements of manufacturers, more and more new products are appearing on the market. In the following section, we present the most frequent building materials, grouped by functionality. Their detailed properties are described in the annex of this handbook.

Concrete – a mixture of cement, water, aggregate (typically gravel -with a professional expression: sandy gravel) and in some cases, admixtures. It is incorporated in a wet-plastic state and acquires its final shape and load-bearing capacity during the chemical transformation that takes place during drying-solidification (usually within 28 days). It usually has high load-bearing capacity and strength, but its load-bearing capacity depends on many factors (amount of cement, type of aggregate, etc.). Steel bars and nets are often used to increase the load-bearing capacity, in which case they are referred to as reinforced concrete. Prefabricated elements can also be made from it. It is not combustible. It can be waterproof if properly formulated. It is versatile and can be used for almost any supporting structure from base to flat roof.

Most common types:

brick (fired clay masonry element) - building elements made of clay, which, after moulding, burned out at an ambient temperature of 1000 ° C. Its main varieties are solid, hollow bricks. Not combustible. Moderately sensitive to water. Fired clay is also used as a slab lining element and a bridge in various building systems, and can be used also as a facade cladding element. One of the most common masonry elements is the frame ceramic brick, which in case of light load - e.g. it can also be used as a 1-2 storey house - load-bearing wall, but it is built as a space delimiting, space dividing and facade infill masonry.

aerated concrete - a masonry element based on lightweight concrete or aerated concrete. A pore-forming additive is added to the fresh concrete mix, which will thus have a "perforated" structure. It is significantly lighter than conventional concrete, so masonry elements have a manually movable mass and are better thermal insulators. Not combustible. Less sensitive to water. In addition to masonry elements, large wall, ceiling- and roof planks can also be made of aerated concrete.

Masonry elements

–building blocks of a size movable with hands from which masonry can be made. Masonry elements are usually clamped to each other with a mortar or a special adhesive mortar, but the geometrical design of the adjacent elements can be (so called groove design) that does not require fastening material.

Most common types:

clay/loam- a mineral additive mixed with organic fibres (e.g. straw), a mixture of clay, sand and occasionally sludge. The mineral part can also come from clay soil or an artificial mixture of clay and sand. A homogeneous structure can be made of it by compaction (so-called beat wall), or it can be made of moulded and compacted bricks. It is one of the basic building materials of folk architecture. It is not combustible, but its load capacity is reduced by fire. Sensitive to water. It is usually used for walls.

natural stones - materials rarely used today, these masonry materials are carved natural stones, e.g. andesittufa, rhyolite tuff, basalt. They are not combustible. They are sensitive to water to varying degrees. In the past, they were used for both priming and wall making in easily accessible areas.

Thermal insulation materials – low-density building materials for thermal insulation. They are also varied in material and construction. They are usually in the form of boards, quilts or bulk. If they absorb water, it greatly impairs their thermal insulation capacity. Their important property is vapour permeability, which affects the type structures they can be incorporated into.

Most common types:

ESP (expanded polystyrene) - thermal insulation made of foamed plastic (polystyrene), which consists of small spheres. They can be enriched with graphite, which improves its thermal insulation. It is usually low-solidity, but there is also a "step-resistant" version with increased firmness. Combustible. It can absorb water. Moderately vapour permeable. Uncompressed spheres typically sold in slabs, but also used also as concrete additive. Its main areas of application are thermal insulations for facade walls, flat roofs and floors on the ground.

XPS (extruded polystyrene) - homogeneous, foamed plastic (polystyrene) thermal insulation. It usually has a low-solidity, but there is also a "step-resistant" version with increased firmness. Combustible. It does not absorb water (this is the most significant difference in terms of use between EPS and XPS). Its vapour permeability is low. They are sold in boards of different thicknesses. Its main areas of application are the thermal insulation of plinths, flat roofs and floors on the ground.

