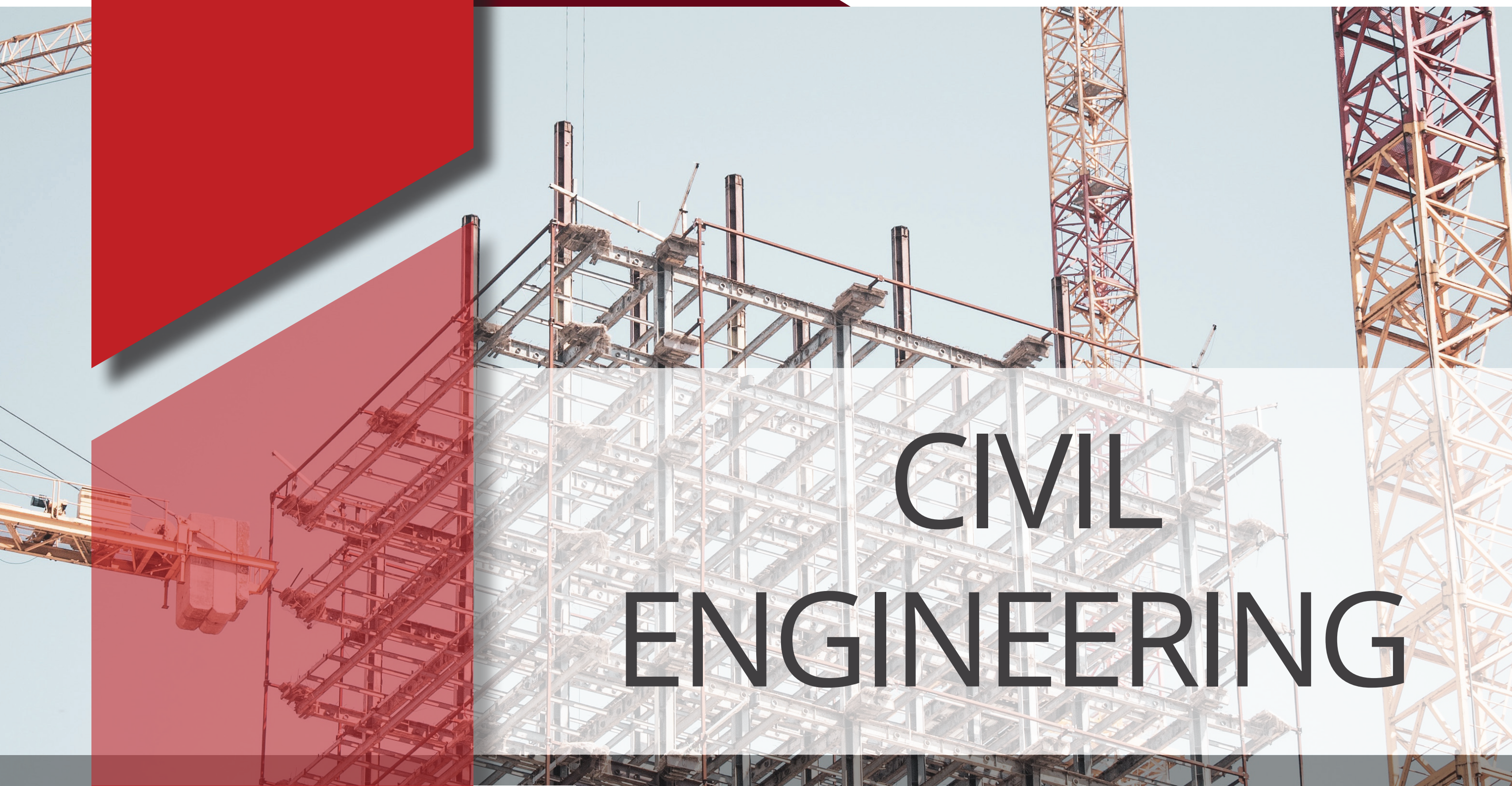
Interreg
EUROPEAN UNION
Austria-Czech Republic
European Regional Development Fund



CIVIL ENGINEERING

Building construction 2

UNIVERSITY OF APPLIED SCIENCES UPPER AUSTRIA
VŠTE
EUROPEAN UNION

CONTENTS

1. SHALLOW FOUNDATIONS

1.1. Shallow foundations

Shallow foundations are the most widely used type of foundation structures. Shallow foundations are used when a sufficiently bearing layer of soil is under the footing bottom. The material of the foundation structures must withstand the effects of load and ground moisture. The minimum depth of foundation is 800 - 1200 mm below the surface so that the footing bottom is in a non-frosty depth. The most commonly used materials are quarry stone, concrete or reinforced concrete. The foundation structures include pad footing, strip footing, footing grid and foundation slab.

1.2. Pad footing

Pad footing are the foundation structures that are mostly made for the foundation of the column construction system. Pad footings transmit point loads from the columns into the ground. The ground plan of pad footings is mostly square, less often rectangular or circular. Square pad footings are designed especially for the centre load. The pad footings are economically and productively advantageous if their side is not more than half the axle spacing of the columns, otherwise grid, slab or pile foundations are more useful.

Vertical constructions such as partition walls, perimeter structures, or staircase walls are based on foundation lintels or foundation thresholds that carry the load on individual pad footings.

The shape, material and dimensional design of the pad footings depends on the anchorages of the columns or other structures mounted on the feet. pad footings can be one-stage or two-step.

Classification of pad footings according to the technology implementation:

- Monolithic pad footings:
  - Pad footings made of plain concrete
  - Pads footings made of reinforced concrete
  - Pad footings interspersed with stones

- Prefabricated pad footings:
  - o Hollow (calyx) pad footings
  - o Full pad footings

MONOLITHIC PAD FOOTINGS

Monolithic pads are made of plain concrete or reinforced concrete, optionally as combined:

- Pads made of plain concrete are used only for small layout plan dimensions (up to 2 m of side size), for centrifugal loads and for bottom footing with permissible load capacities above 2 MPa. Surface of the pad is defined by the load and permissible bearing capacity of the foundation soil. The height of the monolithic pad is determined by the size of the lining and the displacement angle. If the pad height is greater than 1 meter, the pads are designed to be stepped. The concrete foot can be concreted directly into the formwork. Pads made of plain concrete can be concreted directly into the formwork.

- Pads made of reinforced concrete are designed for larger layout plan dimensions, eccentric loads and base soil with accessible stresses up to 0.15 MPa. Reinforced concrete pads are relatively low because the displacement angle tgα is 0.5 - 1. The top surface of the pads is most often skewed. If the angle of inclination of the upper surface is less than 35 °, the top of the pads can be concreted without formwork. At a higher slope, formwork is required. The pads are concreted into ready formwork, for which the excavation on each side needs to be extended by the necessary handling space. Below the reinforced concrete pads, it is necessary to make a concrete foundation layer with a thickness of 50 to 100 mm to protect the reinforcement against corrosion.

PREFABRICATED PAD FOOTINGS

Pre-cast pad footings made of reinforced concrete or pre-stressed concrete are used for assembled skeleton structures. Prefabricated pad footings may have different ground planes (rectangular, circular, polygonal, star-shaped, etc.). The most widespread are the pads with rectangular cross sections. These pads are manufactured in two basic design variants:

- Hollow (calyx) pads footings or nesting pads have a recess into which a prefabricated column is mounted on a cement mortar bed, and after locking they are concreted.

- Full pads footings are manufactured as one-stage or multi-stage. Column connection with pad provides reinforcement anchor inserted into the opening in the pads and potting cement mortar. The reinforcement is welded to the shod foot of column.

Pre-cast pad footings are laid on the base panels or on monolithic load distribution slab. The dimensions are determined by calculating the column load and bearing capacity of the foundation soil. The bottom footing must be aligned with a layer of sand or base concrete at a thickness of 100 and 150 mm. The foundation lintels can be supported by the pad footings.

1.3. Foundation lintels

Lightweight continuous structures (walls of non-cellar light buildings, perimeter walls, etc.) can be based on a foundation lintel which load is transferred to the foundation block to the bottom footing in frost-free depth.

1.4. Strip footing

Strip footings are used to support both load-bearing and non-load-bearing walls from 6 N/m2 - i.e. approximately 150 mm thick and 3 m high. Lightweight partitions and structures are placed directly on reinforced concrete. The minimum size of the strip footing is 300 x 300 mm. Columns are based on strip footings in cases where the pads are too large or in the case of the skeletons with unevenly laid ceilings.

Strip footing forms a continuous beam, which may be rectangular, stepped, plate or ribbed in cross-section. Depending on the material used, we can distinguish strip footings made of quarry stone, plane concrete and reinforced concrete. Concrete and reinforced concrete structures may be monolithic or prefabricated.

The width of the strip footing (b) is determined by the load and admissible bearing capacity of the subsoil. The height of the base (h) is derived from the size of the foundation extension (a) and the size of the displacement angle and the permissible load of the suboil. For the calculation of the height of the strip footing, the relation can be used: $h = a.tg\alpha$, where $tg\alpha$ is for the stone 2 - 3, for plain concrete 1,5 - 2 and for reinforced concrete 0,5 - 1.

STRIP FOOTING MADE OF QUARRY STONE

Strip footings made of quarry stone are used only rarely. The most commonly used stone is marlite. Strip footings can be used for low-load walls. Strip footings can be made one or two steps.

STRIP FOOTING MADE OF PLAIN CONCRETE

Strip footings made of plain concrete are used for wall constructions. They can be single-stage (rectangular cross section) or graded at higher base heights. The plain concrete strips have a minimum size of 300 x 300 mm

STRIP FOOTING MADE OF REINFORCED CONCRETE

Strip footings made of reinforced concrete are used for heavy loads transmitted to the foundations with less bearing and non-homogeneous subsoil. The shape of the reinforced concrete strips may be rectangular, with a sloping upper surface or a cross-section of the inverted T. Strip footings made of reinforced concrete are concreted either in longitudinal or transverse alignment with the supporting beams of the skeleton. The stiffness of the strips for large buildings can be increased by stiffening strip footings located perpendicular to the main strip footings. Below the reinforced concrete strip footings, it is necessary to make a base layer.

PREFABRICATED STRIP FOOTING

Strip footings assembled buildings can be made of prefabricated panels. Prefabricated strip footings are used when loading the foundation soil is from 0.2 MPa to 0.35 MPa. The prefabricated parts are made of concrete or reinforced concrete with dimensions graduated for different loads and up to 3 meters. The parts have a rectangular or trapezoidal cross-section. The pre-cast strip footings are put into a sand bed of 100-150 mm thickness, which equalizes the bottom of the excavation.

1.5. Grid footing

Grid footings are formed by strip footings, generally perpendicular to each other. Footing grid are used for heavily loaded skeletal structures designed in non-homogeneous subsoil in soils with high compressibility, undermining or seismically unstable areas.

1.6. Foundation slab

The foundation slabs distribute the load on the entire surface of the ground plan of the building so that the bottom footing is stressed more evenly than other types of foundations. Foundation slabs are used in inhomogeneous, low-load-bearing and extensively compressible base soil. The slabs are designed if the calculated width of the strip footing is so large that there is little soil between the concurrent strips. The slabs are used for the construction of high-rise buildings and for extremely heavy-load structures. The foundation slabs can also be used for groundwater foundation.

It is always necessary to consider the use of the foundation slab, since it is rather expensive and demanding for mass consumption and, especially in the case of insufficient reinforcement, is subject to failure due to the uneven settlement of the building.