PUR - homogeneous, foamed plastic (polyurethane) material for thermal insulation. Due to its very good thermal insulation ability, it often used in cold stores and other areas where a thinner layer requires more thermal insulation performance. Its solidity can even be extremely high, depending on its chemical composition. Combustible (there are versions that are less combustible – e.g. PIR foam). It does not absorb water. Its vapour permeability is low. It used in several forms. It can be panelled, sandwich panelled, or foamed on site (two-component). Its main areas of use are sandwich panels and cold stores.

Most common types:

rock wool - a thermal insulation material made mainly of glassy fibres and thermosetting (usually phenol-formaldehyde) binder resin made from a melt of a mixture of volcanic and sedimentary rocks (e.g. basalt, diabase, limestone, etc.). Its solidity ranges from relatively high (step-resistant versions) to negligible. Non-combustible and even is used as a flame retardant. It has the ability to absorb water. Due to its fibrous structure, it is vapour permeable. It can also be in the form of boards and quilts. The panel version is used for the insulation of facades and flat roofs, the quilt (which is sold in rolls) is used to fill the frame structures (walls, ceilings, roofs).

glass wool - a thermal insulation material made of mineral fibres similar to rock wool. Its raw material is sand, recycled glass and binder resin (usually phenol-formaldehyde). Its solidity ranges from relatively high (step-resistant versions) to negligible. Not combustible. It has the ability to absorb water. Due to its fibrous structure, it is vapour permeable. It can be in the form of boards, quilts, or bulk fibres. The panel version is mainly used for sound insulation, but there is also a version suitable for facade thermal insulation. The quilt (which sold in rolls) used to fill frame structures (walls, ceilings, roofs). Bulk fibrous glass wool, which is blown in with a special machine, can be used to insulate hard-to-reach places (e.g. cavities).

cellulose - bulk thermal insulation made from recycled paper to which additives (usually boron, boric acid and phosphate) added to protect against fire and biological pests (mould, rodents). The solidity of the material is negligible and it is not loadable. Not combustible. It has the ability to absorb water. Vapour permeable. They are introduced into the building structure by machine blowing, it also fills irregular or small gaps and gaps between the frame columns and beams.

straw - a natural thermal insulation material, an agricultural by-product consisting of the stalks of cereals after ripening. Its use in construction is limited. Combustible. It has the ability to absorb water. Vapour permeable. Its most common application is the filling thermal insulation of frame structures, which can be in bales or in bulk and compacted. It is extremely important that the structural design have to provide protection against fire, water, and biological pests.

wood wool - a thermal insulation product made of wood fibres with the addition of a binder or adhesive. The binder can be an organic or inorganic resin, or even cement. It is made with a variety of fibre sizes and densities. It can also be heavy duty. It is hardly flammable (but it depends on the density and the binder). It has the ability to absorb water. Vapour permeable. Manufactured in slabs, used for facade, flat roof and ceiling thermal insulation.

Frame materials - in lightweight structures, load bearing is provided by beams and columns, as they do not form a continuous wall or ceiling surface, therefore, their function is limited to load-bearing capacity. In larger buildings (for high loads) they are made of concrete or thick-walled steel profiles, while for lower loads, wood and thin-walled steel are common.

Most common types:

wood - a natural building material. Its strength properties can be very assorted, strongly depending on the species of wood, moisture content, cramping, etc. In the construction industry, typically pines are used. Common methods of improving the properties of construction wood products are longitudinal expansion, artificial drying and ply gluing. Wood is treated with wood preservatives against fire and biological pests.

thin-walled steel - the various profiles (U, C, Z - these symbols refer to the shape of the profile) are produced by cold rolling, from sheet steel. It must be protected against corrosion (galvanizing). It is non-combustible, but loses most of its load-bearing capacity at temperatures around 600 ° C. It is resistant to biological pests, but its protection against water must be ensured with a layer of zinc.