The foundation slabs are made of reinforced concrete as straight, ribbed, grate, headed, shell or gable. Straight slabs have a constant height of 400 and 1200 m across the floor plan and are used at distances of supporting walls or columns up to 4 m. With the greater axial spacing of vertical structures or greater load on the slabs, it is preferable to reinforce the slabs with ribs that are better resistant to deformations. The rib can be placed above or below the slab. The advantage of a top ribbed slab is that it allows positioning between the ribs. The disadvantage is the need to create a formwork ribs and separate floor construction. The slabs with the lower ribs are not suitable for foundation below the water due to the complicated implementation excavation and waterproofing. Heavily loaded skeletal structures can be based on head or grate foundation slabs. The head slab is very advantageous both in terms of production and economy and is also the most commonly used. The only disadvantage is the protruding feet above the floor level. Instead of a slab, a monastery vault or slab reinforced with a beam system can be designed, which is more rigid than a simple slab.

2. DEEP FOUNDATIONS

2.1. Deep foundations

Deep or vertical foundations transmit the load to the depth through vertical elements. Deep bases are proposed in the case of insufficient bearing capacity and high compressibility of the surface layers. Ground structures are mostly based on pilots. Less often on shaft pillars, foundations wells or caissons.

2.2. Foundation piles

Foundation piles are rod elements of the circular or square section, which transfer the load of the building on the foundation soil in depth. Piles are elements whose length to transverse dimension is at least 5: 1.

Depending on the transmit the load to the subsoil, the piles are pushed, tensile, oblique, and piled loaded by bending and buckling. Most often there are pushed pilots (end bear, friction and bearing-cum-friction pile). End-bearing piles carry the load predominantly by a tip that is supported by a bearing suboil. Bearing-cum-friction pile carry the load on both the tip and the friction on the casing. Friction piles do not interfere with load-bearing soil and are all their length in the non-loading-bearing soil to which they carry the load only by friction on the casing.

Depending on the material piles are distinguished by wood, concrete, reinforced concrete, pre-stressed concrete and steel.

According to the relationship, we distinguish the solitary pilots and group pilots. Solitary pilots do not affect each other. The contours of the loaded areas are not intersected at their peak and their axial distance is at least 6 x the diameter of the pile. Group piles are made up of several piles arranged below the shallow foundation structure. Group piles are affected and are always considered as one.

According to the manufacturing process, we distinguish pilots prefabricated (driven) and monolithic piles (excavated).

PREFABRICATED (DRIVEN) PILES

Prefabricated driven piles can be wooden, reinforced concrete, pre-stressed concrete and metal. They are made as full or hollow. They are driven by ramming, flushing, pushing, vibrating or other methods. The most widespread method is ramming. The pilot's heads must be protected from damage by a protective shard. Flushing is based on the flooding of the soil under the pile tip. The pile penetrates into the ground with his own weight, or with a slight ramming, to the into the flooded ground. Pushing the pile is done by hydraulic presses. The Vibration driven is mainly used for steel pilots.

Wooden piles are used in places permanently below the groundwater level. Parts of water must be impregnated. The most commonly used square or circular diameters of 200 to 400 mm in length are up to 10 meters. The tip of the wooden pilot is provided with a steel shoe; the head is protected by the shards. The advantage of wood pilots is long life underground water and easy adjustment of length (shortening).

Reinforced concrete piles and prestressed concrete piles are used to a depth of 20 meters, exceptionally up to a depth of 50 meters. The piles are produced with a hollow cross section or full. Full pilots usually have a circular, polygonal or square cross-section with bevelled edges. Piles with cross-sections of 250 x 250 to 600 x 600 mm are strongly reinforced with longitudinal reinforcement with stirrups or spiral-shaped reinforcement. The tip of the pile should be protected with steel tip. Hollow pilots are not load-bearing capacity and are replaced by pipe with the steel piles.

Steel piles are made of molded steel profiles or steel pipes. Their advantage is high strength, easy adjustment and reduction, and especially easy pushed into the soil, steel piles are used up to 60 meters deep.

MONOLITHIC (EXCAVATED) PILES

Monolithic piles are manufactured on-site into pre-drilled wells as either sheeted or non-sheeted (with or without a casing pipe). Monolithic pilots may have a fixed cross-section along their entire length or are expanded. Monolithic piles are made of concrete or reinforced concrete. Concrete piles are used in the case of stress only. Reinforced concrete piles are used for stress and tension and bending. We distinguish between three basic types of monolithic piles – non-sheeted piles, piles with a casing pipe withdrawn and piles with a casing pipe left.

Non-sheeted piles can only be carried out in cohesive soils and above the groundwater level. Digging is usually done by drilling with a diameter of 600 to 800 mm. The concrete mixture is stored directly into the borehole. The piles must be concreted immediately after the excavation. If necessary, the borehole walls can be strengthened with clay lather.

Piles with a casing pipe withdrawn are used in all soil types and below groundwater. The casing pipe is a steel tube which drives into the soil by ramming, bruising or vibrating. The casing pipe may be open or closed at the bottom.

Piles with a casing pipe left are used in an aggressive environment where it is necessary to protect concrete against harmful effects. Kept steel casing pipe reduce the value of surface friction. These piles cannot be used as friction piles. When using open casing pipe, the soil remains inside the casing pipe and is subsequently extracted, for example by drilling. Concreting is carried out in the prepared borehole. These pilots are referred to as pre-drilled piles. Closed casing pipe are fitted with a plug in the heel which prevents the soil from penetrating in. The closed casing pipe is used in the so-called pre-driven piles. Once the required depth has been reached, the plug will come out. The concreting is carried out under the protection of the casing pipe for its gradual pulling out. Piles with a casing pipe withdrawn have a rough surface and can be used as friction pilots.

Micropiles or root piles are short piles of small diameter (80 to 250 mm) which are reinforced with reinforced concrete or steel pipe. Micropiles are made using a variety of technologies. Pre-drilled holes can be filled with cement grout and a perforated pipe is inserted into the drill. After the bore is sealed, this mixture is injected. It penetrates under pressure into the lower part of the borehole and into the boundary in the soil to form an expanded root. The fifth micropile achieves high strength. Micropiles are used for reconstructions and for the capture of buildings. Micropiles may be vertical or oblique.

2.3. Large-diameter piles

Large-dimensional piles are prismatic or cylindrical deep foundations with a diameter of more than 0.6 meters. In the case of a diameter of more than 1.2 m are referred to shaft pillar. Large-diameter piles are used as a single pile and replace the whole group of pilots. Large-diameter piles are made of reinforced concrete, possibly coupled with a steel pipe.

The shaft pillars are either dredged or drilled. They are used up to a depth of up to 4 m, to which the piloting is not economical and at a depth of more than 4 meters in case of higher load carrying. In larger buildings, only pillars are drilled. Dredged shaft pillars are suitable for dry or soils with little leakage of water.

2.4. Foundation wells

The foundation wells are underground structures of cylindrical or prismatic shape with a minimum diameter of 1 meter. The foundation wells are mainly used for the foundation in water-borne and easily disconnectable soils that allow the wells to be quick submerged.

The lifting of the soil is carried out under the protection of the shell consisting of hollow prefabricated elements, usually from the rings provided at the bottom with the cutting edge. The soil is extracted from the interior of the foundation well, and the substructures are gradually undermined and their own weight enters the subsoil. The inner space is concreted after reaching load-bearing soil.

2.5. Caissons

The caissons are used for building foundations in the water. The caissons are large-area wells enclosed by a ceiling structure that creates a working chamber secured against water ingress and allows construction work under water.

To dispose of water from a caisson, it is necessary to achieve a pressure equal to the pressure from the outside of the caisson. Afterwards, workers can enter the caisson, extract the earth, and thus the caisson submerges. After lowering to the desired depth, the inside of the the caisson be cast. Caisson form deep foundations overlying structure.

3. VERTICAL LOAD-BEARING MASONRY STRUCTURES

3.1. Vertical load-bearing structures

The basic function of vertical load-bearing structures is to transfer all loads from horizontal structures to the foundations of the object and stiffened the object. Other features may be dividing, thermal, acoustic, fireproof or aesthetic. According to the ground plan position, the vertical structure includes inner load-bearing walls, stairwells walls, peripheral walls, reinforcing walls, columns, pillars and partitions.

The walls are structures where the height and length of the wall outweigh its thickness (usually a rectangular cross-section).

The columns are structures where the height prevails above floor plan dimensions (typically square, rectangular, circular).

The pillar is a structure where the height of the pillar prevails over floor plan dimensions (versus the column is more massive, usually square or rectangular cross-section).

3.2. Load-bearing masonry structures

The masonry structures are made of individual natural or artificial masonry elements connected by mortar or laid dry. The design of brick walls is based on static calculation, thermal-technical assessment and fire resistance assessment.

Masonry structure has relatively good resistance to compressive stress. The tensile load-bearing capacity of the masonry is practically negligible. The load-bearing capacity of the masonry is determined by the used wall elements, the mortar type and the masonry bonding.

According to the type of masonry element used, there are brick masonry, block masonry, stone masonry and mixed masonry.

3.3. Brick masonry

Bricks are manufactured in various materials and dimensional formats with holes or without holes. The most commonly used were burnt bricks of and metric perforated bricks.

The mortar is a mixture of binders, fillers and water. The strength of the mortar is chosen according to the required load capacity of the masonry. Depending on the amount of binder and final strength, we divide mortars into:

- Lime mortars with a compressive strength of max. 1.0 MPa
- Limestone cement mortars with a compressive strength of 1.0 - 2.5 MPa
- Cement mortars with a compressive strength of 5.0 - 20.0 MPa

The final load-bearing capacity of the masonry does not only the properties of the used materials but also their mutual arrangement or bond.

The classic brick bond is characterized by:

- A masonry pieces that are placed in horizontal layers
- Head joints should be shifted in two layers above each other
- Bed joints and head joins should be completely filled with mortar

According to the orientation of the bricks in the masonry, there are stretcher and header. The stretcher is a longitudinally oriented element applied in the face of the masonry by its length. The header is a transversely oriented element applied in the face of the masonry by its width.

The resulting load-bearing capacity of the masonry affects not only the mechanical parameters of the bonded materials but also masonry bonding. Classic masonry bonding includes stretcher bond, header bond and English bond. The cross bond, Dutch bond, or Polish (Gothic) bond are applied less. Stretcher bond is composed only of stretchers that are bonding by ½ bricks. Header bond is composed only of headers bonded by ¼ bricks. English bond (semi-cross bond) rotates stretcher bonds and header bonds. In each layer, the bricks overlap in the transverse direction by ½ bricks, in the longitudinal direction by ¼ bricks.

3.4. Block masonry

Block masonry have evolved from brick masonry in response to stricter thermal technical requirements. The block masonry wall is implemented as brickwork. Thermally stricter requirements satisfy the blocks, which are lightened from the cavities or are lightened in mass. Blocks are made from lightweight concrete, diatomaceous earth, slag, fly ash, etc. The cavities are either continuous or closed. Blocks of closed-cell cavities are laid down. The blocks with closed cavities are laid down by cavities oriented downwards.

CERAMIC BLOCKS

Ceramic blocks of older types such as CD-INA, CD-IVA, CD-IZA have been replaced by a new generation of blocks, such as Porotherm, Kintherm or Supertherm, which are produced in dimensional series for single-layer load-bearing masonry. With the latest types, blocks are already filled with heat insulating material (EPS, mineral wool) from production. In addition to the basic elements, additional elements are available - half blocks, end blocks, and others.

The mortar layer in the bed joint, or even in the head join, of 10 mm thick, reduces the thermal properties of the masonry. For this reason, the head joints are only partly filled. Two or three strips of mortar bed are realized in the bed joints. Alternatively, special lightened mortars, such as perlite, ceramics, etc., or heat insulating tapes may be used.