Most common types:

bituminous insulation - bitumen is a black, thermoplastic hydrocarbon mixture which remains after the distillation of mineral oil. It can be used in several forms as insulation: lubricated insulation (bitumen emulsion, solvent bitumen), thin and thick sheets, which can be provided with surface protection if necessary. They are sold in rolls. They are usually made in multiple layers. It is also widely used as an insulation against soil- moisture and vapour, rainwater, service water and vapour.

plastic waterproofing materials - waterproofing sheets can be made of different types of plastics. They can be thermoplastic so-called plastomer (e.g. plasticized PVC (polyvinyl chloride)) or non-thermoplastic elastomeric (rubber-like, e.g. butyl rubber, EPDM) materials. They are usually made in a single layer. They are rarely used as insulation against soil moisture and soil vapour, usually used as insulation against rainwater.

polyethylene (PE) film - a thin film made of polyethylene, its main mode of application is vapour barrier. Fibre reinforcement is used to improve its mechanical properties.

aluminium foil - a thin aluminium foil used for vapour barrier. It can be multilayer and fibre reinforced.

Water and vapour insulation - we use different insulation sheets and foils against water and vapour. In case of insulations, durability and UV resistance in locations that are exposed to sunlight, as well as the formulation of waterproof design of splices and fixings are important. Insulating materials are bitumen, plastic (most commonly PVC and polyethylene) or aluminium. Based on function, we distinguish between insulation against soil- moisture and vapour, rainwater, service water (e.g. bathroom) and vapour.

Roofing - building materials used for covering high roofs. They are diverse in both material and form. Their primary function is to prevent rainwater from entering the structure. At the same time, it is important to emphasize that they are not waterproof as they only form a watertight surface, so underlay is necessary under them. As an outermost layer, it also strongly influences the architectural appearance of the building.

Most common types:

tile (clay and concrete) - a single-element roofing material that can be made of fired clay or concrete. It characterized by a variety of formal designs. The tiles are fixed to roof slats, the elements overlap. The angle of inclination of such covered roofs is preferably 35-45 °.

bituminous shingles - self-adhesive roofing material made of bitumen applied on a strong substrate, its surface is covered by granules. It must be fixed on a continuous substrate (e.g. OSB) and the elements overlap. It can also cover a variety of roof shapes and can be used at an angle of between 15 and 90 °.

Most common types:

sheet metal - roofing materials made of thin sheet metal, usually with surface protection against corrosion. Their materials can be varied, the most commonly used are galvanized steel, titanium-zinc, aluminium and copper. In terms of form and fixation, the most common types are:

metal roof - a metal plate forming a tile in its appearance, it is fixed to roof slats with the elements overlapping each other. The roof inclination is at least 15 °.

trapezoidal plate - a self-supporting plate with a characteristic of a trapezoidal cross-section, it is fixed to flanges. The minimum roof inclination is 5 °

standing seam metal roof - long sheets are fastened together at their edges with special tools. They need full-surface support. The roof angle is at least 10 °.

slate - single-element roofing material, made of natural slate rock. Once the use of asbestos slate (of which there was a single-element and a large-element so-called corrugated slate) was widespread, which is a roofing material made of asbestos and cement. Usage is now banned, as asbestos presents a serious health hazard. Fibre cement is a slate-like roofing material produced with asbestos-free technology. The slate fixed to the surface-continuous substrate by nailing or stapling, the elements overlapping each other. The minimum roof inclination is 22 °.

wooden shingles - one to two centimetres thick, six to fifteen centimetres wide, thirty to sixty centimetres long, split or sawn wood roofing material. They fastened to the roof battens with nails and the elements overlap. The minimum roof inclination is 10 °.

reed - a natural roofing material, the reed is tied into sheaves and fixated to the roof slats with a large thickness (50-100 cm). It has good thermal insulation, but it is highly flammable. The angle of inclination of the roof is usually 30-45 °.

Most common types:

plasters - the most common facade-forming materials. The plaster mixture is applied to the wall after mixing it with water. It usually consists of several layers with different functions. To improve their mechanical properties, plaster reinforcement mesh is installed. It is applied directly to the thermal insulation system or to the masonry unit.

metal cladding - thin, shaped metal sheets that are attached to some secondary structure (i.e. not directly to the retaining wall). The material can be varied, the most common is galvanized steel, titanium-zinc and the aluminium. According to their design, the most common types are:

trapezoidal plate - a self-supporting plate with a characteristic trapezoidal cross-section.

cassette cover - small and medium-sized bent sheet made of rectangular elements.

panel cladding (sandwich panel) - not only wall cladding, as it also provides space and thermal insulation as an element. There is a thermal insulation core (usually PUR, PIR, rock wool) between two metal sheets.