LIGHTWEIGHT CONCRETE BLOCKS

Lightweight concrete blocks are manufactured in different strength classes. The products have high precision and can be bonded dry in the head joints without the use of mortar or can be bonded by tongue and groove. Precision calibrated blocks can be glued (joint thickness 1 - 3 mm).

Lightweight concrete blocks are characterized by a low density (500-1000 kg/m3), which makes it possible to produce and use large-dimension blocks to accelerate the brickwork process. Porous concrete products are easily workable. The disadvantage is their water absorption. In their soaked condition, their thermal insulating properties and load-bearing capacity are reduced. Relatively low compressive strength limits the use of lightweight concrete blocks to low-floor structures.

3.5. Stone masonry

Natural stone masonry is currently not used widely. The disadvantage is mainly its density (2200 to 2400 kg/m3), difficult and costly workability, poor thermal insulation properties and airtightness. The advantage is resistance to weather and mechanical influences and aesthetic architectural effect.

For stone masonry, stone elements of different sizes and shapes are used. The random rubble is characterized by irregular shapes without stoneworking. Rubbles are roughly worked stone elements of the shape of an approximate parallelepiped. Ashlar is prism-shaped elements roughly machined used for facing masonry. Stone blocks feature regular shapes and stoneworking as needed.

Stone masonry is not usually plastered and joints are filled with cement mortar. The width of the head joint and bed joints is 15 - 40 mm. According to the arrangement of the layers and shapes of stones, stone masonry is divided into:

- Random rubble masonry is used for base structures and plinths. The strength of masonry from unprocessed stone is influenced by the quality of its bonding. The joint joints are not to be continuous, the width of the load joints is 15 - 40 mm.

- Squared rubble masonry is made of partially worked stones (squared rubble). Depending on the method of processing, we recognize the rough squared rubble and fine squared rubble. Rough squared rubble masonry may not have the same thickness of the layers and the joints may be oblique. Fine squared rubble masonry is done from fine squared rubble with a clean machined line and the head joints must be vertical.

- Polygonal rubble masonry is used for terrain and decorative purposes. Polygonal masonry is most commonly used for decorative purposes. The masonry consists of selected stone, which has the shape of irregular four to octagonal. The linkage and bed joints are machined to a depth of about 80 mm and the visible face is left untreated.

- Ashlar masonry is made from machined stones of prescribed shapes and dimensions. Ashlar masonry is used for tiling of representative buildings, monuments, etc.

3.6. Mixed masonry

Mixed masonry is a combination of two or more building materials in one construction unit. Typically, this is a combination of bricks and stones, bricks and concrete, concrete and stone, blocks and concrete. The advantage of mixed masonry is the possibility of using the advantages of individual materials, such as the aesthetic effect of stone on the outer face of the building and high strength of concrete.

4. VERTICAL LOAD-BEARING MONOLITHIC AND PREFABRICATED STRUCTURES

4.1. Monolithic wall and column structures

Monolithic structures are carried out directly on the site by placing a ductile construction material (concrete) into a prefabricated formwork in which the necessary reinforcement is deposited.

MONOLITHIC CONCRETE AND REINFORCED CONCRETE

Concrete wall structural system is roughly 10 times more bearable compared to brick masonry system. For monolithic load-bearing walls, heavy concrete (1800-2400 kg/m3) and medium-heavy (1200-1600 kg/m3, e.g. ceramsite concrete, slag-cement concrete) are used. The concrete has a high compressive strength and transmits tensile stress if it is reinforced. Plain concrete is used only for compressive structures. Reinforced concrete can be used for structures stressed by tension and bending. Heavy concrete walls are usually designed with a thickness of 150 to 200 mm and must always be accompanied with thermal insulation.

Monolithic concrete load-bearing walls are used mainly for civil buildings, for buildings of diverse shapes and complicated floor plans, receding and overhanging structures, high-rise buildings and buildings with high architectural demands.

The concrete mixture is poured into the prepared formwork. Formwork gives the structure a shape and divides it into individual work units. Formwork must allow easy storage of the reinforcement and the concrete mix. Different materials such as wood, steel, plywood or paper are used for formwork. Traditional wooden individual wooden formwork is laborious and uneconomical. Currently, the large-area formwork systems are used. Partial formwork of horizontal plywood or metal or plastic panels with reinforced frame enables multiple uses. The forming system which consists of large panels has different design variants. There is also paper formwork for columns of circular and irregular shapes. The perfectly rigid connection of the concrete walls with the ceiling structure can be achieved by using tunnel formwork, which allows concreting of ceilings and walls at the same time. On high-rise buildings, a sliding or drawn formwork is used, which is formed by formwork panels attached to the lifting frame. Concreting of the walls into the sliding formwork is continuous, the formwork continuously moves vertically at a speed of 100 to 150 mm/hour. Sliding formwork is mainly used in the construction of chimneys, silos, reinforcement cores. Built-in lost formwork remains a permanent part of the building where it performs the function of surface coating, thermal or sound insulation and fire protection. The construction can also be improved from the thermal insulation by inserting polystyrene boards into a lost formwork. In addition to the cladding boards, reinforced concrete blocks may be used, where the closed cavities with the insulated thermal insulation are cast with concrete dressing. Sheeting cement-bonded bricks with insulated thermal insulation boards as lost formwork.

Surface coating of monolithic walls is made by plastering or facing. The perimeter walls of heavy concrete should be thermally insulated.

MONOLITHIC REINFORCED CONCRETE COLUMN STRUCTURE

Monolithic reinforced concrete column systems are solid structures made of columns, beams or heads and ceiling structure. The monolithic connection of the vertical and horizontal elements gives the skeleton sufficient stiffness even for high-rise buildings. The advantages of the monolithic skeleton are mainly the integrity of the structure, strength, stiffness and resistance to the effects of extraordinary loads or in the undermined and seismically unstable area.

Columns of monolithic skeletons have squares, rectangles, circles, or composed cross-sections (eg shape I or T). Columns are mainly stressed. However, the monolithic connection with horizontal structures also brings bending stress to them, so they have to be reinforced. The minimum size of monolithic columns is 200 mm. Columns 300 x 400 to 400 x 500 m are usually used in conventional rectangular skeleton structural system. Elements sizes must always be verified by static assessment.

Supporting beams and ceilings beams are also dimensioned based on static calculation. The supporting beam height is approximately 1/8 to 1/12 axis distance of the columns.

Monolithic reinforced concrete skeletons are made as frame, head or slab structures:

- Frame skeleton system: The load-bearing frames can be arranged in the transverse direction, in the longitudinal direction or in the two-way direction (space frames). Supporting beams can be cantilevered in front of pillars.

- Flat slab with column head skeleton system: Flat slab with column head skeleton system is a special case design with two-way arrangements supporting beams. The supporting beams are reduced to heavily reinforced stripes running in the ceilings above the head of the columns. These hidden beams carry a bi-directionally reinforced ceiling slab. Ceiling heads may be rectangular, polygonal or circular. This system is used for objects loaded with large payloads. The disadvantage is complicated formwork.

- Flat slab skeleton system. The slab monolithic skeleton has a ceiling structure directly supported by columns. The slab has a flat ceiling. A flat head is formed around the column. Columns are usually located in a square module network. Ceiling slab should be circumferentially cantilevered that large bending moments are not brought into the outer columns. Skeletons with slab ceilings are used for objects with lower payloads. Their advantage is a flat view, the possibility of free partitioning of the partitions and easy execution.

Column structure systems are also stressed by volume changes due to temperature effects. Expansion joints can be made in reinforced concrete skeletons in several ways:

- Duplication of columns is the most common way of dilatation. The disadvantage of this modification is the interruption of the modular system, which is unfavorably reflected in the front of the building
- Duplication of supporting beams can be done in duplicate. One of the beams is mounted on a column bracket or on the rebate of a neighbouring beam having a higher height.
- The ceiling panel can be created by an inserted field.

4.2. Prefabricated wall and column structures

Prefabricated structures consist of prefabricated full-area or rod-shaped parts, which are bonded to the structure e.g. by welding, concrete dressing, in the historic stone pillars of 2500 years BC using coupling pins of hard (e.g. cedar) wood.

Prefabricated parts of vertical structures can be made of ceramic, heavy or lightweight concrete or steel. The rigid connection of reinforced concrete columns with supporting beam (welds + concrete dressing) formed frames that are the basis of prefabricated skeletons.

PREFABRICATED CONCERETE AND REINFORCED CONCRETE WALLS

The load-bearing walls of the prefabricated elements began to be widely used in the 1950s. The first prefabricated panels were made in the form of blocks and blocopanels, later in the form of panels:

Blocks are wall element panels, their height is ½ to 1/3 of floor height, thickness 300 to 400 mm. Blocks were made of crushed concrete, slag-cement, porous concrete, and they are placed in a mortar bed. Block constructions were referred to as a semi-assembled system. They are currently used only exceptionally in the reconstruction and adaptation of apartment buildings.

Blocopanels are wall element of floor height and a width of 1200 to 1500 mm. The thickness of the blockopanels is given by mechanical and thermal-technical properties (250 - 400 mm). They were made from the same materials as blocks. In the wall constructions, they were joined by welding reinforcement and grouting of joints.

Panels are large-area panels whose dimensions are limited by the characteristics of the material used and the lifting device's load. Wall panels typically have an area of 10 to 20 square meters. The height corresponds to the height of the floors. Their usual 150 mm thickness meets acoustic and fire protection requirements. Wall panels are made of concrete, reinforced concrete, lightweight concrete, ceramic blocks or as a layered element (sandwich construction).

Depending on the layout of the load-bearing walls, we recognize transverse, longitudinal and bi-directional systems. Depending on the function, we are able to distinguish the interior load-bearing wall panels and the peripheral load-bearing wall panels. Internal load-bearing panels are produced in thicknesses of 150 - 200 mm and in a length of multiple 300. Wall panels may be full or with holes. Concrete panels must have a structural reinforcement that is particularly relevant for transport and assembly. The interlocking is provided by the contact reinforcement in the form of steel pins, loops or steel joint plates. In addition to the static function, the perimeter wall panel must fulfil the thermal insulation function in particular. Both of these functions can be fulfilled by the single-layer panel. However, it is preferable to manufacture a two-layer or three-layer sandwich panel. Single-layer panels are made of lightweight concrete and hollow ceramic inserts. The two-layer panels have a concrete or reinforced concrete support layer and an outer layer of lightweight concrete or ceramic materials. The three-layer panels consist of a reinforced concrete or reinforced concrete board with a thickness of 100 - 150 mm and a thermal insulating core (polystyrene, mineral wool). The stiffening panels form an internal reinforcing wall, which provides stability prefabricated buildings. The stiffening walls are not loaded with ceilings, but they are stressed by carrying the effects of horizontal forces. Their thickness varies from 80 to 100 mm.

PREFABRICATED REINFORCED CONCRETE COLUMN STRUCTURE

Prefabricated reinforced concrete skeletons have evolved from monolithic structures. The first assembled skeletons appeared in the 1930s. During the development, more than 30 systems of prefabricated skeleton systems were built. Many of these systems have been unified and replaced by a unified system - an open set-up system of assembled frame skeletons characterized by the unified principle of supporting beams and columns that are still in use.