Facade cladding (and cladding systems) - the outer layer of the facade walls, which, in addition to significantly contributing to the appearance of the building, has the main function of protecting the underlying layers from mechanical damage and precipitation. It is characterised by a variation in terms of appearance and material use.

Most common types:

wood cladding - coverings made of planks, planks or plywood, which are fixed to secondary structures (e.g. slats), there is an air gap behind them (therefore it is advisable - in Hungary it is mandatory - to use non-combustible thermal insulation for such coverings). It is necessary to protect it from the weather with surface treatments. The high fluctuations in temperature is not well-tolerated in terms of the material.

stone cladding - natural stones used as facade coverings cut into 2-8 cm tiles. It is usually fixed to the secondary support structure with special fastening elements, but - if the wall structure is suitable, it can also be fastened with gluing. Their durability and the demand for maintenance depend on the material of the stone and surface treatment.

brick cladding - fired clay cladding material. The brick of normal thickness (10-12 cm) is fixed to a secondary support structure, the covering brick, which is 2-3 cm thick, is fixed by gluing. It gives a distinctive look to the building. Minimal maintenance is required for this covering.

Building boards - surface-continuous, self-supporting boards, fastened usually to the back structure mechanically (by nailing or clamping). Their use is extremely versatile, in case of lightweight construction it can be used as a cladding plate, as an underlayer itself for roofing, and in many other cases with the aim of covering gaps and cavities.

Most common types:

gypsum board - the basic material of gypsum and cardboard. It is non-combustible and even has excellent fire protection properties (there is also a version with increased fire protective properties). It is normally sensitive to water but this property can be improved by impregnation. Its stiffness and impact resistance are not outstanding. It can be used indoors.

gypsum fibre board - building board made of gypsum, paper fibres and mineral wool additives. It has high rigidity and high impact resistance. It is non-combustible and it has good fire protective properties. It is less sensitive to water, so it can be used outdoors with adequate surface protection.

cement-bonded chipboard - made of wood chips, cement and additives. It has a high surface hardness, it is rigid and the material is impact resistant. Not combustible. It is not water sensitive and can be used outdoors.

OSB (Oriented Strand Board) - it is a wood-based material. The name refers to its material structure, which ensures the strength of the product. In terms of its structure, it is a three-layer sheet, the position of the chip-layer in the middle is perpendicular to the longitudinal side and in the extreme layers, it is parallel to it. The fibres are compressed under high pressure with a water and heat resistant resin. It has good mechanical properties, is a flexible, impact-resistant and combustible material. It is less sensitive to water, so it can be used outdoors with adequate surface protection.

plywood - a wood panel made up of an odd number of peeled veneer layers. The wood species and thickness of the symmetrically placed layers are the same. The layers used to be glued together, now it is more recently done with resin. The fibre direction of the layers is always perpendicular to the previous one. It has good mechanical properties, flexible, impact resistant. Combustible. It is sensitive to water but can also be used for outdoors with impregnation and adequate surface protection.

a. Construction products, declaration of performance (DOP)

In the minds of builders, such as designers and constructors, a building is made up of structures as well as building engineering, heavy and light current systems. The building engineering and electrical systems include wiring and "units," i.e., items of equipment such as an electric boiler, plumbing, bathtub, and faucet. The building structures consist of building materials and products, such as a slab of slab beams, lining bodies, concrete on top of them and additional reinforcing bars.

Some of the building materials, products, as well some of the equipment and devices are collectively called construction products. It is no coincidence that we wrote that "some" – as in the case of complex structures like buildings for example the whole systems is so complex that overlaps and exceptions quickly peek behind simplifications, but the above approach can be considered as a good one.