Frame assembled skeleton is made up of supporting beam mounted on columns. Frames are formed by dividing the monolithic frame off its joints, at the sites of the smallest bending moments. In columns, it is usually a half to a third of their height. For beams is in a quarter to a fifth of the span. The H-frames are formed in such a division and retaining the rigid joints. The frames Π are created by dividing the columns in the heel. Console columns and split beams are formed by separating the beam from the columns on which the brackets remain. Columns with continuous beams are formed by dividing monolithic skeletons in the joint. Supporting beams are interconnected either directly above the columns, or extend over the columns and contact the field. The basic connections include the intersection of two columns, the intersection of two beams and the contact of the beam and the column.

5.OPENINGS IN WALLS

5.1. Openings in walls

The openings in the walls and partitions are designed to illuminate the room with daylight and to connect the adjacent spaces or outer environment with the interior of the building.

The wall openings are divided according to their purpose:

- Window openings that perform lighting and room ventilation functions
- Door openings that function as a room entry and room connection
- Gate openings which are used for vehicle entry
- Passes are openings without filling
- Other openings such as niches

All openings have head of openings and jambs. The jamb is the lateral surface of the opening in the wall. The jamb may be straight or craned. The head of opening is the construction above the opening. The window openings also have the window sill (window ledge). The window ledge is the bottom part of the niche and the entire lining under the window, that is, the wall from the floor to the window. The niche is usually a decorative recess in the strength of the building's brickwork. Door and gate openings have a threshold at the bottom or they are without a threshold.

5.2. Lintels

The lintel must be placed over the openings. The lintel must be able to transmit the load from the adjacent part of the ceiling and walls to the vertical support along the opening.

Requirements for the lintel:

- Static requirements - Load transfer to support

- Compositional - In the case of assembled lintels, the dimensions must correspond to the compositional dimension of the vertical structures and ceilings

- Thermal insulation requirements - to ensure the minimization of thermal bridges

Loads of lintels may be equally continuous (e.g. reinforced concrete slab) or with the group of solitary loads (e.g. beams). According to the position of the load, there are one-sided load eccentricity (the peripheral wall) and a load-sided (at the middle of the wall). Depending on the shape of the centerline, the head of opening can be straight (pressed or bent) or arched (strain dependent on pressure or flexural pressure).

The lintels must ensure the transfer of loads to the adjacent supports. The loading effect on lintels is not constant, but usually triangular. The size of the displacement angle depends on the stiffness of the wall and its height above the lintel. Thermal bridges must be excluded in peripheral structures. Modern lintels made of reinforced ceramic blocks or porous concrete have the supporting function and thermal insulation function.

According to the technological implementation, the lintels may be monolithic or prefabricated. Prefabricated lintels can be stone or brick, from steel beams or from ceramic block beams. Prefabricated lintels are made of reinforced concrete or lightweight concrete.

STONE AND BRICK LINTEL

The direct stone lintels are made up of precisely placed bevelled blocks and connected by stoneware clinch. The arched stone lintels consist of stone vaults of different shapes and sizes. Due to the great difficulty in realizing the stone lintels and due to the insufficient thermal insulation of the stone, at present, the stone lintels are not used in new constructions.

The lintels from stone blocks should have upper and lower obverses horizontal. The lintel line is wedged from both sides and closed with a central wedge, the joints are straight or oblique.

The direct reinforced lintels use tape steel to transfer the tensile stresses in the lower face. Arched lintels into the foot are either common bricks with a wedge of mortar or sliced conical bricks. The static effect of the lintels is similar to the vaults, with a span of about 3.0 m. The head joint formed by the wedge of the mortar has a minimum width of 8 mm and a maximum of 20 mm. Joints wider than 20 mm are wedged by flat fragments of bricks or roof tiles. The crushed bricks must have a minimum thickness of 45 mm.

Simple brickwork head of openings is done as a reinforced brick lintel. It is made as a straight vault made of hard bricks and reinforced in the joints by a 20/1 - 30/2 mm strap taking the pull at the bottom of the lintel.

The brick strip is vaulted in the wall thickness on the wooden, or mortar, shoulders. It is suitable for smaller spans and for the head of openings without indentation. The masonry is done from the foot towards the center. The direction of the joint is controlled by a template or a lath. The slope of the raised or recessed foot is determined by a center angle, preferably 30 °.

STEEL LINTEL

The steel lintels from rolled I-beams are used for heavy loads and large spans (up to 6 meters) as well as for renovations. The advantage of steel lintels is their ability to transfer loads immediately. The supporting length is affected by the overall length of the beam and the load, but at least 150 mm.
The lintels from steel beams are made of rolled profiles laid on concrete or stone bed foundation. The embedded traverses are either concreted or encircled by bricks and wrapped in ceramic or rag-mesh and plastered (fire protection). These lintels should be additionally insulated by thermal insulation to avoid the thermal bridge.

CERAMIC LINTEL

Ceramics have the low tensile strength and thus ceramic lintels are complemented by the reinforcement in ceramic blocks. Ceramic shaped brick acts as a lost formwork. And also forms a suitable base for plastering. Ceramic lintels parts are manufactured in various shapes. The ceramic parts are placed vertically into a prepared bed of cement mortar (supporting length 150 to 300 mm). In the perimeter walls, they are combined with a thermal insulator.

LIGHTWEIGHT CONCRETE LINTEL

Lightweight concrete lintels can be made from porous concrete, ceramsite concrete and other materials. The lintels from lightweight concrete can be box, roller, segment or arc.

The lintels from lightweight concrete are used in most cases for brickwork made of blocks of the same material. Flat load-bearing porous concrete lintels are supporting elements reinforced by welded concrete reinforcement. They have excellent thermal insulation properties and are therefore a suitable supplement to massive masonry made of aerated concrete without changing the underlying material for plastering and with minimal thermal bridges.

PREFABRICATED REINFORCED CONCRETE LINTEL

Prefabricated reinforced concrete lintels are assembled from prefabricated rod-shaped elements of which it is possible to compose multipart lintels. The lintels are made in lengths from 1.2 to 3 meters. The supporting length of the lintels is given by the width of the lintel, but not less than 150 mm. Prefabricated reinforced concrete lintels can be loaded immediately after installation.

MONOLITHIC REINFORCED CONCRETE LINTEL

Monolithic reinforced concrete lintels are applicable for any load range. The advantage of monolithic lintels is their shape and dimensional variability. The disadvantage is considerable labor, the need for formwork and the possibility of loading until the concrete is hardened. Monolithic lintels may act as a single beam over one or a continuous beam over multiple openings. If the head of the opening is closely related to the ceiling structure, the monolithic lintel can be associated with the reinforced concrete rim. Support of monolithic lintel should be at least 7,5% clearance opening (minimum 200 mm). The reinforcement of the translation must correspond to their static effect.

6.CHIMNEYS

6.1. Basic characteristics and classification of chimneys

Chimneys are designed to remove flue gases from appliances to a free space outside the building where they are scattered so as not to endanger the quality of the living environment of the house's residents.

Chimneys are among the most stressed building elements - they are exposed to extreme temperature conditions and aggressive flue gases.

The chimney consists of:

- One or more chimney flues
- Chimney casing
- Sweep openings
- Pickup openings
- Vent connector
- Chimney heads, or extensions

CLASSIFICATION OF CHIMNEYS

According to the appliances we distinguish chimneys for:

- Solid fuel chimney
- Liquid fuel chambers
- Gaseous fuel chimney

According to the structure, we distinguish chimneys for:

- Single-layer chimneys - The chimney's passage is formed by a chimney casing

- Multi-layer chimneys - The chimney consist of a structure consisting of a chimney liner, an insulating layer and a chimney casing

According to the location of chimneys, we distinguish chimneys for:

- Fitted or built-in chimneys
- Solitary chimneys

According to the ground plan shape of the chimneys we distinguish:

- Square chimneys
- Rectangular chimneys (up to 1: 1.5)
- Circular chimneys

According to the size of the flue to distinguish:

- Narrow chimneys (up to 40,000 mm2)
- Medium chimneys (over 40,000 mm2)
- Man chimney (minimum cross-section up to 10 m high is 450 x 450 mm)

According to the built-in material we distinguish chimneys for:

- Chimneys made of non-flammable or non-easy possibly flammable materials

- Chimneys made of materials with an absorption capacity not exceeding 20% of the specific weight

- Chimneys made of materials resistant to the effects of flue gases

- Chimneys made of frost-resistant materials

According to the arrangement of flues, we distinguish chimneys for:

- Continuous chimneys
- Storeys chimneys
- Overflow chimneys
- Tree chimneys

According to continuous longitudinal axes we distinguish chimneys for:

- Direct chimneys
- Moving chimneys

6.2. Design and implementation of chimneys

The flue gas is exhausted by chimney flues formed in the chimney casing. The hole through which the flue gas is fed into the flue is called the vent connector. Other openings in the chimney enclosure are used for cleaning the flues - pickup hole and sweep hole. The chimney ends the chimney head.

The chimney draft depends on the difference in mass of hot combustion gases and fresh air in the chimney head. The draft of the chimney also depends on the size and shape of the flue, on the smoothness of the interior surface of the flue, and also on the effective height. The effective height is part of the chimney from the chimney to the chimney head and is intended for flue gas removal. Part of the chimney from the flue connector to the chimney soil is used to collect solids of flue gas and condensate.

The chimney flue should have a constant cross-section along the height. Chimneys may contain flue for exhaust gas and may have ventilating vents (vents). Flues for exhaust gas cannot be used as ventilation vents and vice versa. Flues are designed generally vertical and straight. Any deviation from the vertical should not be greater than 15°. The flues may have a square, circular or rectangular cross section.

The chimney casing should be non-flammable, low absorptive and resistant to flue gases. The chimney passing through the interior or building structure shall not have an outer surface temperature above 52°C during operating. A part of the chimney directly exposed to atmospheric influences should be protected from freezing.

Single-layer chimneys must have a masonry chimney thickness of at least 140 mm. The curvature of chimney's flue shall be formed by a smooth curve with a radius of at least 300 mm. The outer surface of the monolayer masonry chimney can be plastered or sprinkled, or fitted with a non-flammable coating.

Multi-layer chimneys are usually three-component. They are consisting of chimney liner, an insulating layer and a chimney casing.

Openings in the chimney must always be accessible. The flue connector is part of the chimney, which connects the appliance and the chimney flue to which the exhaust gas. The flue connector cannot be larger than the light cross section of the flue into which they are inserted. The flue connector should be direct and toward the flue should rise. Sweep openings are designed for flue and liquid fuels that cannot be swept straight through the chimney head. The holes are placed over the roof or in the attic. Pickup openings are designed at the level of the soil of the chimney flue. The floor around the selection holes must be non-combustible. All chimney openings should be closed with chimney door made of non-combustible materials.

Chimneys are positioned above the roof so high that they do not disturb the environment or pollute the surroundings with flue gases. The smallest permitted chimney height is given by the type of roofing and the location of the chimney.

LITERATURE

HÁJEK, P. a kol. *Konstrukce pozemních staveb 1. Nosné konstrukce I*. 3. vyd. Praha: ČVUT, 2007. ISBN 978-80-01-03589-4.

HANÁK, M. *Pozemní stavitelství: cvičení I*. 6. přeprac. vyd. Praha: ČVUT, 2005. ISBN 80-01-03267-1.

LORENZ, K. *Nosné konstrukce I. Základy navrhování nosných konstrukcí*. 1. vyd. Praha: ČVUT, 2005. ISBN 80-01-03168-3.

MATOUŠOVÁ, D., SOLAŘ, J., *Pozemní stavitelství I*. 1. vyd. Ostrava: VŠB TU, 2005. ISBN 80-248-0830-7.

NESTLE, H. a kol. *Moderní stavitelství pro školu i praxi*. Praha: Sobotáles, Praha, 2005. ISBN:80-86706-11-7.