Construction is a serious matter as houses are built for a long time and a significant amount of money is involved, so it is essential to appropriately and precisely regulate the processes and conditions by means of law. The above-mentioned Building Act stipulates that a construction product may only be designed or installed in a construction if the basic requirements for construction are met. These basic requirements are also defined in the already mentioned government decree, Government Decree 253/1997 on national settlement planning and construction requirements, abbreviated and commonly known as OTÉK.

The essential requirements are described in more detail in Chapter 4.1 of the Handbook.

A product is considered suitable for a given design and installation situation if the essential requirements for construction works are met either directly or indirectly by the performance of the installed product. This means that the construction products are suitable, if the house built from them functions well and safely for a long time.

A construction product may be used if - with a few exceptions -, its performance is certified by a declaration of performance (DOP). This is a document issued by the manufacturer of the product, and it contains the characteristics required for its use, more specifically the performances at related to the essential requirements at least.

The DOP has been invented by the European Union. The EU regulation No 305/2011 of the European Parliament and of the Council entered into force on 1 July 2013, and it sets harmonised conditions about the distribution of construction products. This decree regulates the distribution of some construction products within the Union. The DOP summarizes in a document what we need to know about the product from a technical point of view. Its legitimate existence enables the product to hold a "passport", the well-known CE mark, which allows free travel throughout the internal borders.

DOP, as a type of document, therefore derives from this EU regulation, called CPR according to its abbreviation in English, which entails the EU market, the free movement and distribution of goods. A special Hungarian legislation, Government Decree no. 275/2013 about the design and installation of a construction product into a building and about the detailed regulation of certification regarding performance states that a construction product can be used only if it holds a DOP. This decree is only valid in Hungary, although the requirements are similar in many countries of the EU.

From the above-mentioned aspects, we can already see how it is important for all participants in the construction process, including the builder and the future residents, that the designed and installed materials, so the construction products have their appropriate DOP.

For a better understanding, we will briefly and, of course in a simplified way summarise the related elements of the design and construction process.

To provide an example, the client wants to let build a house. The client has a vague or general idea on how the building should look like, and then together with the designer they discuss and finalise their ideas in a so-called designer program. This is also important because this way a competent professional can help in formulating the ideas, and in clarifying processes that can be done and whether if it is worth to be done as well as what cannot be implemented as of the constructors' thoughts.

After that, the architect designs the house, getting there in numerous steps to think about how the building will be implemented. This includes determining the expected technical performance of the construction product to be used

in relation to the essential requirements already listed above. It is also based on the effects arising from the construction and the use of the building, as well as on the legal requirements and professional rules. This is also part of the design process.

The constructor may only install such construction products into the house whose performance - as specified by the manufacturer in the declaration of performance - corresponds to the expected technical performance specified by the designer. Finally, all the process is documented by the declarations of performance.

4.4 Building services systems - heating, cooling, ventilation

Residential buildings today are almost unimaginable without various technical building systems. Most of these have become a part of our everyday lives that we hardly even notice there functioning. But what are these systems? To put it very simply, any equipment that is related to piping or wiring within a building can be considered. It includes plumbing, electricity and natural gas, as well as the chimney and associated machinery and fittings (boiler, vents, thermostat, radiators, etc.).

Building services systems play a variety of roles. They provide adequate comfort, such as heating in winter, and pleasant cooling in summer, hot and cold-water supply, drainage of the generated wastewater, and more and more often ventilation as well. Furthermore, these systems make sure that electricity from the grid is properly supplied to our electrical gadgets and equipment, or we can even produce our own energy using solar panels, solar collectors and so on. Further relatively common systems are alarm and access control systems, elevators and, much less frequently, central vacuum systems and automatic shielding systems.

From an environmental point of view, such equipment must be produced in the same way as building materials and, eventually, once they cease functioning, they will become waste. More importantly, however, their operation involves energy consumption, which is not only costly, but energy production is one of the most polluting industries.

The different building services systems are detailed in chapter 6.1.